TECHNISCHE UNIVERSITÄT DRESDEN

FAKULTÄT ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Chair and Laboratory of Measurement and Sensor System Technique (MST) / Czarske Lab

Annual Report 2022

MST
Professur für
Mess- und Sensorsystemtechnik

CZARSKE LAB

BIOLAS
BIOMEDICAL COMPUTATIONAL LASER SYSTEMS

DRESDEN concept

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PREAMBLE

Dear friends and partners of the Chair MST / Czarske Lab,

The Chair of Measurement and Sensor Systems (MST) / Czarske Lab celebrates the anniversary of 18 years. We look back on an eventful year. It is a great pleasure to report on our activities this year. First and foremost, it should be highlighted, after a long time we were again able to meet in-person at congresses, which cannot be replaced by digital meetings, but, of course, supplemented with digital project meetings. Many trips to conferences could be scheduled this year, such as the first trip of the year to San Francisco (by Robert Kuschmierz), followed by a large number of journeys to Strasbourg, Vancouver, Cambridge, LA, San Diego, Porto, Rochester, Brno, Tel Aviv, London, New York City, Hanover, Rostock, Freiburg, Venice, etc.

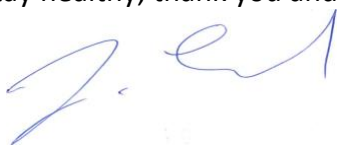
A record in the history of Czarske Lab of invited talks was achieved, we have followed about 30 invitations for talks at conferences and seminars. In the years 2021 and 2022 invited talks were presented in 4A (Africa, Asia, America, and Amazing Europe). In 2017, the general congress ICO-24 was opened in Tokyo by the Japanese Emperor and Dresden was chosen for the next world congress. After 3 years of intensive preparation with support of OPTICA, SPIE, IEEE, EOS, DGaO, ZEISS, TU Dresden, ICO, OWLS, and further partners the congress could not take place due to the covid-19 pandemic. It was postponed for a year and then postponed again after an intensive discussion in the general assembly of ICO about digital formats. This year, the in-person world congress ICO-25-OWLS-16 was held with great success with unexpected high international presence and quality. Attendees from 55 countries from 5 A (Africa, America, Asia, Australia, Amazing Europe) and an extraordinary quality density with 3 Nobel laureates have to be highlighted. We acknowledge all supporters and staff members, especially Nektarios Koukourakis and Lars Buettner. Furthermore, Michael Pfeffer and Wolfgang Osten are to be thanked for the commitment to the on-site organization and the scientific program, respectively. Information about the world congress ICO-25-OWLS-16-Dresden-Germany-5-9-September-2022 with the theme "Advancing Society with Light" can be found at the website https://www.ico25.org

It is also pleasing that many prizes were awarded again this year. The students and staff members of the Czarske Lab have received in total more than 90 honors, prizes and awards, including recently the Berta Benz award for Katrin Philip, donated with 10 000 Euro. It is gratifying that an ERC was received from the alumni (Andreas Fischer, Bremen). Several new projects were acquired. An international project is running too. The output of research can be measured with publications, talks and patents. About 20 journal papers were published. An impact of journal paper of over 20 was achieved by Jiawei Sun et al. The commercial success of the laser profile sensor for velocity and temperature measurements has to be highlighted, which was enforced by Lars Buettner et al. The transfer was accomplished in cooperation with the company ILA R&D GmbH, Jülich. This successful innovation at the market was awarded with the Berthold Leibinger Innovation Award.

The Czarske Lab has successfully acquired projects in new research topics such as optogenetics with human stem-cell-derived organoids. First we have starting with visions on optogenetics only, then a very successful project cooperation with the genetic labs at CRTD was running. This year high-quality papers were published, such as in Life Science Alliance, titled “Tracking connectivity maps in human stem cell–derived neuronal networks by holographic optogenetics”. For multimode fiber transmission new approaches for physical layer security were demonstrated. The control of the scattering processes in fibers or tissues with modern wavefront shaping techniques opens up new directions of transfer to applications. Projects were acquired on quantum technology of the second generation too. Furthermore, 3D printing by femtosecondlaser Two-Photon polymerization onside the fiber facet has enabled novel low-cost single-to-use multicore-fiber endoscopes, which are promising for biomedicine. Artificial Intelligence, Machine Learning and Deep Learning are playing

a more and more important role. Deep neural networks can learn the light propagation through lensless fiber endoscopes towards a classification of human brain tumors. This new differentiation approaches of malignant and benign tumors using ultrathin endoscopes are promising for advanced medical diagnoses in real-time. High-quality papers were published on these new topic, such as “Beyond Janus Geometry: Characterization of Flow Fields around Nonspherical Photocatalytic Microswimmers”, Advanced Science; „Real-time complex light field generation through a multi-core fiber with deep learning”, Scientific Reports; "Learning the matrix of few-mode fibers for high-fidelity spatial mode transmission", APL Photonics; “Quantitative phase imaging through an ultra-thin lensless fiber endoscope”, Light: Science and Applications of Nature Publishing.
In the faculty of electrical and computer engineering (EE) of the TU Dresden, the measurement systems technique plays a crucial role. Without measurements, the control of systems is not possible and measurement and sensor systems are an essential part of AMR (automation, measurement and control technique). The Czarske Lab is an integral part of the studies in electrical engineering, mechatronics, biomedical engineering, information system engineering and especially AMR. Starting with the 4th semester, basics in measurement data analysis as well as sensor technique are introduced. In the 5th semester, the approaches in digital measurement techniques, measurement system theory and advanced sensor techniques for biomedicine too are introduced. Further lectures are offered in the higher semesters for the specialization in computational metrology for technical processes and biomedicine.
Since 2019, the Czarske Lab offers a lecture on “Biomedical Systems and Optogenetics” (9th Semester), which is presented in English now. It should be integrated to moduls of the study of the cluster Physics of Life. E-learning plays an important role in modern lecturing, especially since the covid-19 pandemic. For the lecture Measurement Systems I, 4th Semester, we offer a digital bonus examination. In the lecture Measurement Systems II, 5th Semester, a Python programming task as bonus is scheduled online. In total, the Czarske Lab conducted more than 15,000 exams and over 200 defenses of Bachelor and Master Theses (“Studienarbeiten, Diplomarbeiten”). The extraordinary commitment of the staff members has to be appreciated. It is very gratifying that every course of the lecture program of Czarske Lab could be offered especially during covid-19 in a digital format. I acknowledge the great team work. An extraordinary research-oriented lecturing was established with the OPTICA-SPIE student chapter to foster students in optics and photonics (President Katharina Schmidt). In the Czarske Lab we follow the idea of Humboldtian education ideally to combine research and studies. Students are actively involved in research by attending at conferences already in their undergraduate studies. Regular excursions to companies in the region, such as SICK Engineering GmbH, Ottendorf-Okrilla, are offered. Our employees and partners actively contribute every day towards scientific and transfer success.
The computational adaptive metrology systems enable a multitude of demanding applications in biomedicine, fiber communication, and further areas. With the center BIOLAS we aim to transfer novel adaptive laser systems towards real-world application in biomedicine. In order to maintain our successful course, we are looking for committed physicists, engineers and other employees who will further advance the Czarske Lab with their great ideas.
I acknowledge the team members for the committed research and teaching and our partners for the efficient and effective cooperation.

Stay healthy, thank you and all the best



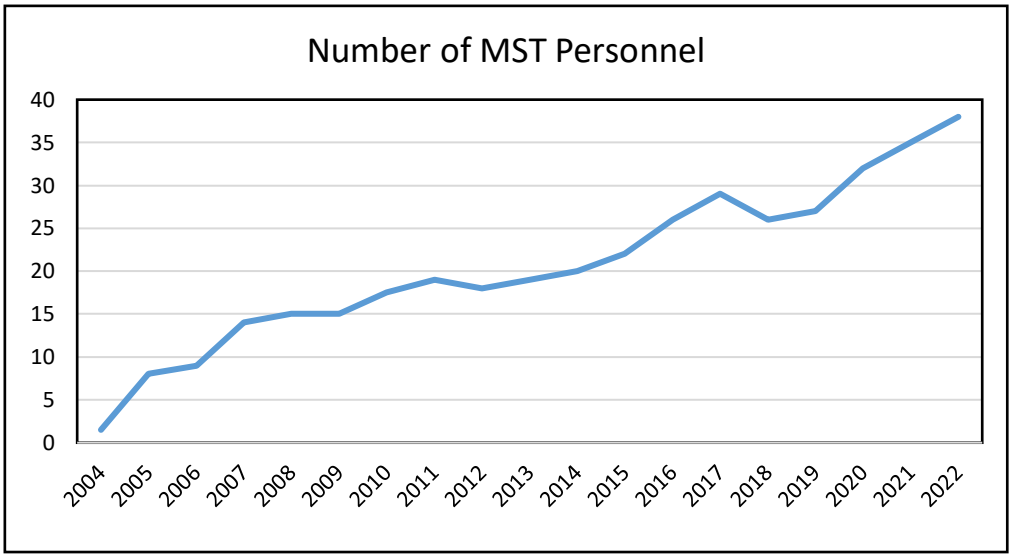
Prof Juergen Czarske

STAFF

1	Bürkle, Florian	Dr.-Ing., M. Sc.	Research Assistant
2	Bilsing, Clemens	Dipl.-Ing.	Research Assistant
3	Büttner, Lars	Dr. rer. nat.	Postdoc, Research Fellow; Head of Department „Laser Measurement Systems“
4	Czarske, Jürgen	Prof. Dr.-Ing. habil.	Full Professor, Head of MST and Director of the Czarske Lab, Director of BIOLAS Center
5	Dremel, Jakob	Dipl.-Ing.	Student Assistant
6	Dou, Zehua	M. Sc.	Research Assistant
7	Emmerich, Hannes	Dipl.-Ing.	Research Assistant
8	Geppert, Anna-Lena		Student Assistant
9	Glosemeyer, Tom	Dipl.-Ing.	Research Assistant
10	Gonzalez, David	Dipl.-Ing.	Research Assistant
11	Grüter, Lars	Dipl.-Ing.	Research Assistant
12	Gürtler, Johannes	Dr.-Ing.	Postdoc / Research Assistant
13	Guo, Ning		Research Assistant
14	Harloff, Anne		Student Assistant
15	Hoppe, Johanna		Student Assistant
16	John, Cathleen		Senior Executive Team Assistant
17	Koukourakis, Nektarios	Dr.-Ing.	Postdoc, Research Fellow, Head of Department “Bio-photonics and Laser Metrology”, CEO of BIOLAS center
18	Krause, David	Dipl.-Ing.	Research Assistant
19	Kroll, Martin	Dr., M. Sc.	Research Assistant
20	Krug, Benedikt	Dipl. -Ing.	Research Assistant
21	Kuschmierz, Robert	Dr.-Ing.	Postdoc, Research Fellow, Head of Group “Laser Systems for Biomedicine”
22	Lich, Julian	M. Sc.	Research Assistant
23	Liebig, Leon	Dipl. -Ing.	Research Assistant
24	Liu, Zhaohong	Dr.	Postdoc, Scholarship
25	Matzke, Jessica		Team Assistant, part-time
26	Pohle, Dennis	Dipl. -Ing.	Research Assistant

27	Rothe, Stefan	Dipl.- Ing.	Research Assistant/Head of Group “Multimode Fiber Security”
28	Schaller, Ludwig	Dipl. -Ing.	Research Assistant
29	Scharf, Elias	Dipl.-Ing.	Research Assistant
30	Schmidt, Katharina	M. Sc.	Research Assistant
31	Schmieder, Felix	Dr.-Ing., Dipl.-Phys.	Research Assistant
32	Sui, Yuan		Student Assistant
33	Sun, Jiawei	M. Sc.	Research Assistant
34	Wang, Tijue	M. Sc.	Research Assistant
35	Wang, Wenjie	M. Sc.	Full-Time Visiting Scientist
36	Weber, Julius		Student Assistant
37	Weik, David	Dipl.-Ing.	Research Fellow, Head of Group “Computational Imaging”
38	Zhang, Qian	Dipl.-Ing.	Research Assistant

External Ph.D. Student:
Meloni, Ilenia, M. Sc., Topic Optogenetics, Kurt-Schwabe-Institut Meinsberg e.V.



Number of staff members, excluding adminstration and technical members of the workshop etc.

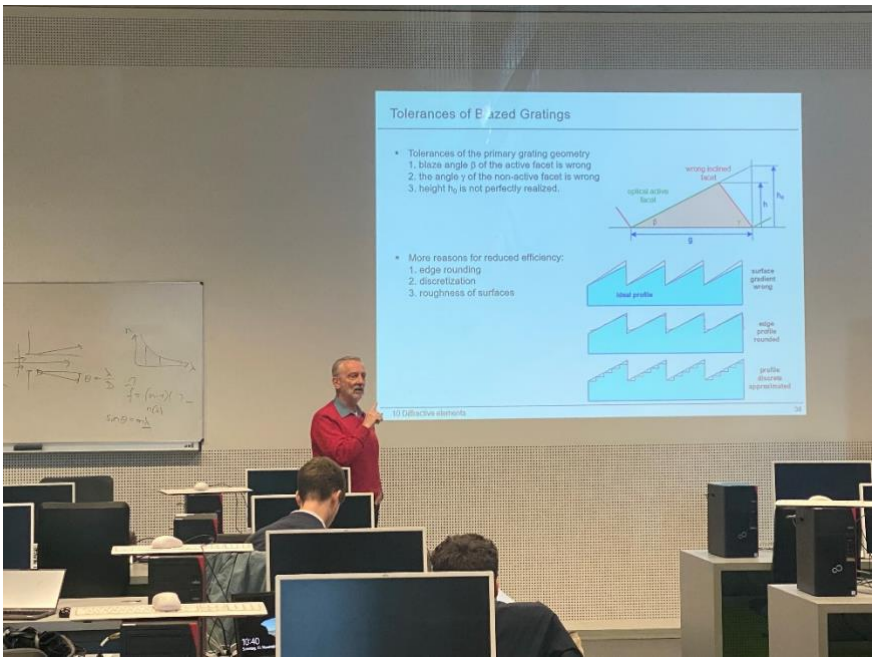
SPIE. STUDENT CHAPTER
TECHNISCHE UNIVERSITÄT DRESDEN

OPTICA
Formerly OSA

The OPTICA-SPIE student chapter of TU Dresden is a group of undergraduate and graduate students in Dresden, Germany, with an interest in Optics and Photonics. Since September 2017, we belong to a worldwide network of student chapters supported by SPIE (The international society of optics and photonics, Washington, USA) and since 2022 additionally to the OPTICA chapters. We maintain contacts to other international student chapters in South Africa, Poland, Czech Republic, UK and Germany. Several pre-diploma students are members of the OPTICA-SPIE chapter. Our objective is to establish and intensify the contact between students and faculty at different optics-related groups and institutes in the Dresden area. Therefore, we host regular public lecture series with speakers from research groups and institutes relevant to optics and photonics. Besides that, we are organizing excursions to nearby companies. The highlights of this year have been the Zemax workshops of Prof. Gross, the excursion to HoloEye GmbH in Berlin as well as the numerous talks that were given by external speakers.

The student chapter of TU Dresden is a unique opportunity for students to build knowledge and their own network in optics and photonics. We are looking forward to further planned activities and new chapter members in 2023.

The OPTICA-SPIE Student Chapter of TU Dresden

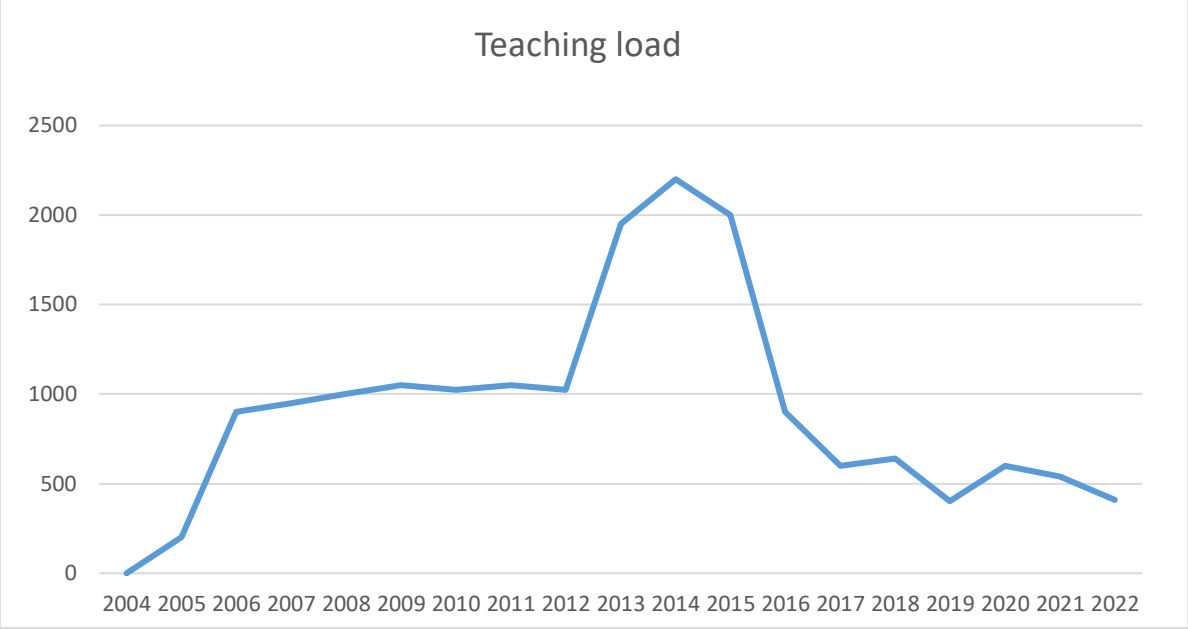


Lecture from 10. – 13. Nov. 2022 by Prof Herbert Gross, Jena, Photos by MST

TEACHING

		WS 21/22	SS 2022
Grundzüge des Messens 4. Sem.	V: Prof. Czarske Ü: Dipl.-Ing. Emmerich, Dipl.-Ing. Gürtler	11	104
Mess- und Sensortechnik 5. Sem.	V: Prof. Czarske, V: Dipl.-Ing. Weik Ü: Dipl.-Ing. Gürtler, Dipl.-Ing. Emmerich	84	16
Praktikum Mess- und Sensortechnik 5.+6. Sem.	P: Julian Lich, Tom Glosemeyer, et al. Prof. Czarske	98	19
Messsystemtechnik 6. Sem.	V: Prof. Czarske Ü: Katharina Schmidt Dipl.-Phys. Schmieder	-	15
Lasermesstechnik 8. Sem.	V: Prof. Czarske Ü: Dr. Büttner	-	11
Mechatronische Lasersensoren 8. Sem.	V: Dr. Büttner, Prof. Czarske	-	11
Lasermesssysteme für die Fluidtechnik 9. Sem.	V: Dr. Büttner, Prof. Czarske	8	-
Digitale Holographie und Bildverarbeitung 9. Sem.	V: Dr. Koukourakis, Prof. Czarske	8	-
Biomedizinische Laser-Systemtechnik und Optogenetik	V: Dr. Kuschmierz, Prof. Czarske	8	-
Praktikum Lasersensorik	V: Prof. Czarske P: Dipl.-Ing E. Scharf	-	3
Hauptseminar AMR	Dipl.-Ing E. Scharf Dr. Kuschmierz, Prof. Czarske	5	10
	Sub-Total:	**222**	**189**
	Total:	**411**	

Total number in 18 years: 17.706


Teaching load
2500
2000
1500
1000
500
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022

INVITED TALKS

Date	Guest Speaker	Topic
13 June 2022	Ilenia Meloni Kurt-Schwabe-Institut für Mess- und Sensortechnik Meinsberg e.V.	Adaptive light sources for optogenetic stimulation of Drosophila melanogaster
27 June 2022	Prof. Michael Kues Institute of Photonics, Leibniz University Hanover	Integrated quantum frequency combs for complex photon state creation and processing
27 June 2022	Prof Yoshio Hayasaki Center for Optical Research and Education (CORE), Utsunomiya University	In-system optimization of a hologram for shaped-beam laser processing
29 June 2022	Dr. Joel Carpenter University of Queensland	Arbitrary vector spatiotemporal beamshaping: Any amplitude, phase and polarization at any delay
08 Nov. 2022	Dr. Wouter Derks CRTD Dresden	Optogenetic Control of Human Stem Cell-Derived Cardiac Models
29 Nov. 2022	Prof Guohai Situ, Shanghai Institute of Optics and Fine Mechanics, China	Physics-enhanced deep neural networks for computational optical imaging
15 Dec. 2022	Prof Florian Willomitzer, Associate Professor, Wyant College of Optical Sciences at University of Arizona	Imaging through Scatterers and the Fun of utilizing Nature's Limits in Computational 3D Sensors
16 Dec. 2022	Prof Riccardo Bassoli, Assistant Professor at the Deutsche Telekom Chair of Communication Networks and Head of the Quantum Communication Networks Research Group, TU Dresden	The integration of quantum technologies in future 6G networks: the why and the how

Prof. Jürgen Czarske

2022 Chandra S Vikram Award in Optical Metrology of SPIE (The international society for optics and photonics, Washington, USA), awarded during the SPIE Conference Optics&Photonics at Marriott Hotel in San Diego, USA, August 2022

Dr. Bernard Kress, Google, SPIE President elect 2022 (left) and Prof. Anita Mahadevan-Jansen, Vanderbilt Univ, SPIE President 2022 (right) presenting the Chandra S Vikram Award to Prof Czarske (Photos by SPIE)

Prof Czarske at the award banquet at Marriott Marquis Hotel and Marina in San Diego, August 24th 2022 during Optica + Photonics Conference of SPIE – The International Society for Optics and Photonics, Washington, USA (Photos by SPIE)

Prof. Anita Mahadevan-Jansen, Vanderbilt Univ., SPIE President 2022 presenting the Chandra S Vikram Award to Prof Czarske (Photos by SPIE, left and by AHMT, right))

Anna-Lena Geppert

Theodore-Maiman-Stipendium 2022 der Wissenschaftlichen Gesellschaft Lasertechnik e.V., Juli 2022 (Prize for the Studienarbeit/Bachelor Thesis, co-supervised by Stefan Rothe, donation of the prize: 2 000 Euro)

Anna-Lena Geppert, (Photo by MST)

Dipl.-Ing. Dennis Pohle

DGaO Young Talent Award 2022 for his diploma thesis ”Investigating information security for an optical network using Deep Learning”, 09.06.2022 Pforzheim

Prof. A. Heinrich, D. Pohle, R. Kafka (President of DGaO), Photo by DGaO

Prof. Jürgen Czarske

Fellow of the Institute of Physics (IOP), 23.07.2022

Dipl.-Ing. Tijue Wang

Young talent awards of the Gisela and Erwin Sick Foundation for his diploma thesis "High-resolution Fiber Bundle Imaging Using Deep Learning", 12.04.2022

Prof. J Czarske, T. Wang, Dr E. Starke (Photos by MST)

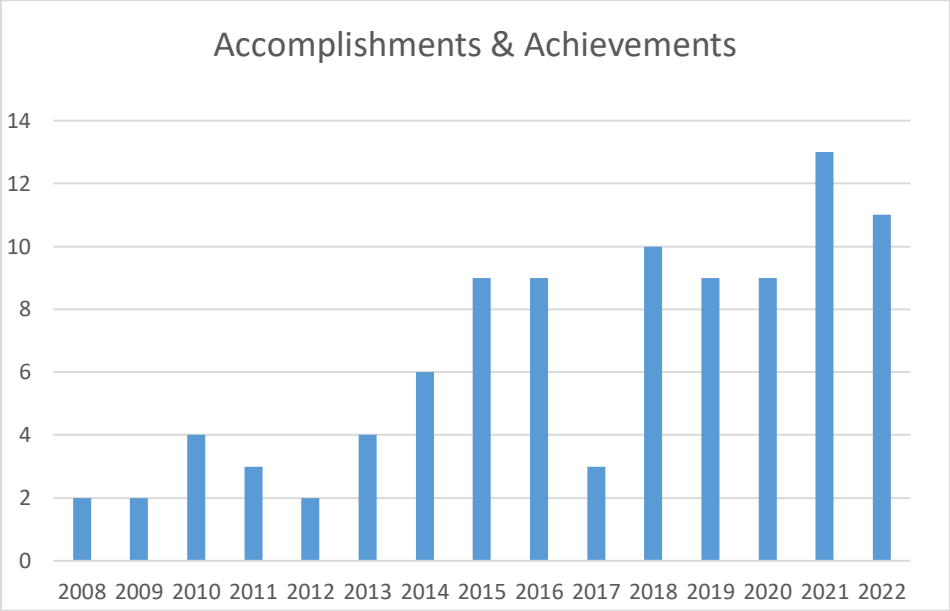
Prof. Jürgen Czarske

Award outstanding editor for Light: Advanced Manufacturing in Year 2021, 15.2.2022

Stefan Rothe

Stefan Rothe, Karl-Ludwig Besser, Nektarios Koukourakis, Eduard Jorswieck, and Juergen W. Czarske. Best student paper for his talk "Physical layer security for confidential data transmission through multimode fibres", 25th Congress of International Commission for Optics and 16th International Conference of Optics Within Life Sciences - ICO-25-OWLS-16, 05-09 September 2022, Dresden

Jiawei Sun	Jiawei Sun, N. Koukourakis, R. Kuschmierz, J. W. Czarske. Best paper student price for his talk "Multi-Dimensional Cell Rotation with Multi-Core Fibers and Wavefront Shaping", 25th Congress of International Commission for Optics and 16th International Conference of Optics Within Life Sciences - ICO-25-OWLS-16, 05-09 September 2022, Dresden
Wenjie Wang	Wenjie Wang, F. Lemke, U. Wallrabe, M. C. Wapler, J. Czarske, N. Koukourakis. Best paper student price for her talk "3D scanning microscopy for zebrafish imaging using adaptive prisms and lenses", 25th Congress of International Commission for Optics and 16th International Conference of Optics Within Life Sciences - ICO-25-OWLS-16, 05-09 September 2022, Dresden
Jakob Dremel	Best Student Award of TU Dresden, presented by Prof. Ursula Staudinger, Rector of TU Dresden
Tom Glosemeyer	SPIE Scholarship to cover traveling expenses for San Francisco – SPIE: The international society for optics and photonics, USA



Total number of elections, honors, prizes and awards: over 90

Photo gallery (All Photos by MST)


Left: Opening of the General Congress ICO-25-OWLS-16 /
Right: First Mayor Sittel and General Chair Czarske in the City Hall (from right)

Photo of the participants of the General Congress on Monday morning

Nobel Laureate Gérard Mourou and General Chair Juergen Czarske (from left)

Nobel Laureate Stefan Hell and General Chair Juergen Czarske (from left)

Nobel Laureate Reinhard Genzel and General Chair Juergen Czarske (from right)

Welcome Reception and Organ Concert in the Frauenkirche

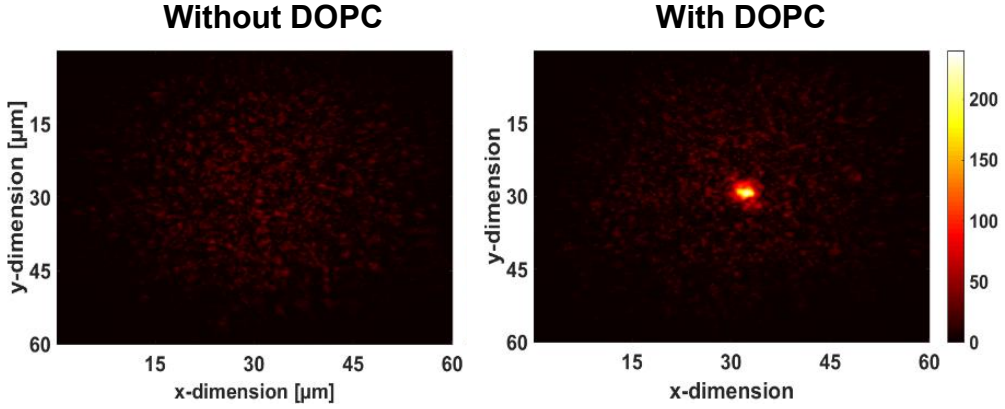
General Assembly of ICO, group photo in front of the Venue

Preproject **Focusing light through scattering tissue**

Staff: N. Koukourakis, J. Czarske

Aim: Targeted light-delivery through scattering tissue is strongly limited by light scrambling. However, the technological improvement in hardware, computational power and methodology in recent years made it possible to control light inside or behind scattering media, by shaping the wavefront using a spatial light modulator before the light enters the scattering media. The main hurdle is to determine an adequate mask that allows pre-scrambling the light, so that the desired light pattern is delivered to the region of interest after scrambling. These are for example iterative optimization of the wave front, measurement of the transmission matrix, and digital optical phase conjugation (DOPC). DOPC has the advantage that it does not require time-consuming iterations or time-consuming calibration measurements, but instead enables direct shaping with a single measurement. Commonly guide stars are used to probe the light scrambling. The phase of the guide star light is recorded by quantitative phase measurements, e.g. performed by digital holography, and a phase mask of the phase conjugate is displayed on the spatial light modulator. This approach enables to time reverse the scrambling effects and to recreate the guide star. We applied DOPC for example, to focus light through 400 µm thick part of a mouse skull. While without DOPC strong scattering is observable (Figure, left), DOPC allows focusing through mouse skull with high quality (Figure, right). Such an approach is important for the optogenetic stimulation.

Partner: Max Planck Institute of Molecular Cell Biology and Genetics, Dr. M. Kreysing



Focusing through mouse skull, (left) without digital optical phase conjugation and (right) with digital optical phase conjugation.

N. Koukourakis, M. Kreysing, J. Czarske, "Wave front shaping method to focus through mouse skull", OSA Imaging and Applied Optics, Contribution OW2J.3, 25.–28.6.18, Orlando/USA

N. Koukourakis; M. Kreysing; J. Czarske, „Focusing Through Mouse Skull Using Wave front Shaping", OSA, Biophotonics Congress: Biomedical Optics, 03.-06.04.2018, Hollywood, Florida, USA

Azaam Aziz, Stefano Pane, Veronica Iacovacci, Nektarios Koukourakis, Jürgen Czarske, Arianna Men-ciassi, Mariana Medina-Sánchez, and Oliver G. Schmidt, „Medical Imaging of Microrobots: Towards In Vivo Applications"; ACS Nano, 09/2020; DOI: 10.1021/acsnano.0c05530

Kayvan Forouhesh Tehrani; Nektarios Koukourakis; Jürgen Czarske; Luke J Mortensen, "In situ measurement of the isoplanatic patch for imaging through intact bone", Journal of Biophotonics; 08/2020

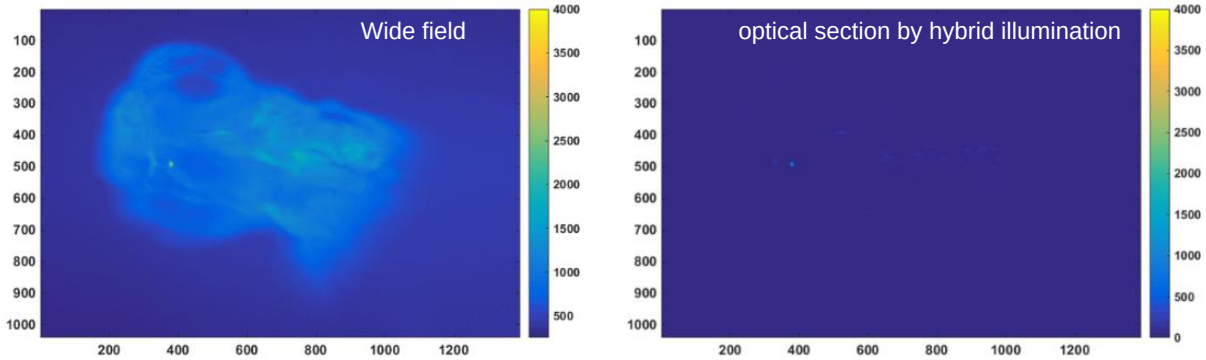
Preproject **Volumetric hybrid illumination microscopy**

Staff: N. Koukourakis, J. Czarske

Aim: Wide field microscopy is well established in biological and medical applications. However, its reduced depth sectioning capability leads to background signals originating outside the depth of interest that degrade the contrast and limit the usability. To solve this limitation, a variety of microscopic techniques offering adequate depth sectioning have been introduced, the most prominent one being confocal microscopy. However, although confocal microscopy is advantageous, it is a pointwise technique and thus requires scanning in three dimensions to obtain 3D information.

Hybrid illumination microscopy enables to record optically sectioned wide field images by analyzing the spatial frequency content of the recorded image. As the maximum spatial frequency bandwidth is transported through the system for in-focus sample parts, high-spatial frequencies that inherently occur from the specimen, already lead to an optical sectioning. To get access to the low spatial frequency part of the focal region, a speckled illumination can be used, to artificially introduce high spatial frequencies. Thus, the combination of an uniform and a non-uniform illumination bears the potential to record optically sectioned images, with a strongly reduced scanning requirement. Just one axial scan is required. Using adaptive lenses allows to circumvent any mechanical scanning and to implement fast axial scanning without moving parts enabling rapid volumetric recordings. We use this technique to analyze fluorescence of transgene zebrafish larvae

Partner: Helmholtz Zentrum für Umweltforschung, Leipzig, Dr. Stefan Scholz



Left: Wide field fluorescence measurement of zebrafish larvae. Right: After spatial frequency analysis, the strong auto fluorescent background is removed.

N. Koukourakis, K. Philipp, M. Stürmer, F. Lemke, M. Wapler, U. Wallrabe, J. Czarske, “Adaptive lenses for axial scanning in HiLo microscopy”, Optics in the Life Sciences Congress, OSA, 2-Page-Paper: BoTu1A.2, San Diego, CA, USA, 02.04.-05.04 (2017).

J. W. Czarske, K. Philipp, N. Koukourakis, „Structured illumination 3D microscopy using adaptive lenses and multimode fibers”, SPIE Digital Optical Technologies, Proceedings pp. [10335-44], Munich, Germany, 26.06. – 28.06.2017 (2017).

K. Philipp, A. Smolarski, N. Koukourakis, A. Fischer, M. Stürmer, U. Wallrabe, and J. W. Czarske, „Volumetric HiLo microscopy employing an electrically tunable lens,“ Opt. Express 24, No 13, 15029 (2016).

DFG **Investigations on Brillouin elastography using a pulsed laser for biomedical applications**

Staff: L. Liebig, N. Koukourakis, J. Czarske

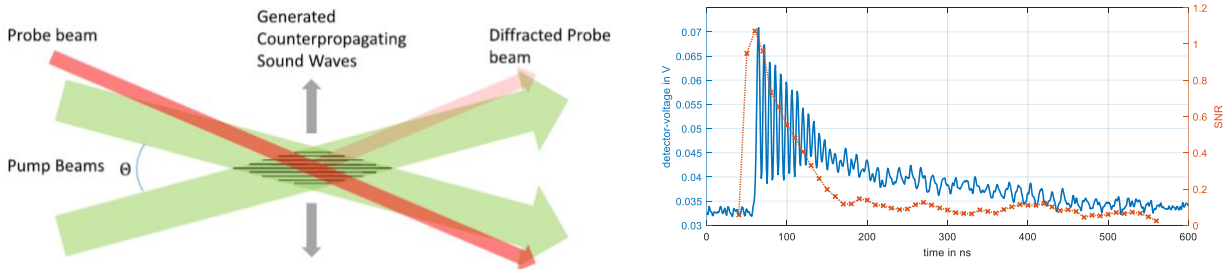
Aim: The measurement of the elasticity of cells and tissues plays a major role in the investigation of pathological processes. Since the first report on non-contact, three-dimensional in-situ measurements of the elasticity of biological tissue using the spontaneous scattering between light and sound waves, great attention has been paid to Brillouin microscopy. Spontaneous Brillouin scattering is used, which allows locally high-resolution measurements but requires long integration times for each measuring point. The related technique of Impulsive Stimulated Brillouin Spectroscopy (ISBS) allows the measurement of the same tissue properties with a significantly increased time resolution. Imaging in real-time video resolution is therefore conceivable.

With ISBS, a standing acoustic wave is excited by a pulse laser in the measuring volume. The superposition of the pulse laser, which is divided into two beams, produces an intensity-striped pattern, which generates a force effect via electrostriction and thus the standing acoustic wave. By this standing wave, a second continuous wave laser is reflected and evaluated on a detector. The reflected beam is modulated according to the frequency of the standing wave. The strip spacing d given by the geometry, the frequency of the intensity of the reflected beam f and the speed of sound in the material v are related as follows: $v = 0.5\ f\ d$.

Thus, the measured frequency can be used to determine the speed of sound and therefore the modulus of elasticity of the material. For initial measurements and the characterization of such a measuring system, measurements on reference liquids such as methanol, ethanol and water were successfully carried out. Measurements on biological reference samples, e.g. hydrogels were also accomplished. Brillioun-microscopy based on impulsive stimulation is particularly promising for scanning imaging but also high-speed measurements such as in the field of cytometry.

Period: 05/2019 – 04/2022

Partner: BIOTEC, Dresden, Prof. Jochen Guck



Left: Geometry for stimulated Brillouin. Right: Measurement at Methanol.

Giuseppe Antonacci, Timon Beck, Alberto Bilenca, Jürgen Czarske, Kareem Elsayad, Jochen Guck. Kyoohyun Kim, Benedikt Krug, Francesca Palombo, Robert Prevedel, Giuliano Scarcelli, "Recent progress and current opinions in Brillouin Microscopy for life science Applications", Biophysical Reviews, 2020

Impulsive stimulated Brillouin microscopy for non-contact, fast mechanical investigations of hydrogels, B Krug, N Koukourakis, JW Czarske - Optics express, 2019 - osapublishing.org

B Krug, N Koukourakis, J Guck, J Czarske, „Nonlinear microscopy using impulsive stimulated Brillouin scattering for high-speed elastography," Optics Express **30** (4), 4748-4758 (2022).

China **Quantitative phase imaging for confocal adaptive lens microscopy (CAL)**

Staff: W. Wang, N. Koukourakis, J. Czarske

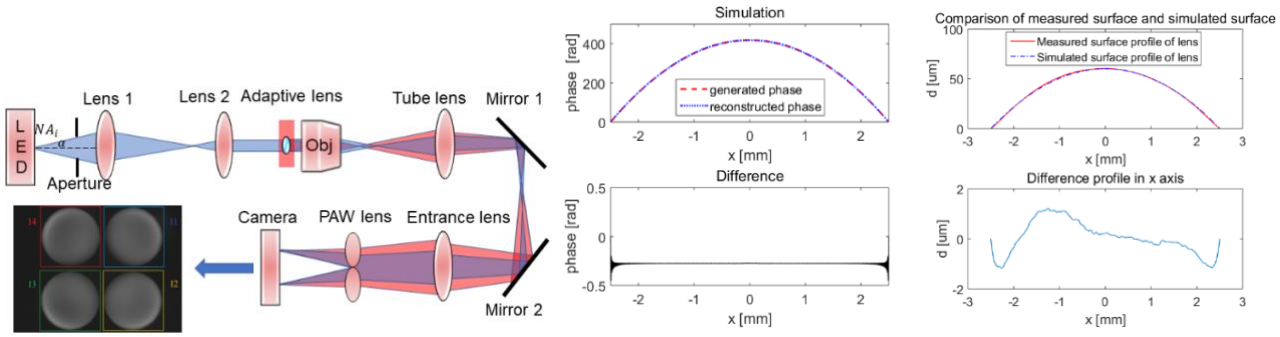
Aim: Quantitative phase imaging (QPI) has become a very important tool in metrology and biomedical applications. Commonly digital holography is applied for QPI. However, as it is an interferometric technique it requires coherent illumination, an additional reference beam and the recordable spatial frequencies are strongly limited by the pixel size of the camera. Shack-Hartmann sensor (SHH) is a non-interferometric alternative, but it suffers of limited resolution and allows recording only wave front tilts of small degree.

We apply the partitioned aperture wave front (PAW) sensing technique to combine the advantages of both approaches, having a technique that records the phase at high spatial resolution, at high wave front tilts non-interferometrically. PAW uses an array of four off-axis lenses, which divides a beam of light into four separated intensity images on the camera. Then, two-phase gradients can be obtained from the four intensity images by the PAW algorithm. Finally, the quantitative phase can be calculated by integrating the phase gradients and inverse Fourier transform.

We use PAW to measure the phase of light transmitting through an adaptive lens with high speed and high resolution. Driving complex adaptive lenses is often a difficult task. PAW is perfectly suited to characterize the lens behavior in a closed feedback loop.

Period: 04/2019 – 03/2022

Partner: University of Freiburg, Prof. Ulrike Wallrabe



PAW imaging device in a Köhler illumination (left), the reconstructed phase shift induced by a simulated lens (middle) and the reconstructed phase shift of a fix lens in experiment (right).

W. Wang, K. Philipp, N. Koukourakis and J.W. Czarske, “Characterization of Adaptive Lenses using Partitioned Aperture Wavefront Imaging”, EOSAM 2018, TOM 6 S04, (2018)

W. Wang, K. Philipp, J. Czarske, N. Koukourakis, “Real-time monitoring of adaptive lenses with high tuning range and multiple degrees of freedom”, Optics Letters 45(2), 272-275, 2020

Lemke, Florian; Weber, Pascal; Philipp, Katrin; Czarske, Juergen; Koukourakis, Nektarios; Wallrabe, Ulrike; Wapler, Matthias, “Piezo-actuated adaptive prisms for continuously adjustable bi-axial scanning”, Smart Materials and Structures, 2020

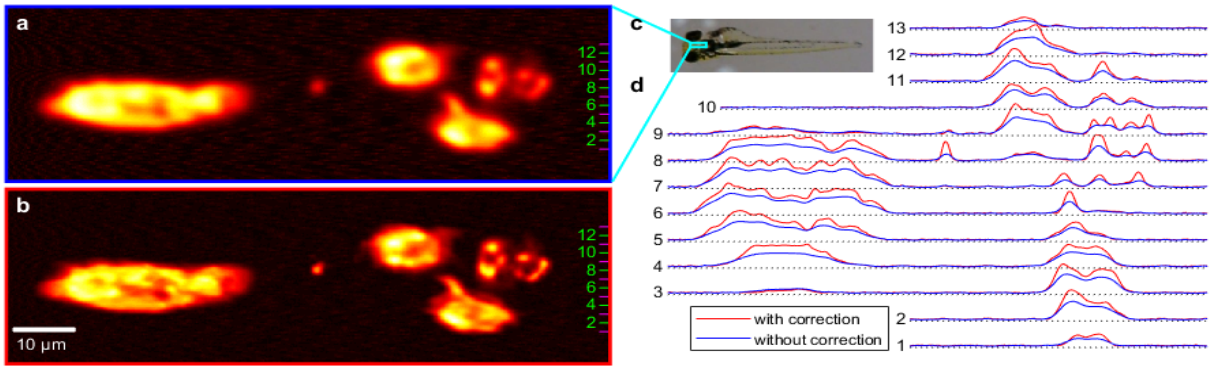
DFG **Aberration correction for real-time measurements in adaptive confocal microscope**

Staff: K. Schmidt, N. Koukourakis, J. Czarske

Aim: Microscopic techniques with high spatial and temporal resolution are required for measuring biological cells and tissues. Confocal microscopy is an established technique, which is based on a pinhole detection that introduces optical sectioning abilities. The usage of microscope objectives with high numerical aperture allows achieving high spatial resolution, but simultaneously increases the impact of systematic aberrations. These aberrations add to sample induced aberrations and limit the achievable resolution of a confocal microscope. Aberrations can be addressed by using adaptive optical elements. Furthermore, adaptive elements allow for fast scanning. In the preparatory work we successfully verified, that two adaptive lenses, one in the illumination and the second in the detection path, allow for the first time, to create axial scans with homogeneous axial resolution over the whole depth-range. The aim of the project is to create a fully-adaptive confocal microscope, which enables both fast scanning and high spatial resolution due to aberration correction. For this purpose, novel adaptive lenses with integrated aberration correction are developed and used to create the axial scanning. These lenses enable to compensate for both symmetric (spherical, defocus) und asymmetric (astigmatism, coma)-aberrations our confocal microscope. Furthermore, adaptive achromatic lenses for the correction of chromatic aberrations are developed. For lateral scanning adaptive prisms are used, which enable fast lateral scans with less aberrations and compact setup. Using the novel adaptive devices opens up the possibility to miniaturize the confocal setup and to create a compact microscope. As a first test paradigm, the new confocal microscope is used to identify thyroid gland disruptors in Zebrafish embryos.

Period: 10/2019 – 09/2022

Partner: Universität Freiburg, Prof. Wallrabe; UFZ Leibzig, Dr. Stefan Scholz



Fluoreszenzaufnahmen der Schilddrüse von transgenen Zebrabärblingsembryonen ohne (a) und mit (b) Korrektur sphärischer Aberrationen. Aufnahme des gesamten Embryos, Dimensionen sind ca (1.5x5) mm2 (c). Intensitätsprofile entlang spezifischer Zeilen (d). Die Aufnahmen erfolgten 110 Stunden nach der Befruchtung.

K. Philipp, A. Smolarski, N. Koukourakis, A. Fischer, M. Stürmer, U. Wallrabe, J. Czarske “Volumetric HiLo microscopy employing an electrically tunable lens”, Opt. Express 24(13), 15029-15041 (2016).
W. Wang, F. Lemke, M. Wapler, U. Wallrabe, J. Czarske, “3D-scanning microscopy with adaptive lenses and prisms for zebrafish studies", SPIE Journal of Optical Microsystems (invited by Hans Zappe), 2021
K. Schmidt, N. Koukourakis, J.W. Czarske, “Assignment of Focus Position with Convolutional Neural Networks in Adaptive Lens Based Axial Scanning for Confocal Microscopy”, *Appl. Sci. Vol* (12), 661 (2022)

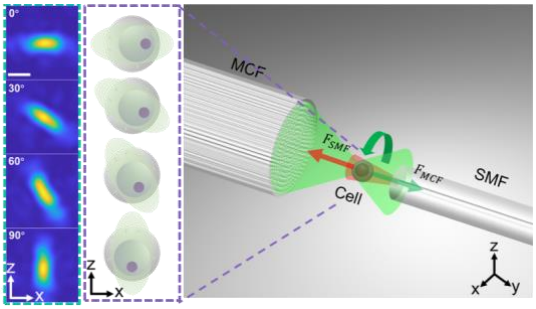
DFG **Tomographic refractive index measurement using Adaptive fiber-optical cell ROTation (TAROT)**

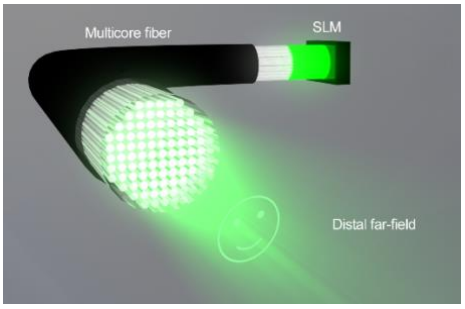
Staff: J. Sun, N. Koukourakis, J. Czarske

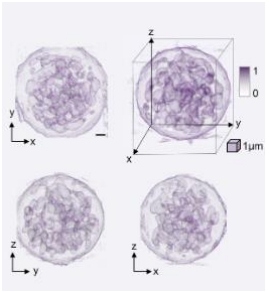
Aim: The three-dimensional refractive index (RI) distribution of biological cells contains rich information on the metabolism, health and on intracellular structure. An important biophysical parameter that can be accessed without invasive cell staining by quantitative phase imaging (QPI). As QPI techniques are sensitive to integral path-length information the reconstruction of the three dimensional refractive index requires a multitude of projections under varying angles to enable 3D reconstruction using tomographic approaches. Changing the illumination angle via rotation of the specimen bears maximum spatial frequency coverage and is therefore advantageous compared to variation of the illumination angle. In this project, we aim to realize a versatile adaptive optical platform based on a novel dual-beam trap that enables for the first-time targeted cell-rotation about arbitrary axes in all spatial dimensions. The unique feature of our dual-beam trap is that light-delivery is accomplished by multi-core fibers (MCF) as key components of the system. Using an in-situ calibration by digital optical phase conjugation allows tailoring any desired light field distribution. To rotate the cells about the optical axis at least one beam has to have an asymmetric intensity profile to break the trap symmetry. Adaptively rotating this intensity profile results in a cell-rotation. The full light-field control further enables to induce additional targeted rotation by misaligning the traps or by illuminating with tailored intensity-gradients, enabling rotation in three dimensions. Quantitative phase imaging with full cell-rotation about two perpendicular axes will be realizable for the first time with fiber-based endoscopes.

Partner: Max Planck Institute for the Science of Light, Prof. Jochen Guck

Period: 11/2018 – 02/2023







J. Sun, J. Wu, S. Wu, L. Cao, R. Goswami, S. Girardo, J. Guck, N. Koukourakis, J. Czarske, “Quantitative phase imaging through an ultra-thin lensless fiber endoscope,” Light Science & Applications, 2022
J. Sun, J. Wu, N. Koukourakis, L. Cao, R. Kuschmierz and J. Czarske, “Real-time complex light field generation through a multi-core fiber with deep learning,” Scientific Reports, 2022
J. Sun, N. Koukourakis, J. Guck and J. W. Czarske, “Rapid computational cell-rotation around arbitrary axes in 3D with multi-core fiber,” Biomedical Optics Express, 2021
J. Sun, N. Koukourakis and J. W. Czarske, “Complex wavefront shaping through a multi-core fiber,” Applied Sciences, 2021

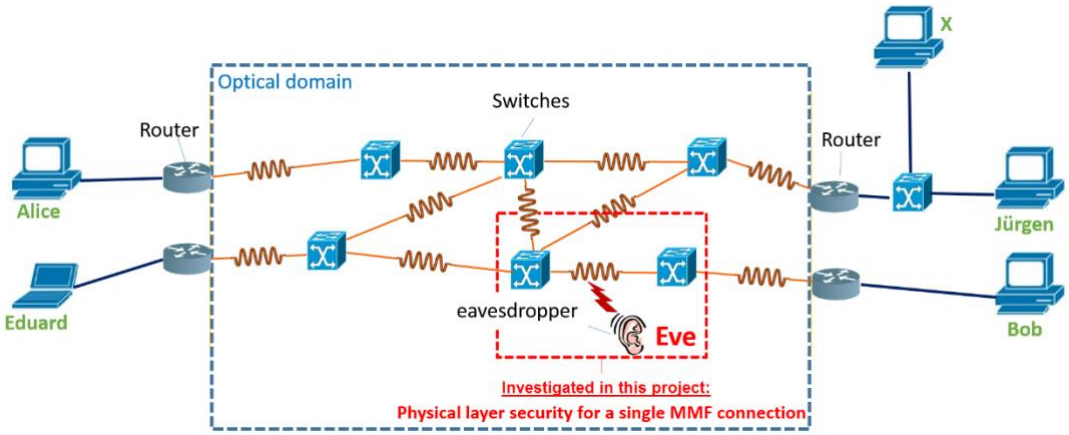
DFG **Physical Layer Security of Multimode Optical Fiber Transmission Systems**

Staff: S. Rothe, D. Pohle, N. Koukourakis, J. Czarske

Aim: Optical networks are the backbone of our information and communication society. The data traffic includes not only user data but also mission critical communication services, which are sensitive to eavesdropping and jamming attacks. This project studies the fundamental limits of physical layer security for data transmission through optical multimode fibers (MMF). In contrast to cryptographic security whose security is derived from the computational complexity of a cryptographic algorithm, in our project we are looking at the information theoretic security of the system, which guarantees secrecy regardless of the computation power available at the eavesdropper. Hence, this project concentrates on the fundamental limits of the security rate of MMFs between two legitimate nodes.
Experiments will be conducted at the Chair of Measurement and Sensor System Technique (MST) to determine the relationship between input and output modes of the MMF, i.e. the transmission matrix, to obtain reliable channel information, which will help the Communications Theory Chair (TNT) setting up and optimizing channel models, with the aim to maximize the confidelity of communication and prohibit that the eavesdropper gains any valuable knowledge of the transmitted data. To prohibit that the eavesdropper gains any information of the channels during calibration, a public key method will be initially used. Finally, a demonstration of the feasibility of physical layer security using MIMO-SDM will be conducted.

Period: 09/2018 – 08/2021

Partner: Technische Universität Braunschweig, Institute for Communications Technology (IfN), Prof. E. Jorswieck, M. Sc. A. Lonnstrom/ M. Sc. Karl-Ludwig Besser



Optical network. In this project together with our partner, the physical layer security for a single MMF connection between two network nodes is investigated.

S. Rothe, N. Koukourakis, H. Radner, A. Lonnstrom, E. Jorswieck, J. Czarske, "Physical Layer Security in Multimode Fiber Optical Networks." Scientific Reports, 2020
S. Rothe, Q. Zhang, N. Koukourakis, J. Czarske, “Intensity-only Mode Decomposition on Multimode Fibers using a Densely Connected Convolutional Network”, Journal of Lightwave Technology, DOI: 10.1109/JLT.2020.3041374 (2021).
S. Rothe, P. Daferner, S. Heide, D. Krause, F. Schmieder, N. Koukourakis, J. Czarske, "Benchmarking analysis of computer generated holograms for complex wavefront shaping using pixelated phase modulators." OPTICA Optics Express 29(23), 37602-37616 (2021)

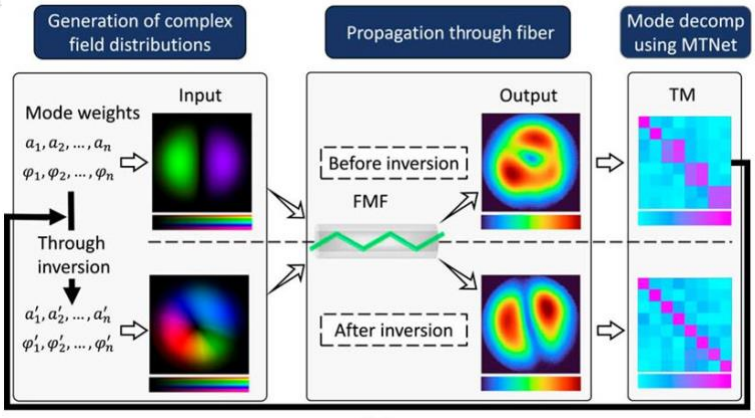
BMBF **6G Life Hub**

Staff: Q. Zhang, D. Pohle, S. Rothe, J. Czarske

Aim: Digitalization, or digital transformation, is one of the next great challenges facing humanity after the Neolithic and Industrial Revolutions. The future standard of mobile communications 6G will play a central role in this revolution. With 5G, the gateway to digitization in industry has been thrown wide open. While its predecessors 2G, 3G and 4G exclusively covered the consumer sector, 5G also supports the control of machines. 5G makes the Internet of Things possible in real time. However, a major drawback with 5G communication networks is the limited use of novel technologies. The Project, 6G-life, will drive cutting-edge research for 6G communication networks with a focus on human-machine collaboration. 6G-life provides new approaches for sustainability, security, resilience and latency.
The research hub 6G-life is spanned by the TU Dresden (TUD) and TU Munich (TUM). The Chair of Measurement and Sensor System Technique (MST) is working on optical communication. MST will concentrate on Physical Layer Security (PLS) with optical MIMO systems, especially few-mode and multimode fiber using advanced deep neural networks such as the MTNet. Instead of increasing the security via mathematical approaches, the laws of physics can be used, as single photons cannot be measured without destruction. However, transmission over the spatial domain of multi-mode optical fibers requires further research. Using single-photon sources (e.g. Q-Dots), the goal is to make a sustainable 6G contribution to quantum communications. The vision is to bring modern computer-based aberration correction methods of optics and photonics into the 6G quantum testbed.

Period: 09/2021 – 09/2025

Partner: TU Munich, Institute for Communications Engineering
Prof. Gerhard Kramer, Prof. Dr.-Ing. Norbert Hanik, Dr. Carmen Mas Machuca
TU Dresden, Chair of radio frequency and photonics engineering
Prof. Dirk Plettemeier, Prof. Kambiz Jamshidi



6G-life

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Controlling light propagation through a few-mode fiber using intelligent mode decomposition.

D. Pohle, S. Rothe, N. Koukourakis and J. Czarske, "Surveillance of few-mode fiber-communication channels with a single hidden layer neural network.", Optics Letters 47 (5), 1275-1278, 2022
Q. Zhang, S. Rothe, N. Koukourakis and J. Czarske, “Learning the matrix of few-mode fibers for high-fidelity spatial mode transmission”, APL Photonics, 7(6), 066104, 2022

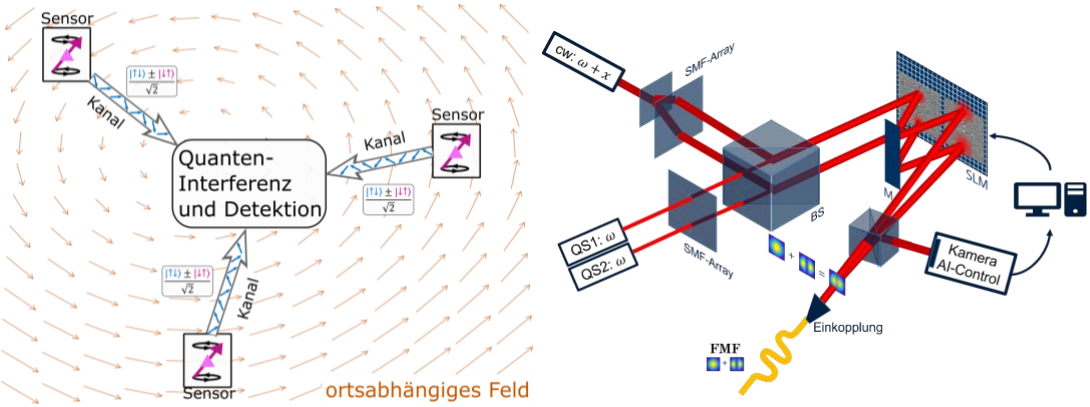
BMBF **Quantum Internet of Things (QUIET)**

Staff: D. Pohle, A. Geppert, S. Rothe, J. Czarske

Aim: In current 5G and future 6G networks, a data explosion is expected due to massive machine communication, involving thousands of sensors. The increasing energy consumption associated with data growth can also only be managed with strongly performance-enhancing innovations. Quantum characteristics such as entanglement provide the feature of generating perfectly distributed and private randomness, which is a valuable resource for overcoming above mentioned challenges in quantum communications. In addition, quantum computing and quantum sensing provide opportunities on the basis of which quantum communication networks can deliver unique added value by distributing resources locally - and thus transferring them to a cloud. The object of the QUIET project is therefore the prototypical design and realization of an end-to-end system solution that implements the new approaches of quantum technologies in IoT communication networks, from IoT sensors or IoT sensor networks to smart networks and cloud applications, to solve the above mentioned hurdles. Lab MST focuses on the transmission of quantum states from the sensor to a central server. The quantum signals provided by a sensor are to be transported over short to medium distances to a network node using optical fibers. Maintenance of quantum states necessitates transmission with as little loss as possible. Few-mode fibers (FMF) are suitable for transmission, because they have lower coupling losses compared to conventional single-mode fibers. FMFs support multiple transverse modes, which can be used as spatial parallel channels and are proposed for quantum signal transmission. Since only one physical fiber channel is required for simultaneous transmission of multiple quantum states, they can reduce both space and resources per channel. Using an SLM and multiple illuminations, a translation of distributed quantum signals towards a superposition of modes shall be achieved. This approach is called Multiplane Light Conversion.

Period: 06/2022 – 06/2025

Partner: Deutsche Telekom AG (Dr.-Ing. Oliver Holschke), TU Munich (Prof. Holger Boche, Dr.-Math. Christian Deppe, Dr. rer. nat. Janis Nötzel), IFW Dresden (Dr. rer. nat. Caspar Hopfmann), TU Dresden (Prof. Fitzek, Prof. Jamshidi, Prof. Plettemeier)



Left: Concept of spatially distributed quantum sensing as an IoT network service. Spin qubits serve as sensors, which transmit the quantum information in the form of photons superimposed at a central server. Right: envisaged approach to translate distributed quantum signals (QS) to a superposition of modes using an SLM and multiplane light conversion.

Q. Zhang, S. Rothe, N. Koukourakis and J. Czarske, “Learning the matrix of few-mode fibers for high-fidelity spatial mode transmission”, APL Photonics, 7(6), 066104, 2022

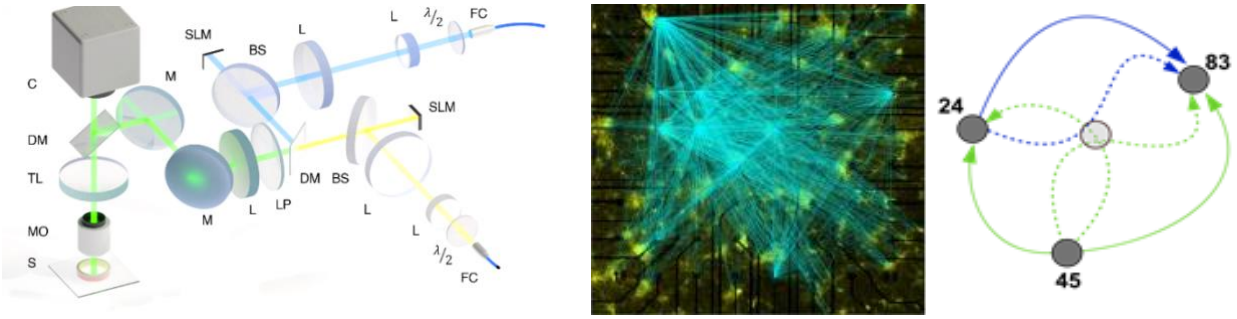
DFG **Laser System for Optogenetic Stimulation for the Subcellular Investigation of neural Networks**

Staff: F. Schmieder, L. Büttner, J. Czarske

Aim: The young research field of optogenetics focuses on the highly specific investigation and control of cell characteristics like signaling. Cells, e.g. neurons, are genetically altered to express light-gated ion channels in the cell membrane, which allow for the control of the cell´s electrical activity by optical means. This offers the opportunity for experiments with higher spatial resolution and specificity compared to electrical stimulation, which is most commonly used. As of today, many experiments on larger samples such as neural networks in vivo often lose this spatial specificity by simply illuminating the whole cell culture. In cooperation with the Busskamp Group of Medical Faculty of University of Bonn, new experiments on induced human stem-cell-derived (iPSC) neural networks are conducted in this recent project using holographically shaped illumination.
One of the aims of this project is to analyze the time-dependent structure and plasticity of said neural networks by simultaneously exciting and inhibiting multiple cells at different locations. Long-term experiments spanning 110 days post induction (dpi) employing excitation only in planar random networks were conducted. We were able to extract functional neuron-to-electrodes connectivity patterns in developing neuronal networks from 35-80 dpi as well as local connectivity graphs including direct and indirect connections from peristimulus time histogram features. We aim to continue this work with similar studies in structured networks with defined pre- and postsynaptic neurons as well as with the targeted subcellular stimulation and inhibition of single neurons processes, e.g. to elucidate the signal summation and to create an “excitation map”.

Period: 07/2018 – 08/2021

Partner: Center for Regenerative Therapies Dresden/Univ. Bonn, Dr. R. Habibey, Dr. V. Busskamp



Left: Schematic of holographic illumination setup for single cell stimulation. Middle: Example of functional neuron-electrode connectivity patterns extracted from holographic-stimulation-based electrophysiological recordings overlaid on a fluorescence microscopy of a neuronal network on an MEA at 60 dpi. Right: Tentative local connectivity graph for 3 electrodes extracted from Peristimulus time histogram features.

Junge, S., Schmieder, F., Sasse, P., Czarske, J., Torres-Mapa, M. L. & Heisterkamp, A. Holographic optogenetic stimulation with calcium imaging as an all optical tool for cardiac electrophysiology. Journal of Biophotonics e202100352.

Schmieder, F., Büttner, L., Hanitzsch, T., Busskamp, V. & Czarske, J. W. Two-Wavelength Computational Holography for Aberration-Corrected Simultaneous Optogenetic Stimulation and Inhibition of In Vitro Biological Samples. Appl. Sci. 12, 2283 (2022).

Schmieder, F., Habibey, R., Striebel, J., Büttner, L., Czarske, J. & Busskamp, V. Tracking connectivity maps in human stem cell–derived neuronal networks by holographic optogenetics. Life Science Alliance 5, (2022).

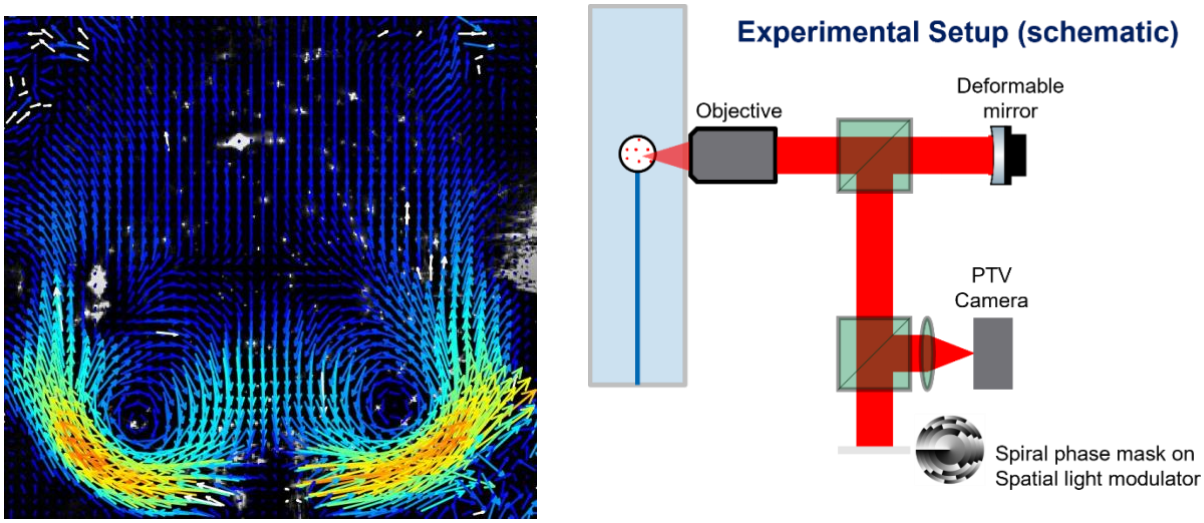
TUD **H2 Lab – Investigation of dynamics of hydrogen gas bubbles at microelectrodes in electrolysis using 3D optical flow measurement techniques and adaptive optics**

Staff: F. Bürkle, L. Büttner, J. Czarske

Aim: Gas-evolving electrodes are a central element in technologically important processes such as chlor-alkali or alkaline water electrolysis. However, an in-depth understanding of bubble nucleation, growth, coalescence and bubble detachment is not yet achieved. The studies aim on fundamental understanding of bubble dynamics, especially single hydrogen bubble generated by water electrolysis at a microelectrode. Electrochemical investigations are supported by high-speed optical imaging, velocity and temperature measurements and numerical simulation in cooperation. Previous studies focused on the electrolyte flow around the growing bubbles and size and shape measurements by shadowgraphy. It was found that droplets are generated during bubble growth allowing for optical flow measurements by Particle Tracking methods.

The goal of the project is to track and evaluate the internal flow of growing hydrogen bubbles at microelectrodes. It is assumed that the flow inside the bubble is three-dimensional requiring a 3D3C measurement technique. Hence, helical Particle Tracking Velocimetry shall be employed. Difficulties arise due to the spherical bubble shape resulting in strong aberrations requiring a compensating optical system or simulations to correct the aberrations which would otherwise lead to high systematic deviations. Furthermore, the process of bubble growth is transient resulting in changing radii of curvature during the process making the use of adaptive optical systems feasible.

Period: 07/2022 – 06/2023



Left: Vector plot of the flow inside a hydrogen bubble shortly before detachement from the micro-electrode
Right: Scheme of the experimental setup showing the most relevant parts

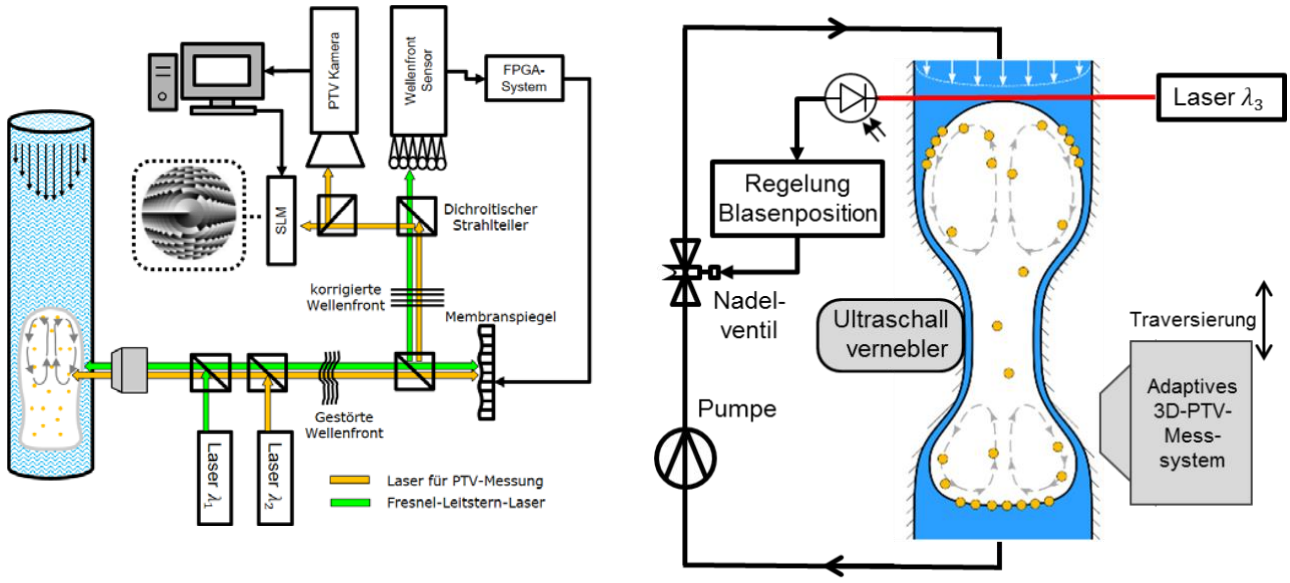
DFG **Investigation of the transition of aerosol particles in liquids with an adaptive optical measurement technique for highly dynamic phase boundaries**

Staff: F. Bürkle, L. Büttner, J. Czarske

Aim: In many industrial and medical applications the transport of aerosol particles in gas flows and their transition into a liquid phase play a significant role. Examples are wet scrubbers as a cost efficient alternative for the filtering of fine dust out of exhaust gases or aerosols from metal coating processes. To achieve this, an air flow containing particles is led through a washing liquid. In the same way, viral particles can be filtered. In future, miniaturized and portable separators may be used to fight pandemics. However, the models for the description of particle separation are not sufficiently accurate for particles in the micrometer range. Previous works show that there might be a significant dependence of the particle separation and the involved flow fields and the shape of the phase boundary, which are not considered yet.
To investigate the flow inside gas bubbles with a varying surface, adaptive optical systems are necessary. In this work a camera-based, 3D-method will be realized and used to measure the flow inside the bubbles as well as in the surrounding liquid. An especially interesting flow can be found in and around a stabilized Taylor bubble. The particle separation on a fixed droplet inside an air flow will be investigated as well.

Period: 09/2021 – 09/2025

Partner: Dr. Grégory Lecrivain, Prof. Dr.-Ing. habil. Dr. h. c. Uwe Hampel, Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf (HZDR)



Left: Scheme of the measurement system with the experimental setup with the Taylor bubble. Right: Special kind of a Taylor bubble in a wavy channel.

H. Radner, J. Stange, L. Büttner, J. Czarske, “Field programmable system-on-chip based control system for real-time distortion correction in optical imaging”, IEEE Transactions on Industrial Electronics 68(4), 3370-3379, 2021

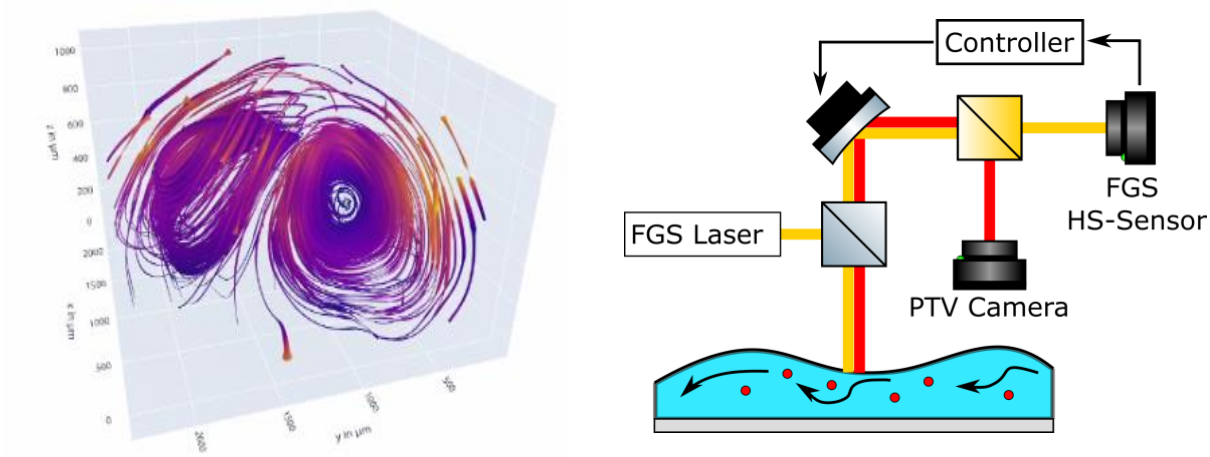
AiF **Transport processes at oscillating droplets and liquid films – Development of an adaptive measurement technique and a code-based description**

Staff: C. Bilsing, L. Büttner, J Czarske

Aim: Various technical processes in chemical, automotive, energy and building services potential for optimizing such processes. The aim of this research project lies in the development of a code-based description of the behavior of liquid films and droplets on substrates in the presence of a grazing gas flow. To this end, a three-dimensional, camera-based flow measurement technique with included adaptive-optical real-time aberration correction will be realized. Flow measurements in droplets through the fluctuating phase boundary will be conducted for the first time with unprecedented accuracy. Together with numeric simulations of moving films and droplets, new findings on the behavior of unstable droplets and films are expected. This will lead to a code-based description, which can be applied by small and medium-sized enterprises to describe industrial cleaning, entrainment or material exchange processes.

Period: 08/2020 – 01/2023

Partner: Dr. Sebastian Burgmann, University of Wuppertal



Left: A grazing flow induces a complex flow pattern in droplets which was measured three-dimensionally for the first time in this project. The tilt of the vortex pairs could be resolved experimentally for the first time.
Right: Measurements through the fluctuating phase boundary can be performed for the first time using adaptive optics, here a deformable membrane mirror.

Bilsing, C., Radner, H., Burgmann, S., Czarske, J., & Büttner, L. (2022). 3D Imaging with Double-Helix Point Spread Function and Dynamic Aberration Correction Using a Deformable Mirror. Optics and Lasers in Engineering, 154, 107044.

Bilsing, C., Büttner, L., Czarske, J., Janoske, U., Burgmann, S. (2022). 3D-PTV-Messung in einem oszillierenden Tropfen mittels Doppelhelix-Punktspreizfunktion (DH-PSF).

C. Bilsing, H. Radner, L. Büttner, S. Burgmann, A. Metzmacher, J. Czarske, „Neuartiges Lasermesssystem mit adaptiver Bildkorrektur unter Nutzung von helikalen Wellenfronten und eines deformierbaren Spiegels“, 122. Jahrestagung der DGaO, Preisträgervortrag NWP4, Bremen, 21.–23.09.2021

DFG **Lensless holographic endoscopy with self-calibration**

Staff: E. Scharf, R. Kuschmierz, J. Czarske

Aim: Flexible endoscopes are used in medicine and industrial applications for minimal invasive imaging. They employ miniaturized optics in the probe tip and a coherent fiber bundle (CFB) with 10,000 to 100,000 fiber cores for transferring the image outwards. The working principle and setup result in a pixelated image due to the limited core number as well as a fixed image plane. Furthermore, the optics in the probe tip limit the minimum diameter of the probe tip to several millimeters. With the approach of the lensless holographic endoscope, it is possible to eliminate or greatly improve the disadvantages of pixilation, fixed image plane and limited minimal diameter. The holographic endoscope does not use the single fibers to transfer single image points out of the sample. They are used to transport light from a laser into the interior of the sample. Due to the multitude of fibers and the wave character of light, the lensless probe tip can be regarded as a phased array. Using a Spatial Light Modulator (SLM) outside of the CFB it is possible to control the phase through each fiber core individually. While a new calibration is needed after each movement of the CFB, we found a way to calibrate continuously and in-vivo, without access to the probe tip. One single fiber core acts as a guide star through a semi-reflective plane (see Fig. 1). Such that, the relative phase delays between neighboring cores are determinable via holography. The SLM is used to compensate distortions within the CFB and to shape the out coming beam. Thus, it is possible to create a free-moving focus to scan the object. Like the functionality of a scanning microscope, an image can be assembled from the backscattered light of the individual focus positions. The approach enables setups with sub-millimeter diameters, sub-micron resolution and 3D imaging capability. In addition to its use as an endoscope, this technology can also be used for laser surgery, optogenetics and optical tweezers.

Period: 11/2020 – 10/2023

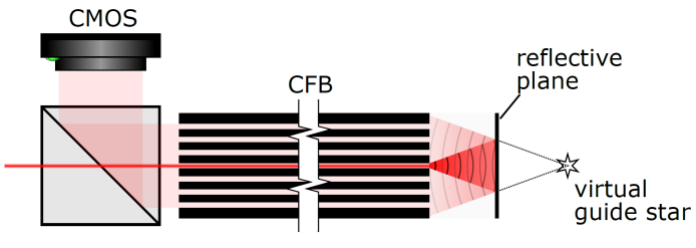


Fig. 1

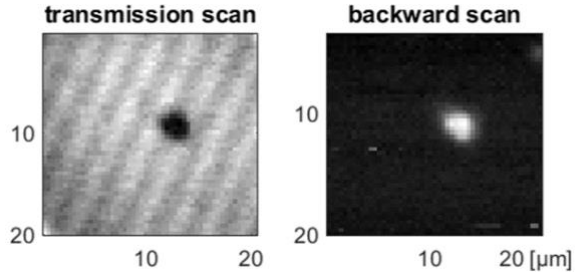


Fig. 2

Left: Scheme virtual guide star calibration. Right: Endoscopic scan of fluorescent particle with diameter of 1 µm.

R. Kuschmierz, E. Scharf, N. Koukourakis, and J. Czarske, “Self-calibration of lensless holographic endoscope using programmable guide stars”, Opt. Lett. 43, 2997-3000 (2018).
E. Scharf, J. Dremel, R. Kuschmierz, J. Czarske, “Video-rate lensless endoscope with self-calibration using wavefront shaping”, Optics Letters 45(13), 3629-3632, 2020
R. Kuschmierz, E. Scharf, D. F. Ortegón-González, T. Glosemeyer, J. Czarske. Ultra-thin 3D lensless fiber endoscopy using diffractive optical elements and deep neural networks. Light: Advanced Manufacturing

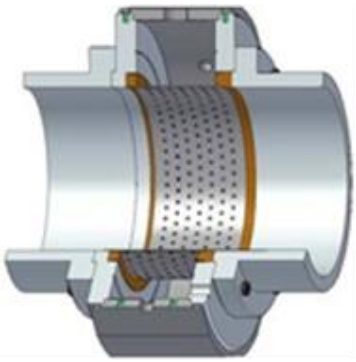
DFG **Laser based tomographic measurement of the local acoustic impedance of overflowed liners (TOMLIM)**

Staff: J. Gürtler, R. Kuschmierz, J. Czarske

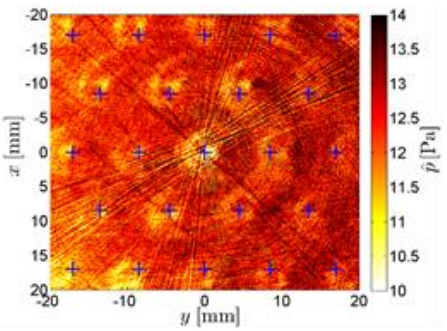
Aim: The increasing growth of air traffic demands highly efficient noise reduction measures especially addressing the noise emitted from aero-engines. Common applications for noise attenuation are acoustically lined surfaces, called liner, placed along the flow pass in the engine nacelle. Liners consist of perforated walls with a cavity structure behind. Up to now the design of these liners for an optimal performance under flow conditions is based on heuristic and empirical methods due to the lack of sufficiently describing, fully analytical models. In previous projects it was shown that under certain circumstances lined surfaces can even contribute to noise generation instead of attenuation. This demonstrates the need for improved liner model descriptions, which allows a liner design optimization with robust prediction ability.
A key quantity in describing the liner performance is the acoustic impedance, the ratio of the pressure fluctuations to the wall-normal velocity fluctuation of the sound field. In order to understand those complex flow phenomena a novel non-intrusive impedance measurement technique with high spatio-temporal resolution is needed. Therefore, a combination of tomographic acoustic pressure measurements and Doppler Global Velocimetry based acoustic particle velocity measurements, will be developed, validated and applied on liner setups under realistic grazing flow conditions. The optical setups as well as the post-processing algorithms need to be developed to facilitate the application with limited optical access to the liner section in a flow duct test rig at the DLR in Berlin.

Period: 11/2018 – 10/2022

Partner: TU Berlin, Prof. L. Enghardt; DLR Berlin, Dr.-Ing. F. Bake



Bias Flow Liner (Model)



Local sound pressure variations, measured at a Bias Flow Liner

D. Haufe, J. Gürtler, A. Schulz, F. Bake, L. Enghardt and J. Czarske, “Aeroacoustic analysis using natural Helmholtz–Hodge decomposition”, J. Sens. Sens. Syst., 7, 113-122, https://doi.org/10.5194/jsss-7-113-2018, 2018.
A. Ramos Ruiz, J. Gürtler, R. Kuschmierz, and J. Czarske, “Measurement of the local sound pressure on a Bias-flow liner using high-speed holography and tomographic reconstruction”, IEEE Access (2019)
Felix Greiffenhagen, Jakob Woisetschläger, Johannes Gürtler, Jürgen Czarske, “Quantitative measurement of density fluctuations with a full-field laser interferometric vibrometer”, Experiments in Fluids, 61, 9, 2020
J. Gürtler, F. Greiffenhagen, J. Woisetschläger, R. Kuschmierz, J. Czarske, “Seedingless measurement of density fluctuations and flow velocity using high-speed holographic interferometry in a swirl-stabilized flame”, Optics and Lasers in Engineering, 2020

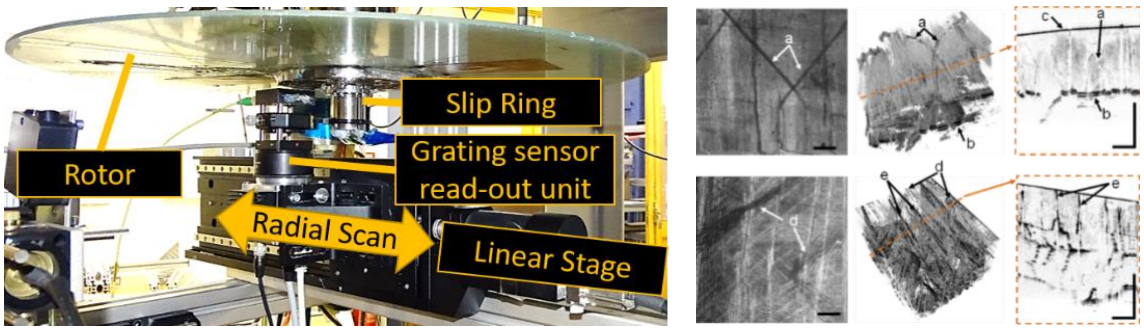
DFG **Investigation of damaged fibre-reinforced high-speed rotors using in-situ measurement systems**

Staff: J. Lich, R. Kuschmierz, J. Czarske

Aim: Fibre-reinforced composites offer excellent properties such as very high specific strength and stiffness as well as high freedom of design due to their anisotropy and gradual damage behavior. Therefore, they are predestined for new high-performance rotors, for example in turbomachinery or centrifuges. However, problem-oriented design tools for the reliable prediction on durability, reliability and energy efficiency of the rotor are still lacking. The aim of the project is to find the fundamental relationship between damage state and dynamic behavior of fast rotating fibre-reinforced rotors. This requires the development of novel measurement systems that allow the simultaneous in-situ measurement of damage state and modal behavior during rotation. Rotor expansion is measured with submicron uncertainty by our unique Multipoint-Laser-Doppler-Distance Sensor. We additionally measure the in-plane strain field and the out-of-plane vibration by reading out diffraction gratings on the rotor surface. To validate and calibrate numerical models developed by our partner “Institut für Leichtbau und Kunstofftechnik”, we further reduce the measurement uncertainty of the Diffraction Grating Sensor and expand its applicability to complex rotor geometries. Furthermore, techniques for the volumetric measurement of local deformations and damages will be qualified and applied for the first time at fast rotating structures together with our partner “Klinisches Sensoring und Monitoring”.

Period: 10/2017 – 04/2021, 11/2021 – 11/2024

Partner: Institut für Leichtbau und Kunststofftechnik - TU Dresden, Prof. Gude
Arbeitsgruppe Klinisches Sensoring und Monitoring – TU Dresden, Prof. Koch



Diffraction Grating Sensors measuring in- and out-of-plane FRP rotor deformation field and vibration at >270 m/s with 20 µε and 15 µrad precision (left). OCT images of internal FRP rotor structure, showing delamination (b) and cracks (e) (right) due to overload.

Lich, Julian, et al. "Spatially Resolved Experimental Modal Analysis on High-Speed Composite Rotors Using a Non-Contact, Non-Rotating Sensor." *Sensors* 21.14 (2021): 4705.
Filippatos, Angelos, et al. "Design and testing of polar-orthotropic multi-layered composites under rotational load." *Materials & Design* (2021): 109853.
Julian Lich, Tino Wollmann, Angelos Filippatos, Maik Gude, Jürgen Czarske, Robert Kuschmierz, “Diffraction-grating based in situ displacement, tilt and strain measurements on high-speed composite rotors”, Applied Optics, 58(29), 8021-8030, (2019)

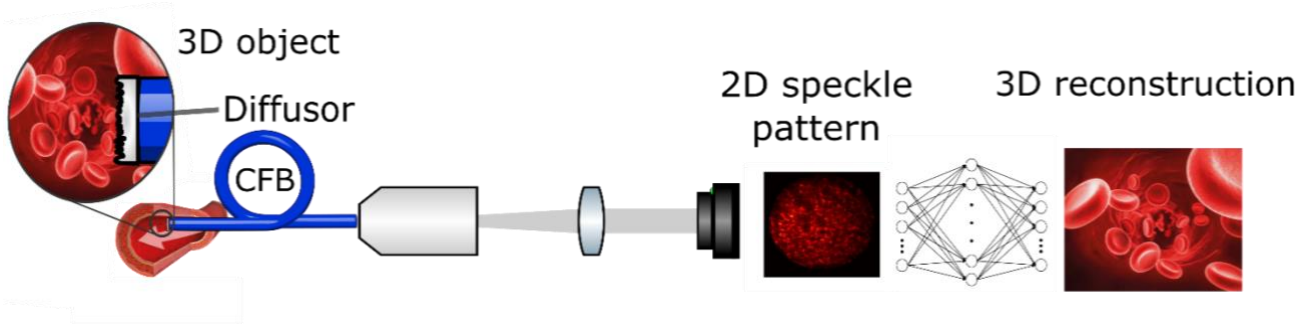
DFG **Minimally Invasive 3D-Imaging using a diffuser and neural networks**

Staff: J. Lich, T. Glosemeyer, R. Kuschmierz, J. Czarske

Aim: The aim of the project is to fundamentally investigate a novel technique for minimally invasive endoscopy. Conventional fiber endoscopes are based on the transmission of intensity patterns through imaging waveguides and on imaging optics with a fixed focal distance for 2D imaging. A paradigm shift towards minimally invasive, single-shot, 3D measurements will be pursued by substituting the imaging optics with a diffuser. The diffuse scattering of light is used to code 3D object information in 2D speckle patterns and relay this information through imaging waveguides. The decoding will be realized in an advantageous manner by neural networks and deep learning.

Endoscopy is of high importance for in-vivo deep-tissue examinations in biological research, for instance in neurosurgery. Stereotactic needle biopsies are performed to enable ex-vivo auto fluorescence microscopy for brain tumor classification. The time delay between biopsy, measurement and diagnosis requires multiple surgeries. A miniaturized endoscope on the other hand can enable an in-vivo-pathology by 3D autofluorescence mapping.
Due to their high 3D displacement resolution, miniaturized diffuser endoscopes can be furthermore used for 3D-3C blood flow measurements.

Period: 04/2021-04/2024



The 3D object is encoded by a diffuser to a 2D speckle pattern which is transmitted through a CFB to a camera. The 3D object is then reconstructed by a neural network.

R. Kuschmierz, E. Scharf, D. F. Ortegón-González, T. Glosemeyer, J. Czarske. Ultra-thin 3D lensless fiber endoscopy using diffractive optical elements and deep neural networks, [J]. Light: Advanced Manufacturing. doi: 10.37188/lam.2021.030, (2021)

AIF **Needle-shaped lensless holographic endoscope (HoloScope)**

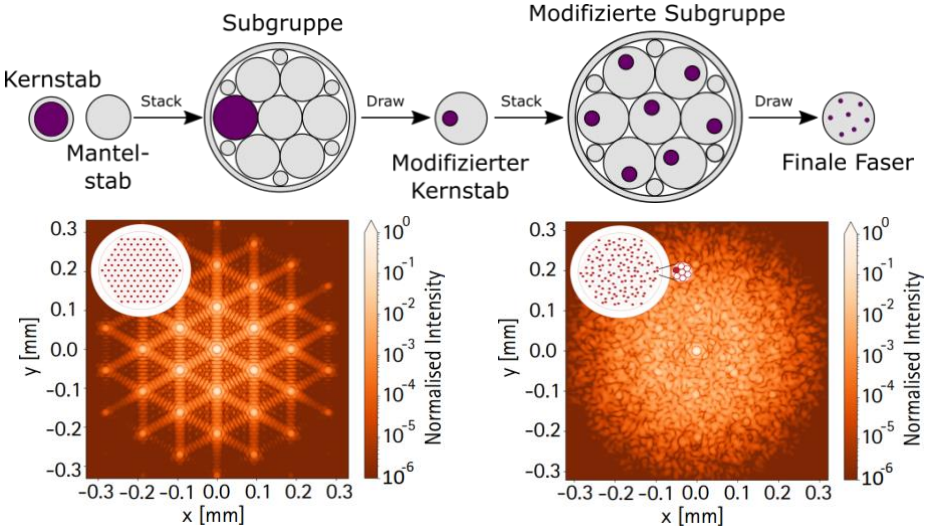
Staff: E. Scharf, R. Kuschmierz, J. Czarske

Aim: Thin and flexible endoscopes for minimally invasive medical diagnostics and therapy only allow for 2D imaging so far while 3D endoscopes exceed the required diameters for minimally invasive applications. Aim of the project “HoloScope” is the realization of endoscopes with diameters down to 300 µm, which allow for 3D imaging with cellular resolution. Current approaches for lensless holographic endoscopes rely on complex setups and programmable optics, are difficult to calibrate, expensive, not real time and generally not suitable for applications outside of research labs. Furthermore, commercially available fiber bundles used in these setups are ill suited for the applied phased array principle.

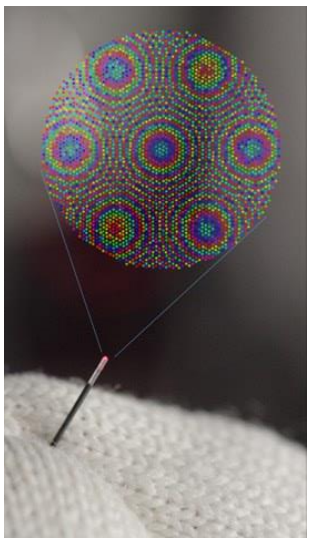
This project aims to overcome some of these issues, by implementing real time and in-situ calibration and closed loop control. Especially novel fiber designs are investigated in cooperation with Hannover Institute of Technology (HITec) of Leibniz-University Hannover, in order to achieve superior imaging quality as well as robustness. This project is additionally supported by 12 companies, including 8 MSEs, as well as 2 clinics.

Period: 08/2021-12/2023

Partner: Dr. M. Steinke & Prof. D. Ristau, Hannover Institute of Technology (HITec), Leibniz-University Hannover



Top: drawing process of aperiodic image guides (stack and draw). Bottom – left: far field of existing fiber with periodically arranged fibers cores. Higher diffraction orders result. Bottom-right: far field of novel fiber with aperiodically arranged fiber cores suppresses higher diffraction orders.



Lensless holographic endoscope: Magnification shows the light phase on the fiber for far field focusing

R. Stephan, M. Steinke, A. Rühl, R. Kuschmierz, K. Hausmann, M. Ließmann, D. Ristau, and J. Czarske, „Design studies of aperiodic multicore fibres for lensless endoscopy“, ePoster ETu2A.30, Advances in Microscopic Imaging, OSA European Conferences on Biomedical Optics, 2021

E. Scharf, R. Stephan, M. Steinke, R. Kuschmierz, D. Ristau, and J. Czarske, „Nadelförmiges linsenloses holografisches Endoskop “, ePoster, F.O.M.-Konferenz 2021, 2021

EKFZ In vivo brain tumor diagnostics by adaptive computational lensless fiber endoscopy (BrainAce)

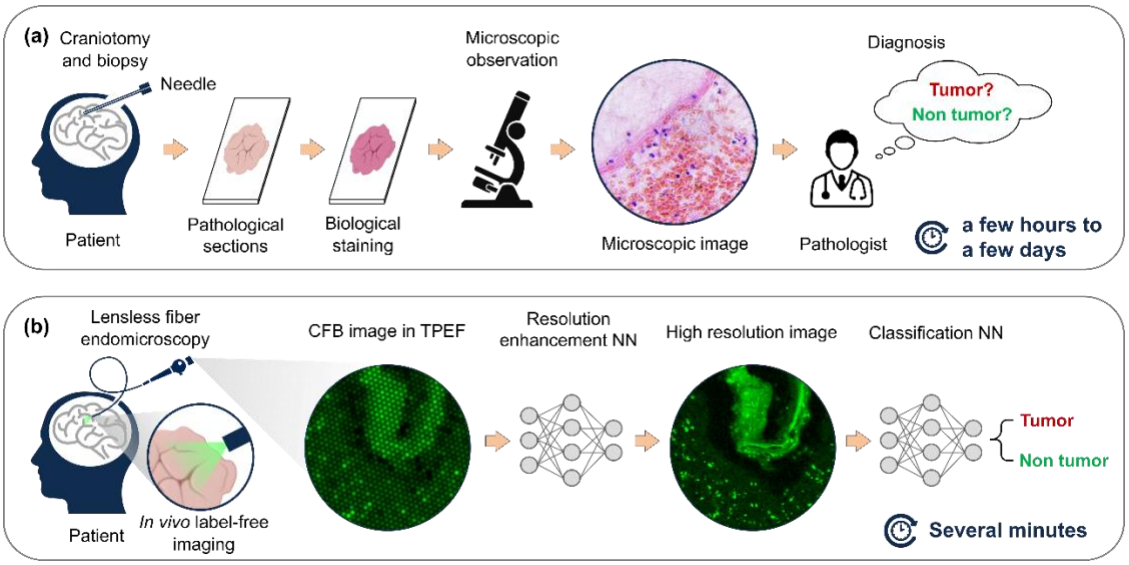
Staff: J. Dremel, T. Wang, J. Czarske, R. Kuschmierz

Aim: In patients with inoperable brain tumors located in eloquent brain regions, histological diagnosis is a prerequisite for the determination of the adjuvant treatment. This requires a minimal-invasive biopsy for histology that requires some days to provide an integrated diagnosis for further clinical decision-making. As a consequence, if the suspicious tissue turns out to be an aggressive brain tumor, the adequate therapy is delayed with negative impact on the patient's prognosis. The development of strategies for direct tumor diagnosis bypassing tissue removal and lengthy pathological evaluation would allow the immediate therapy of affected patients.

We aim to develop and test a prototype of a novel tiny endoscope that probes autofluorescence of brain tissue and allows optical biopsies in situ. In the project, we will research the spectral characteristics of brain tumor fluorescence and miniaturize an endoscopic system while preserving high optical properties. This is achieved by implementation of recent advances in computational optics and programmable light. The development of tissue classification and strategies for integration of AI-supported diagnosis into the clinical workflow will allow successful translation. Moreover, the research may pave the way for future automated brain tumor diagnosis and tumor removal by laser ablation.

Period: 01/2022 – 12/2023

Partners: University Hospital Carl Gustav Carus, Neurosurgery & Division of Medical Biology
Dr. S. Richter, Dr. W. Polanski, Prof. G. Schackert, Dr. O. Uckermann



Workflow of biopsy diagnosis and end-to-end diagnosis

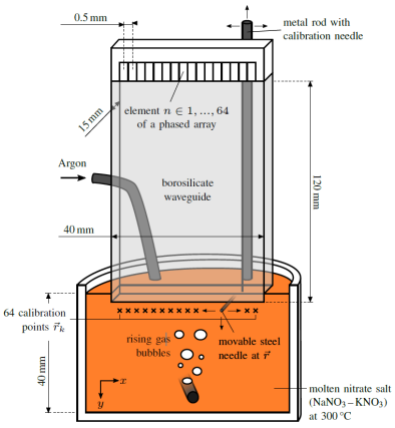
Wu, J., Wang, T., Uckermann, O., Galli, R., Schackert, G., Cao, L., Czarske, J., Kuschmierz, R., 2022. Learned end-to-end high-resolution lensless fiber imaging towards real-time cancer diagnosis. Sci Rep 12, 18846

DFG **Ultrasound measurements through multimode-waveguide based on time reversal for imaging in hot metallic melts**

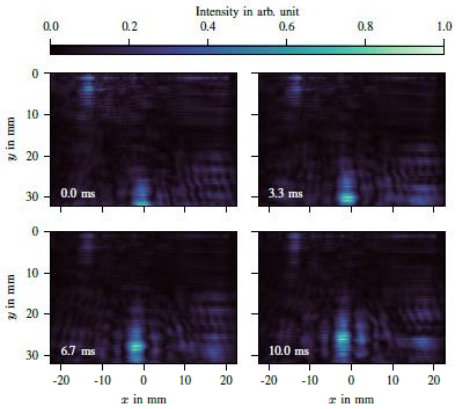
Staff: Z. Dou, L. Grüter, D. Weik, J. Czarske

Aim: In industrial processes, such as continuous steel casting, the quality of the end products depends on the melt flow and structure. Therefore, in situ imaging of opaque melts under harsh conditions is important. Conventional ultrasound measurement systems, which are usually suitable for imaging in opaque fluids, cannot be operated at temperatures beyond Curie temperature of the ultrasound transducer.
An approach is to use a multimode waveguide as a temperature gradient, which spatially separates the sensor from the hot measurement fluid. To overcome the complex ultrasound propagation through the waveguide the time reversal method is used. The time invariance of the wave equation in an unknown, linear and nearly lossless medium allows spatiotemporal refocusing to the initial point. However, the planar imaging would require costly in situ calibration, because each point of interest need to be calibrated with a beacon.
A reduced, non-invasive, ex situ calibration can be achieved by applying the time reversal virtual array method. Therefore only a limited set of precalibrated points at the waveguide-measurement volume interface are needed, which form the virtual array. The virtual array can be conceptually treated as a phased-array for the imaging behind the waveguide. This allows the application of conventional signal processing strategies, such as transmit and receive beamforming to increase the resolution of an image and ultrasound Doppler velocimetry for flow estimations.

Period: 08/2019 – 07/2022
Partner: Helmholtz-Zentrum Dresden-Rossendorf, Dr. Eckert



Cross-section of the experimental setup: A phased array was connected to the end of a borosilicate waveguide and calibrated in the hot melt with a moving needle.



Observation of rising gas bubbles in molten salt at 300 °C.

L.Grüter, R. Nauber, J. Czarske, „Ultrasonic Bubble Imaging in Molten Salt Using a Multi-Mode Waveguide and Time Reversal“, IEEE Transactions on Instrumentation and Measurement 71, 2022, Art. no. 4501810.

Z. Dou, L. Grüter, D. Weik, J. Czarske, "Ultrasound Tracking of Gas Bubbles Through a Multi-Mode Waveguide in Hot Melts", 2022 IEEE International Ultrasonics Symposium (IUS), Oct. 2022.

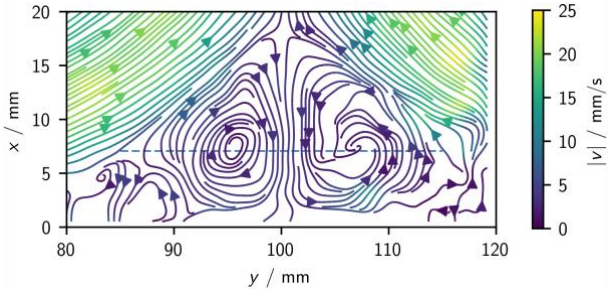
DFG **Investigation of thermal boundary layer dynamics in turbulent liquid metal convection by ultrasound localization microscopy of near-wall velocity fields and temperature measurements**

Staff: D. Weik, L. Büttner, J. Czarske

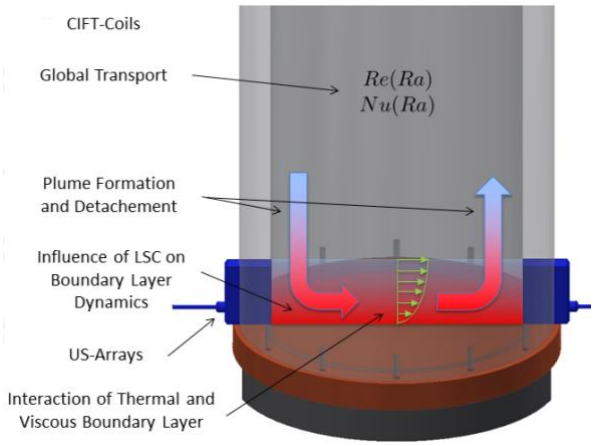
Aim: The dynamics and interaction of thermal and viscous boundary layers (BL's) will be studied experimentally in highly turbulent liquid metal convection at small Prandtl numbers using the ternary alloy GaInSn ($\mathrm{Pr} = 0.03$). Rayleigh-Bénard convection at large Rayleigh numbers of up to $\mathrm{Ra} \cong 5 \times 10^9$ is characterized by a fully turbulent flow field, with the temperature field exhibiting significantly more coherence than the velocity field due to the high thermal diffusivity. A crucial role for heat transport in turbulent convection is played by the BL's. Here, a special feature of liquid metals becomes apparent, which has hardly been researched so far: The much thinner viscous boundary layer is embedded in the thermal BL. Therefore, the thermal BL and thus the convective heat transport are strongly influenced by the turbulent large-scale convection (LSC). By means of *Ultrasound Localization Microscopy* (ULM) of near-wall velocities and high-resolution temperature measurements using fiber optic sensors, the interaction between BL's and LSC will be investigated in detail for the first time in liquid metal laboratory experiments. This parameter range has so far been inaccessible by direct numerical simulations. The experiments, in which near-wall temperatures and flow velocities are measured in liquid metals with high resolution, set a new milestone for the understanding of convective transport processes in fluids at small Pr with their numerous applications in geo- and astrophysical flows as well as in engineering systems.

Period: 10/2022 – 11/2025

Partner: Helmholtz-Zentrum Dresden-Rossendorf, Dr. Eckert, Dr. Vogt



Super-resolution vector flow imaging of a recirculation area in a liquid metal convection.



Projected convection experiment for thermal and viscose boundary layer measurements.

D. Weik, L. Grüter, D. Räbiger, S. Singh, T. Vogt, S. Eckert, J. Czarske, L. Büttner, „Ultrasound Localization Microscopy in Liquid Metal Flows", Applied Sciences 12.9, 4517, 2022.

D. Weik, L. Grüter, D. Räbiger, S. Singh, T. Vogt, S. Eckert, J. Czarske, "Ultrasound Localization Microscopy by Nonlinear Adaptive Beamforming – a Case Study for Super-Resolved Flow Fields in Liquid Metal Experiments", 2022 IEEE International Ultrasonics Symposium (IUS), Oct. 2022.

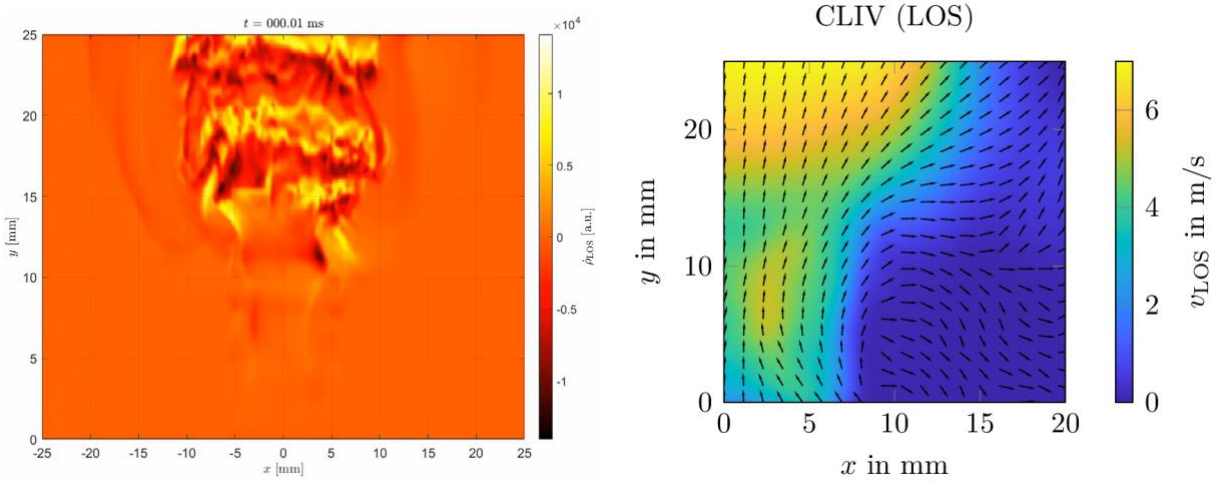
DFG **High-speed 4D measurement of thermoacoustic oscillations**

Staff: J. Gürtler, R. Kuschmierz, J. Czarske

Aim: During the combustion of sustainable fuels, such as green hydrogen for stationary gas turbines, instabilities occur in the form of thermoacoustic oscillations. To ensure safe and efficient turbine operation, a deeper understanding of these oscillations is necessary.
For this purpose, scientists from the Chair of Measurement and Sensor Systems Engineering at TU Dresden and the Institute of Thermal Turbomachinery and Machine Dynamics at TU Graz want to develop and apply new measurement and evaluation techniques. Using modern high-speed camera technology and deep learning based tomographic reconstruction.
The aim of the project is to perform laser-optical measurements inside such oscillating flames, with high demands on the measurement technology due to the necessary spatial (3D, ≤ 500 µm³) and temporal (≤ 10 µs) resolutions. The cooperation project is funded by the Deutsche Forschungsgemeinschaft (DFG) as well as the Austrian Science Fund (FWF) under the project numbers CZ 55/50-1 and I 5392-N.

Period: 11/2022 – 10/2025

Partner: TU Graz, Prof. Woisetschläger



Left: Time resolved densitiy derivative measured line-of-sight in a swirl-stabilized flame. Right: Integral mean velocity, calculated from the line-of-sight density measurement using PIV signal correlation.

Greiffenhagen, F., Peterleithner, J., Woisetschläger, J., Fischer, A., Gürtler, J., Czarske, J., „Discussion of laser interferometric vibrometry for the determination of heat release fluctuations in an unconfined swirl-stabilized flame“. In: Combust. Flame 201 (2019), S. 315–327. doi: 10.1016/j.combustflame.2018.12.019.

Greiffenhagen, F., Woisetschläger, J., Gürtler, J., Czarske, J., „Quantitative measurement of density fluctuations with a full-field laser interferometric vibrometer“. In: Exp. Fluids 61.1 (2020), S. 9. doi: 10.1007/s00348-019-2842-y.

Gürtler, J., Greiffenhagen, F., Woisetschläger, J., Kuschmierz, R., Czarske, J., „Seedingless measurement of density fluctuations and flow velocity using high-speed holographic interferometry in a swirl-stabilized flame“. In: Opt. Lasers Eng. 139.September (2021), S. 106481. doi: 10.1016/j.optlaseng.2020.106481.

Rothkamm, O., Gürtler, J., Czarske, J., Kuschmierz, R., „Dense U-Net for Limited Angle Tomography of Sound Pressure Fields“. In: Appl. Sci. 11.10 (2021), S. 4570. doi: 10.3390/app11104570.

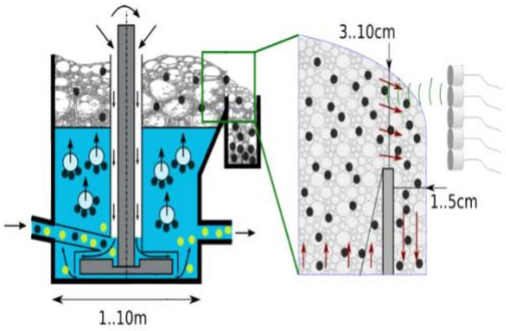
AiF **In-process monitoring of material flows in froth flotation with model-based ultrasonic measurement technology**

Staff: H. Emmerich, L. Büttner, D. Weik, J. Czarske

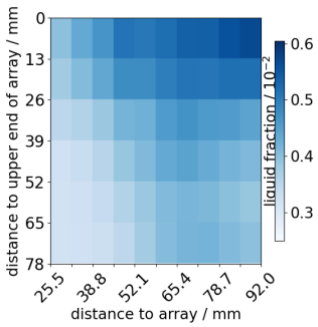
Aim: In 2016, about 20 billion liters of water were used, only to extract copper as a raw material. The process used is the froth flotation. Grained materials are being separated by the use of surfactant solutions. Ascending bubbles transport the hydrophobic materials to the surface, consisting of a bulk foam layer. Due to different material and water qualities, a robust effective process is only partly possible. Information about the material flow might increase these factors. Our aim in that project is to implement a measuring system, giving information about the foam's consistence and the material flow. Conventional optical measurements or level sensors provide a too low penetration depth in opaque bulk foam or give too little information about the foam parameters respectively. Therefore, we use an in-situ ultrasound measurement system. An ultrasound array is used to create a 2D-image. Analyzing the variations in the propagated (transmitted/reflected) ultrasound signal due to different foam parameters as liquid fraction, bubble size or the amount of particles, we are able to draw retrospective conclusions about those parameters. Using different signal processing tools as Doppler Analysis we gain information about the particles velocity and their moving direction. Combining those monitored values, we can infer a statement about the material flow. Thereby we are one step closer to a control loop that potentially increases the yield and saves energy and resources.

Partner: Leon Knüpfer, Dr. Sascha Heitkam, Institute of Fluid Dynamics
Helmholtz-Zentrum Dresden - Rossendorf (HZDR)

Period: 06/2020 – 01/2023



Scheme of a flotation cell and the measurement setup



Spatio-temporally resolved measurement of the liquid fraction

Nauber, Richard & Büttner, Lars & Eckert, Kerstin & Fröhlich, Jochen & Czarske, Jürgen & Heitkam, Sascha. (2018). Ultrasonic measurements of the bulk flow field in foams. Physical Review E. 97. 10.1103/PhysRevE.97.013113.
Emmerich, Hannes, Schaller, Ludwig, Nauber, Richard, Knüpfer, Leon, Heitkam, Sascha, Czarske, Jürgen and Büttner, Lars. "Linear, spatio-temporally resolved ultrasound measurement of the liquid fraction distribution in froth" tm - Technisches Messen, vol. 88, no. 9, 2021, pp. 562-570. https://doi.org/10.1515/teme-2021-0047
H. Emmerich, L. Knüpfer, S. Heitkam, E. Starke, P. Trtik, L. Schaller, D. Weik, J. Czarske, "Ultrasound imaging of liquid fraction in foam", IEEE Transactions on Instrumentation & Measurement, 2022

Dr.-Ing. Felix Schmieder

"Investigations on the application of laser beam shaping with spatial light modulators for optogenetics in stem-cell-based neuronal networks and laser ultrasonics"

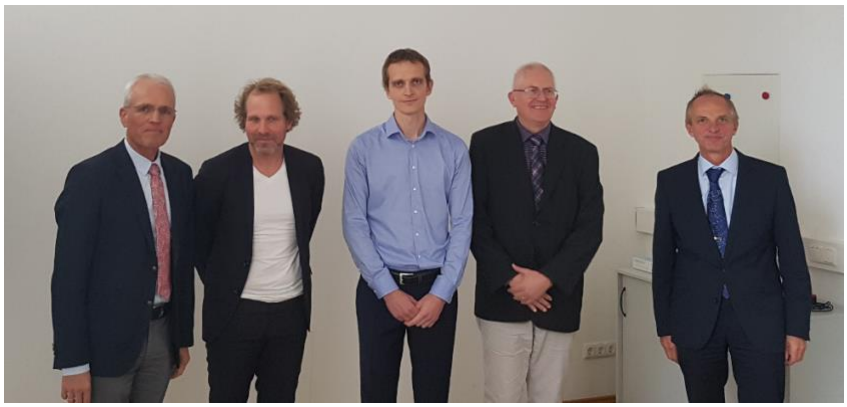
Abstract:
In many application areas of laser measurement technology, adaptive spatial and temporal light field shaping can open up completely new perspectives. In optogenetics, for example, single foci with a maximum diameter of 10 µm, addressable in three dimensions, as well as complex patterns are necessary for the the activation or inhibition of single cells or whole cell groups to perform in-depth analyses of neuronal networks. Computer-generated holograms (CGH) are best suited for this purpose due to their versatile possibilities of amplitude and phase modulation. To display these, fast spatial light modulators (SLM) with a high number of pixels are required. Widely-used liquid crystal SLMs often have a megapixel resolution but a frame rate of only a few hertz. Due to innovations in the consumer sector, microelectromechanical scanner mirrors and ferroelectric binary phase modulators are available, which at the same time offer high spatial and temporal resolution. Based on such devices with 250 Hz and 1.7 kHz frame rates, computer-aided adaptive optical systems for laser-generated ultrasound optogenetics were developed and applied. On the basis of computer simulations, methods for the fast generation of binary phase holograms were compared. For Fresnel holograms, an error diffusion method leads to reconstructed images with highest similarity to the desired intensity distributions and is more than 10× faster than the second-best method, which is based on the Gerchberg-Saxton algorithm.
In the field of laser-generated ultrasound, a microelectromechanical modulator was used to generate ring-shaped illumination patterns of different diameters, which allow a focussing of shear waves in different depths in an aluminium workpiece. This way, material properties can potentially be detected without contact and with a high bandwidth.
For optogenetic network analyses, two systems for cellular and subcellular three-dimensional stimulation and inhibition were developed. Using ferroelectric liquid crystal modulators, frame rates up to the kilohertz range can be achieved. Using an iterative correction procedure with Zernike polynomials, system-inherent aberrations could be corrected to achieve almost diffraction-limited lateral spatial resolution. Thus, the temporal evolution of neural network connectivity was observed. Through targeted single-cell stimulation, effects not visible with electrical stimulation alone, such as distance-dependent signal velocities and connections between neurons undetectable by electrical signals were be observed. This opens up new ways for pharmacological investigations and the analysis of neurodegenerative diseases in vitro.

Date of defense: 10.11.2022

Chairman: Prof. Dr.-Ing. habil. Hagen Malberg, Prof. Dr.-Ing. habil. Gerald Gerlach, TU Dresden

Reviewers: Prof. Dr.-Ing. habil. Jürgen Czarske, TU Dresden
Prof. Dr. Alexander Heisterkamp, Leibniz Universität Hannover
Prof. Dr. rer. nat. Edmund Koch, TU Dresden

Examination: Prof. Dr.-Ing. habil. Jürgen Czarske, TU Dresden
Prof. Dr.-Ing. Hubert Lakner, Fraunhofer IPMS and TU Dresden



Everyone is having a good time! Prof. Gerlach, Prof. Heisterkamp, Dr. Schmieder, Prof. Czarske, Prof. Koch (left to right)

Dr.-Ing. Florian Bürkle

"Investigation of interferometric measurement techniques for high-resolution velocity and temperature profile measurements for fluids in fuel cells”

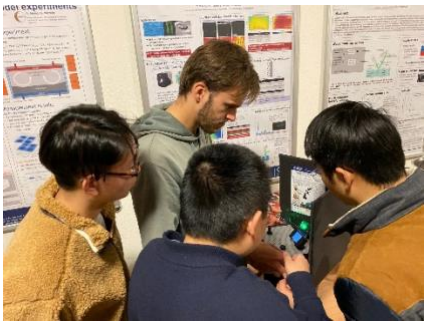
Abstract:
Knowledge of the flow present in technical processes allows insight into the underlying physical and chemical processes, for example in fuel cells, lab-on-a-chip-devices, wet clutches, stratified thermal energy storages or bioreactors. In all these examples, flows in narrow channels, with large velocity gradients and temperature differences are found, requiring high spatial resolution, low velocity uncertainty and high working distance for measurement. For the investigation of thermal effects, the additional measurement of temperature is desirable.
A measurement system that combines high spatial resolution and low velocity uncertainty is the laser Doppler velocity profile sensor (LDV-PS). This is an extension of the conventional laser Doppler velocimeter (LDV). Instead of only one interference fringe pattern, two interference fringe patterns with characteristic fringe spacing curves are superimposed in the measurement volume. There is still a need for research in temperature measurement, which is not yet possible with the LDV-PS, and measurement in dispersive media, since the calibration changes in these.
The LDV-PS is set up in time multiplex, i.e. both fringe systems are alternately active. This makes a monochromatic setup possible, which eliminates dispersion effects when measuring in liquids and simplifies the use of luminescent scattering particles. In this work, the realisation of the time-division multiplex is demonstrated with two fast-switching lasers or with an electro-optical modulator, respectively. Velocity measurements of several 10 m/s with constant low measurement uncertainty even at large working distances are possible.
When measuring in dispersive media, a transition of the laser beams from air to the dispersive medium cannot be avoided. Calibration in the dispersive medium became obsolete in this work by calculating a calibration model that takes both geometric and Gaussian optics into account. Relative systematic measurement deviations of up to 6.5% caused by the transition can be corrected to less than 0.1 %. The calibration model was also used to measure the near-wall and gap flow in a transparent model of a silicon crystal growth furnace.
One application of the LDV-PS was the measurement of the flow distribution of a fuel cell stack model. In such a stack, all fuel cells are supplied with reaction gas via an inlet manifold. An uneven distribution of the reaction gas causes a lower efficiency and lifetime of the entire stack. In the experiment, with the help of an insert for the inlet manifold, the uneven distribution could be reduced from 10% to 4 %. The results can be used to optimise the flow distribution in real fuel cell stacks.
The measurement of the temperature was realised by combining the LDV-PS with laser-induced fluorescence (LIF). For this purpose, two fluorescent dyes were added to a solution, which was then atomised. The resulting droplets were used as scattering particles. Using the temperature dependence of the intensity of the dyes, the temperature could be measured with a measurement deviation of less than 1 °C. The temperature uncertainty can be improved at the expense of the spatial resolution and vice versa. The LDV-PS thus became a micrometre-resolution flow measurement system for velocity and temperature measurement, which, when used in the processes mentioned at the beginning, leads to advances that include higher efficiencies, lower power losses and increased biological activity.

Date of defense: 8.12.2022

Chairman: Prof. Dr.-Ing. Richter, TU Dresden

Reviewers: Prof. Dr.-Ing. habil. Czarske, TU Dresden
Prof. Dr.-Ing. Cierpka, TU Ilmenau

Examination: Prof. Dr.-Ing. habil. Czarske, TU Dresden
Prof. Dr.-Ing. habil. Dr. h. c. Hampel, HZDR and TU Dresden



Diploma and Master Theses

Siyang Sun “Synthetic deep learning based on two dimensional simulated ultrasound echo in bulk foam”, 1/22

Laura Nieber „Untersuchung von Wellenleiter-basierten Luftultraschallarrays zur Erfassung von Schaumparametern in Flotationsprozessen“, 5/22

Ning Guo “Reinforcement Learning based aberration correction using an adaptive achromatic lens for zebra sh studies”, 5/22

Jonas Hitziger „Untersuchung eines Computational Mikroskopie-Lasersystems zur dreidimensionalen Lokalisierung von Herzmuskelzellen“, 5/22

Ya Gao “Connectivity analysis of biological neuronal networks using deep learning”, 5/22

Nam Van Tran „Untersuchung neuronaler Netze für die 3D-Bildrekonstruktion aus Speckle-Mustern eines minimalinvasiven Endoskops mit Diffusor“, 5/22

David Krause „Messung der Transmissionsmatrix von Multimodefasern unter Nutzung von neuronalen Netzen und moderner digitaler Holographie“, 6/22

Bachelor Theses

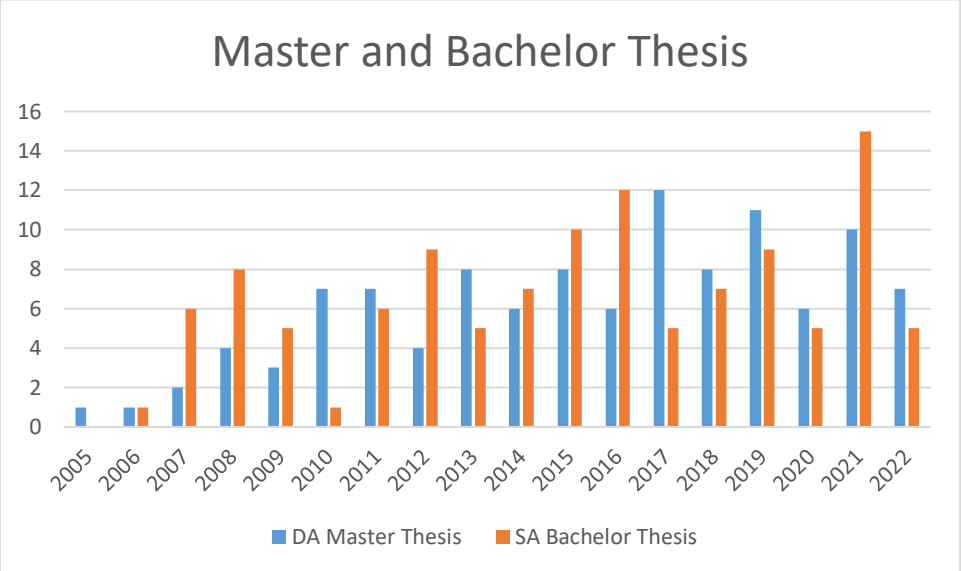
Bin Yang “Optimization of 3D Tomographic Reconstruction via Computer Vision and Deep Learning” 4/22

Benedikt Geiger „Plane-Wave-Compounding mit akustischen Multimode-Wellenleitern und der digitalen Zeitumkehrtechnik“, 5/22

Erik Nützenadel „Untersuchung einer Methode zur Kalibrierung von Fresnel-Leitsternen mit nur einem optischen Zugang“, 10/22

Markus Schmidt „Individuelle Phasenkorrektur für bildgebende Mehrkernfaserbündel mittels 2-Photonen-Laserlithographiesystem“, 11/22

Johanna Hoppe „Untersuchungen zur smarten Mikroskopie mit hybrider Beleuchtung“, 11/22



Total in 18 years: 114 Bachelor Theses (SA) and 111 Master Theses (DA)

PUBLICATIONS AND TALKS

SCI-Publications in journals with peer review process

F. Schmieder, L. Büttner, T. Hanitzsch, V. Busskamp, J. Czarske, “Two-Wavelength Computational Holography for Aberration-Corrected Simultaneous Optogenetic Stimulation and Inhibition of In Vitro Biological Samples” Applied Science 12, 2022

K. Schmidt, N. Koukourakis, J.W. Czarske, “Assignment of Focus Position with Convolutional Neural Networks in Adaptive Lens Based Axial Scanning for Confocal Microscopy”, *Appl. Sci. Vol* (12), 661 (2022)

S. Burgmann, V. Kraemer, M. Dues, J. Steinbock, L. Büttner, J. Czarske, U. Janoske, “Flow-measurements in the wake of an oscillating sessile droplet using laser-Doppler velocity profile sensor”, Technical Measurements - Technisches Messen (2022)

L. Grüter, R. Nauber and J. W. Czarske, "Ultrasonic Bubble Imaging in Molten Salt Using a Multi-Mode Waveguide and Time Reversal", IEEE Transactions on Instrumentation and Measurement 71, 4501810, 2022.

F. Schmieder, R. Habibey, J. Striebel, L. Büttner, J. Czarske, V. Busskamp, “Tracking connectivity maps in human stem cell–derived neuronal networks by holographic optogenetics”, Life Science Alliance, 5(7): e202101268, 2022

O. Pätzold, K. Dadzis, C. Kirmse, D. Weik, L. Büttner, J. Czarske, A. Charitos, „Model experiments for melt flow in Czochralski growth of silicon”, Journal of Crystal Growth 588 (2022)

D. Weik, L. Grüter, D. Räbiger, S. Singh, T. Vogt, S. Eckert, J. Czarske, L. Büttner, „Ultrasound Localization Microscopy in Liquid Metal Flows”, Applied Sciences 12.9, 4517 (2022).

B Krug, N Koukourakis, J Guck, J Czarske, „Nonlinear microscopy using impulsive stimulated Brillouin scattering for high-speed elastography,“ Optics Express **30** (4), 4748-4758 (2022).

J. Sun, J. Wu, N. Koukourakis, L. Cao, R. Kuschmierz, J. Czarske, „Real-time complex light field generation through a multi-core fiber with deep learning”, Scientific Reports, volume 12, 7732 (2022)

Q. Zhang, S. Rothe, N. Koukourakis, J. Czarske, "Learning the matrix of few-mode fibers for high-fidelity spatial mode transmission", APL Photonics, 2022

C. Bilsing, H. Radner, S. Burgmann, J. Czarske, L. Büttner, “3D Imaging with Double-Helix Point Spread Function and Dynamic Aberration Correction Using a Deformable Mirror”, Optics and Lasers in Engineering 154, 107044 (2022)

J. Sun, J. Wu, S. Wu, R. Goswami, S. Girardo, J. Guck, L. Cao, N. Koukourakis, J. Czarske, “Quantitative phase imaging through an ultra-thin lensless fiber endoscope”, Light: Science and Applications of Nature Publishing (2022)

N Koukourakis, F Wagner, S Rothe, MO Karl, JW Czarske, “Investigation of human organoid retina with digital holographic transmission matrix measurements,” Light: Advanced Manufacturing 3 (1), 1-15, (2022)

J. Dremel, E. Scharf, R. Kuschmierz and J. Czarske. "Minimal invasive fiber optical endomicroscopy for the medicine - Minimal-invasive faseroptische Endomikroskopie für die Medizin" tm - Technisches Messen - Proceedings, vol. 89, no. s1, 2022, pp. 25-30. https://doi.org/10.1515/teme-2022-0068

R. Habibey, J. Striebel, F. Schmieder, J. Czarske, V. Busskamp, ”Long-term morphological and functional dynamics of human stem cell-derived neuronal networks on high-density micro-electrode arrays”, Frontiers in Neuroscience 16, (2022).

S. Heckel, C. Bilsing, M. Wittmann, T. Gemming, L. Büttner, J. W. Czarske, J. Simmchen, “Beyond Janus Geometry: Characterization of Flow Fields around Nonspherical Photocatalytic Microswimmers”, Advanced Science, 9, 2105009 (2022)

Dennis Pohle, Stefan Rothe, Nektarios Koukourakis, Juergen W Czarske, "Surveillance of few-mode fiber-communication channels with a single hidden layer neural network", Optics Letters, Vol. 47 No. 3 (2022)

F. Bürkle, M. Förste, K. Dadzis, I. Tsiapkinis, O. Pätzold, A. Charitos, M. Dues, J. Czarske, L. Büttner, “Application of optical velocity measurements including a novel calibration technique for micron-resolution to investigate the gas flow in a model experiment for crystal growth”, Flow Measurement and Instrumentation, 102258, 2022

J. Wu, T. Wang, O. Uckermann, R. Galli, G. Schackert, L. Cao, J. Czarske, and R. Kuschmierz, "Learned end-to-end high-resolution lensless fiber imaging towards real-time cancer diagnosis," Sci Rep 12(1), 18846 (2022).

H. Emmerich, L. Knüpfer, S. Heitkam, E. Starke, P. Trtik, L. Schaller, D. Weik, J. Czarske, “Ultrasound imaging of liquid fraction in foam”, IEEE Transactions on Instrumentation & Measurement, 2022

Invited talks at conferences (with proceedings)

J. Czarske, F. Schmieder, L. Buettner, “Real-Time Computational Holographic Optoelectronics Towards Paradigm-Shifting Biomedicine”, Summit on Semiconductors, Optoelectronics and Nanostructures, MARCH 23-25, 2022 (invited keynote plenary talk, United Arab Emirates-UAE), Dubai

R. Kuschmierz, J. Czarske, “Minimally invasive computational 3D lensless fiber endomicroscopy”, Quantitative Imaging for 3D Metrology; Optics and Photonics for Advanced Dimensional Metrology II, SPIE Photonics Europe, April 2022, Strasbourg (invited by Peter de Groot)

J. Czarske, N. Koukourakis, S. Rothe, F. Wagner, M. Karl, “Understanding neurodegeneration in human organoid retina with optical microscopy”, Advanced Microscopy and Imaging II; Biomedical Spectroscopy, Microscopy, and Imaging II; SPIE Photonics Europe, April 2022, Strasbourg (invited by Juergen Popp)

J. Czarske, R. Kuschmierz, “Lensless 3D fiber endoscopy using diffractive optical elements and deep learning”, SPIE Conference on Optical Technology and Measurement for Industrial
Applications 2022 OPTM 2022, Tokyo Institute of Technology, (invited by Takeshi Hatsuzawa, Rainer Tutsch, Toru Yoshizawa, Yukitoshi Otani), Yokohama, Japan, 21 April 2022

J. Czarske, R. Kuschmierz, “Lensless Fiber Endoscopy Exploiting Deep Learning and Diffractive Optical Elements”, 3D Image Acquisition and Display - Optica Imaging and Applied Optics Congress / Optica Optical Sensors and Sensing Congress, 11 – 15 July 2022, Vancouver, British Columbia, Canada (invited by Bahram Javidi)

J. Czarske, R. Kuschmierz, “Lensless Near-Field Imaging with Enhanced Deep Super-Resolution Towards Real-Time Intraoperative Tumor Classification”, Optica Imaging and Applied Optics Congress / Optica Optical Sensors and Sensing Congress, 11 – 15 July 2022, Vancouver, British Columbia, Canada (invited by Zeev Zalewski)

R. Kuschmierz, J. Czarske, “Lensless Computational Endoscopy Using Digital Holography and Deep Learning”, Optica Digital Holography and Three-Dimensional Imaging, 01-04. August 2022, Cambridge, UK (invited by Daping Chu, Jae-Hyeung Park, Chau-Jern Cheng & Pietro Ferraro)
Nektarios Koukourakis, J W Czarske, „Investigation of Human Organoid Retina with Digital Holographic Transmission Matrix Measurements”, Optica Digital Holography and Three-Dimensional Imaging, 01-04. August 2022, Cambridge, UK (invited by Daping Chu, Jae-Hyeung Park, Chau-Jern Cheng & Pietro Ferraro)

L. Büttner, J. Czarske, H. Radner, C. Bilsing, Z. Gao, “Closed-Loop and Neural Network Aberration Correction Schemes using Fresnel Guide Stars for Microfluidics”, 25th Congress of the International Commission for Optics (ICO) and the 16th International Conference on Optics Within Life Sciences (OWLS), TS 13-3-02, Dresden, 5.–9. Sept. 2022 (invited by the international TPC)

Nektarios Koukourakis, Juergen W Czarske, „Investigation of human organoid retina with digital holographic transmission matrix measurements”, 25th Congress of the International Commission for Optics (ICO) and the 16th International Conference on Optics Within Life Sciences (OWLS), TS 13-3-02, Dresden, 5.–9. Sept. 2022 (invited by the international TPC)

R. Kuschmierz, E. Scharf, J. Czarske “Fast 3D micro endoscopic imaging using wavefront shaping and self-calibration”, 25th Congress of the International Comission for Optics (ICO) & 16th International Conference of Optics Within Life Sciences, September 2022, Dresden, Germany (invited by the international TPC)

Elias Scharf, Jakob Dremel, David Gonzaléz, Robert Kuschmierz, Juergen W Czarske, “Fiber endoscope using 3D printed diffractive optical elements for minimally invasive sensing and actuation in biomedicine“, invited by Alois Herkommer (Stuttgart University), EOS Annual Meeting (EOSAM) 2022, Porto, Portugal, 12.-16. September 2022 (invited talk)

J Czarske, R Kuschmierz, “Deep learning and 3D printed optics for lensless fiber endoscopy in biomedicine“, Frontiers in Optics 2022 + Laser Science (FiO/LS) Conference of OPTICA, FiO1-Fabrication, Design and Instrumentation, Rochester, USA (Invited by Prof Yuzuru Takashima, University of Arizona), 17 October 2022

J W Czarske, R Kuschmierz, “Lensless Multicore Fiber Endoscopy towards NeuroPhotonics”, Conference on Complex Media NeuroPhotonics, Maximus Resort, Brno, Czech Republic, Invited by Tomáš Čižmár (IPHT Jena and University of Brno), 24.-26 Oct 2022

R. Kuschmierz, J. Czarske, ”Lensless endoscopes enabled by 2-photon lithography and deep neural networks”, International Conference on Optical and Photonic Engineering, icOPEN November 2022, Nanjing, China

J. Czarske, F. Schmieder, L. Buettner, “Digitale Holographie in der Optogenetik mit aus Stammzellen gewonnenen neuronalen Netzwerken - Digital holography in optogenetics with neural networks derived from stem cells“ 16. Dresdner Sensor-Symposium 5-7 Dec 2022 (invited by Gerald Gerlach and Andreas Schütze)

J W Czarske, R Kuschmierz, N Koukourakis, “Paradigm-shifts in neuroscience using lensless 3D fiber endoscopy, deep learning and organoids”, Oasis 8 - International Conference and Exhibition on Optics and Electro-Optics, "Optical Engineering", invited by Dr. Hanni Inbar, David Intercontinental Hotel, Tel Aviv, Israel, 12th - 13th December 2022.

Juergen W. Czarske, Jiachen Wu, Tijue Wang, Tom Glosemeyer, Julian Andreas Lich, Robert Kuschmierz, „Learning-based high-resolution lensless fiber microendoscopy”, Proc. SPIE. PC12204, Emerging Topics in Artificial Intelligence (ETAI) 2022, invited talk, SPIE Optics+Photonics, San Diego, United States, Aug. 2022 (invited by A. Ozcan, UCLA, USA, and Giovanni Volpe, University of Gothenburg, Sweden)

Invited talks (at seminars/workshops)

J. Czarske, S. Rothe, “Smart Multimode Fiber Communication using Deep Learning”, University College London-UCL, London, UK (invited by Filipe Marques Ferreira), virtual presentation, 11 April 2022

J. Czarske, S. Rothe “What Optics can do to improve the security, latency and versatility of data information”, DGaO Ringvorlesung-General Lecture especially for Students and Postdocs (invited by Andreas Heinrich), 13 April 2022

J. Czarske, R Kuschmierz, “Exploiting Deep Learning and Lensless Optics for Paradigm Shifts in Biomedicine”, DDc Lunch Retreat, 14 April 2022 (invited by Dresden concept, Dresden Excellence Clusters, Prof Rödel)

J. Czarske, R Kuschmierz, N Koukourakis, “Exploiting Deep Learning and Lensless Optics for Minimally Invasive Endoscopy and Nonlinear Brillouin Microscopy,” (invited by Prof Uwe Morgner), University of Hannover, Excellence Cluster - PhoenixD Plenarkolloquium, in-person-presentation, 2 Mai 2022

J. Czarske, R Kuschmierz, “Exploiting Deep Learning and Lensless Optics for Intraoperative Real-Time Diagnostics and Optogenetics”, Excellence Cluster - BrainLinks-BrainTools, Intelligent Machine-Brain Interfacing Technology, Albert-Ludwigs-Universität Freiburg, 19 May 2022 (invited by Prof Thomas Stieglitz)

J. Czarske, S. Rothe, “Physical Layer Security exploiting the Transmission Matrix of Multimode Fibers”, 23 May 2022, University College London, UCL, London, UK (invited by Polina Bayvel)

R. Kuschmierz, J Czarske, “Minimally invasive endoscopy”, 05 August 2022, University of Nottingham, UK (invited by George Gordon)

J W Czarske, R Kuschmierz, “Exploiting Deep Learning and Lensless Multi-core Fiber Endoscopy for Paradigm Shifts in Cancer Diagnostics”, IUSL/Optica Physics Colloquium, INSTITUTE FOR ULTRAFAST SPECTROSCOPY AND LASERS, City University New York, invited by the Optica Student Chapter of CCNY and R. Alfano, New York City, 20 October 2022

J W Czarske, R Kuschmierz, N Koukourakis, “Exploiting Deep Learning, Digital Holography, Lensless Fiber Endoscopy, and Stem-cell-derived Organoids for Paradigm Shifts in Biomedicine”, Columbia University New York, invited by the SPIE-Optica Student Chapter, 21 October 2022

J W Czarske, R Kuschmierz, L Buettner, N Koukourakis, „Neuartige optische Messtechniken für die Biomedizin-Novel optical metrology towards biomedicine“, University of Rostock, 2 November 2022

R Kuschmierz, „Linsenlose 3D-Endoskopie mit Sub-mm-Durchmesser für die Biophotonik
durch Korrektur der Übertragungsfunktion optischer Bildwellenleiter“, 648. VDE Elektrotechnisches Kolloquium, TU Dresden, 26 October 2022

Juergen W. Czarske, Jiachen Wu, Tijue Wang, Tom Glosemeyer, Julian Andreas Lich, Robert Kuschmierz, „Exploiting Deep Learning and Lensless Fiber Optics for Paradigm Shifts in Biomedicine and Communication”, UCLA, Workshop on Photonics and Deep Learning meets Biomedicine, Aug. 2022 (invited by A. Ozcan)

J. Dremel, S. Richter, T. Wang, G. Schackert, J. Czarske, W. Polanski, R. Kuschmierz, O. Uckermann, „BrainAce: In vivo label-free tumor classification“, EKFZ, InnoDays 2022 in Dresden, 23-24.09.2022

International conferences (reviewed)

R. Kuschmierz, J. Lich, T. Glosemeyer, E. Scharf, J. Czarske, "Minimally invasive 3D endoscopy using diffractive optical elements and deep learning", Endoscopic Microscopy XVII, SPIE BIOS, January 2022, San Francisco

W. Mantei, B. Stender, J. Wiedenmann, E. Scharf, R. Kuschmierz, J. Czarske, „Needle-shaped lensless holographic endoscopes realized with TPP“, Optical Fibers and Sensors for Medical Diagnostics, Treatment and Environmental Applications XXII, SPIE BIOS, January 2022, San Francisco

S. Rothe, K. Besser, N. Koukourakis, E. Jorswieck, J. Czarske, “Confidential optical data transmission through multimode fibres based on holographic transmission matrix measurements”, Advanced Methods: Digital Holography I; Unconventional Optical Imaging III, SPIE Photonics Europe, April 2022, Strasbourg

T. Glosemeyer, Y. Zheng, J. Lich, R. Kuschmierz, J. Czarske, „Multispectral image reconstruction with neural networks for minimally invasive 3D lensless fiber endoscopy using a diffuser”, Advanced Methods: Wavefront Sensing; Unconventional Optical Imaging III, SPIE Photonics Europe, April 2022, Strasbourg

E. Scharf, R. Kuschmierz, R. Stephan, M. Steinke, J. Czarske, „Needle-size fibre endoscope with 3D printed DOEs for minimally invasive procedures in biomedicine”, Advanced Microscopy and Imaging I, Biomedical Spectroscopy; Microscopy, and Imaging II; SPIE Photonics Europe, April 2022, Strasbourg

J. Gürtler, R. Kuschmierz, J. Czarske, „Minimally invasive lensless fiber endoscopy using distal holographic image formation for technical inspections and biomedicine”, Optical Micro- and Nanometrology; Optics and Photonics for Advanced Dimensional Metrology II; SPIE Photonics Europe, April 2022, Strasbourg

J. Wu, R. Kuschmierz, O. Uckermann, R. Galli, G. Schackert, L. Cao, J. Czarske, „Learning-based high-resolution lensless fiber bundle imaging for tumor”, Computing, Modelling, Design: AI for Biomed; Unconventional Optical Imaging III; SPIE Photonics Europe, April 2022, Strasbourg

Ilenia Meloni, Divya Sachidanandan, Andreas S. Thum, Robert J. Kittel, Jürgen Czarske, Michael Mertig, and Caroline Murawski, “Spatial light patterns using smartphone optogenetics for behavioral control of *Drosophila melanogaster* larvae”, 7th International Workshop on Technologies for Optogenetics and Neurophotonics - OPTOGEN2022, Paris, France, May 11-13, 2022

Z. Gao, P. Yang, C. Bilsing, J. Czarske, L. Büttner, “Distortion Correction in Particle Image Velocimetry for Measurements Through Fluctuating Interfaces using a Deep Neural Network and Wavefront Sensing”, 20th International Symposium on Applications of Laser and Imaging Techniques to Fluid Mechanics, contribution #39, 11–14 July 2022, Lisbon/Portugal

S. Pasch, R. Leister, M. Egner, L. Büttner, J. Czarske, J. Kriegseis, “Comparative accuracy study of LDV profile-sensor acquisition modes and particle diameters”, 20th International Symposium on Applications of Laser and Imaging Techniques to Fluid Mechanics, contribution #113, 11–14 July 2022, Lisbon/Portugal

C. Bilsing, H. Radner, L. Büttner, J. Czarske, “Particle Tracking Velocimetry with Dynamic Aberration Correction for 3D Flow Measurements Through Fluctuating Phase Boundaries”, 20th International Symposium on Applications of Laser and Imaging Techniques to Fluid Mechanics, 11–14 July 2022, Lisbon/Portugal

F. Schmieder, R. Habibey, V. Busskamp, J.W. Czarske, L. Büttner, “Adaptive Holographic Optogenetic Illumination for Human Neural Network Analysis”, OPTICA Digital Holography and Three-Dimensional Imaging, W4A.7, 01.–04.08.2022, Cambridge/UK

J. Sun, N. Koukourakis and J. W. Czarske, “3D cell-rotation using multi-core fiber-based lab-on-a-chip for optical tomography”, Optical Trapping and Optical Micromanipulation XIX, SPIE Optics+Photonics, San Diego, United States, Aug. 2022

C.Bilsing, H. Radner, L. Buettner, JW Czarske, ”Dynamic aberration correction using a deformable mirror and double-helix point spread function for flow metrology”, Unconventional Imaging and Adaptive Optics 2022 – SPIE, SPIE Optics+Photonics, San Diego, United States, Aug. 2022

Z. Gao, H. Radner, L. Büttner, C. Bilsing, P. Yang, J. Czarske, “Aberration Correction for Imaging Metrology Using Deep Convolutional Neural Networks”, 25th Congress of the International Commission for Optics (ICO) and the 16th International Conference on Optics Within Life Sciences (OWLS), poster PO-23, Dresden, 5.–9. Sept. 2022

F. Schmieder, R. Habibey, V. Busskamp, L. Büttner, J. Czarske, „Investigation of human neuronal networks using holographic stimulation system with high spatiotemporal resolution”, the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

K. Schmidt, W.Wang, N.Koukourakis, H.B. Gowda, M.C. Wapler, U. Wallrabe, J.W. Czarske “All-Adaptive Smart Microscopy using Machine Learning” the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

Q. Zhang, S. Rothe, N. Koukourakis, J. W. Czarske, “High Fidelity Mode Transmission via Few-mode Fiber using Deep Learning”, the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

H.B. Gowda, M.C. Wapler, K. Schmidt, N. Koukourakis, J.W. Czarske, U.Wallrabe „High-Speed Tunable Aspherical Achromatic Lens“ the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

J. Sun, N. Koukourakis and J. Czarske, “Multi-Dimensional Cell Rotation with Multi-Core Fibers and Wavefront Shaping”, the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

D. Pohle, S. Rothe, F. A. Barbosa, F. M. Ferreira, N.Koukourakis, J. Czarske, “Intelligent Self Calibration Tool for Adaptive Mode Multiplexers using Multiplane Light Conversion”, 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

T. Wang, J. Wu, O. Uckermann, R. Galli, J. Czarske, R. Kuschmierz, “Single-shot high-resolution lensless fiber bundle imaging using deep learning for neurosurgery”, the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

S. Rothe, K.-L. Besser, N. Koukourakis, E. Jorswieck, J. Czarske, “Physical layer security for confidential data transmission through multimode fibres”, the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

W. Wang, F. Lemke, U. Wallrabe, M. Wappler, J. Czarske, and N. Koukourakis, "3D scanning microscopy for zebrafish imaging using adaptive prisms and lenses", the 25th Congress of the International Commission for Optics (ICO), Dresden, Germany, Sep. 2022

J. Lich, T. Glosemeyer, R. Kuschmierz, J. Czarske, „Diffusor Endoscope using Neural Networks for 3D-Single-Shot-Image Reconstruction“, EOS Annual Meeting (EOSAM) 2022, Porto, Portugal, 12.-16. September 2022

D. Weik, L. Grüter, D. Räbiger, S. Singh, T. Vogt, S. Eckert, J. Czarske, "Ultrasound Localization Microscopy by Nonlinear Adaptive Beamforming – a Case Study for Super-Resolved Flow Fields in Liquid Metal Experiments", 2022 IEEE International Ultrasonics Symposium (IUS), Venice, Italy, Oct. 2022.

Z. Dou, L. Grüter, D. Weik, J. Czarske, "Ultrasound Tracking of Gas Bubbles Through a Multi-Mode Waveguide in Hot Melts", 2022 IEEE International Ultrasonics Symposium (IUS), Venice, Italy, Oct. 2022.

J. Zhang, J. Sun, N. Koukourakis and J. Czarske, “Lensless microendoscope: ultra-thin nanoscale surface imaging probe”, icOPEN 2022, Nanjing, China, Nov. 2022

J. Sun, N. Koukourakis and J. W. Czarske, “Real-time quantitative phase imaging through a multicore fiber using deep learning”, SPIE Photonics Asia, Nov. 2022

T. Wang, J. Dremel, J. Wu, O. Uckermann, R. Galli, G. Schackert, J. Czarske, R. Kuschmierz, “High-resolution imaging with multi-core fibers and deep neural networks (DNNs) for cancer diagnostics”, Complex Media NeuroPhotonics (CMNP) workshop, poster, Brno, 24.–27. Oct. 2022

National conferences (reviewed) and Talks (at seminars/workshops)

H. Emmerich, L. Knüpfer, P. Trtik, K. Eckert, S. Heitkam, D. Weik, L. Büttner, J. Czarske, “Planar mapping of the liquid fraction of froth using a 1.5 D ultrasound array”, Sensoren und Messsysteme 2022, 21. ITG / GMA – Fachtagung, 10.-11. Mai 2022

J. Dremel, E. Scharf, J. Czarske, R. Kuschmierz, „Linsenlose Real-Time-Faserbündel-Endoskopie mittels digitaler optischer Phasenkompensation für die Biomedizin“, 123. Jahrestagung der DGaO in Pforzheim, 7. - 11. Juni 2022

K.Schmidt, H. B. Gowda, U. Wallrabe, J.W. Czarske, N. Koukourakis „Adaptiver Achromat zur Korrektur chromatischer Aberrationen“ 123. Jahrestagung der DGaO in Pforzheim, 7. - 11. Juni 2022

D. Pohle, S. Rothe, N.Koukourakis, J. Czarske, “Surveillance of Multimode Fiber Network using Deep Learning”, 123. Jahrestagung der DGaO in Pforzheim, 7. - 11. Juni 2022

L. Grüter, D. Weik, J. Czarske, "Ultraschall-Tracking von Gasblasen durch einen Multimode-Wellenleiter in heißen Schmelzen", Workshop Messtechnische Anwendungen von Ultraschall, Ilsenburg, July 2022.

F. Bürkle, G. Lecrivain, R. Maestri, U. Hampel, J. Czarske, L. Büttner, „Untersuchung der Innenströmung einer Taylorblase mit einem neuartigen PIV-System mit deformierbarem Spiegel“, Beitrag 5, Ilmenau, 6.–8.09.2022

C. Bilsing, L. Büttner, J. Czarske, U. Janoske, S. Burgmann, „3D-PTV-Messung in einem oszillierenden Tropfen mittels Doppelhelix-Punktspreizfunktion“, Beitrag 8, Ilmenau, 6.–8. Sept. 2022

E. Scharf, R. Kuschmierz, J. Czarske, „Nadelförmiges linsenloses holografisches Endoskop - HoloScope“, DGaO Summer School in Aalen, 12.-16. Sept. 2022

J. Dremel, E. Scharf, T. Wang, R. Kuschmierz, J. Czarske, „Minimal-invasive faseroptische Endomikroskopie für die Medizin“, XXXVI. Messtechnisches Symposium des AHMT in Magdeburg, 28. -29. Sept. 2022

E. Scharf, R. Kuschmierz, R. Stephan, M. Steinke, D. Ristau, J. Czarske, „Holoscope - Nadelförmiges linsenloses holografisches Endoskop“, F.O.M.-Konferenz in Berlin, 8.-9. Nov.2022

L. Grüter, C. Bilsing, H. Radner, D. Weik, J Czarske, “PtvPy 0.10.2 - A free and open-source command line tool and Python library for particle tracking velocimetry”, Version 0.10.2, 2022. doi: 10.5281/zenodo.6389891.

Workshops (without review)

F. Schmieder, L. Büttner, J. Czarske, “Optogenetics Research with Human Stell Cell-Derived Cardiomyocytes and Neural Networks”, Poster, Excellence Cluster Physics of Life Christmas Symposium, 15.12.2022

J. Sun, R. Kuschmierz, N. Koukourakis and J. W. Czarske, “Optical computational tomography of single cells using fiber-optic cell rotation”, Poster, Excellence Cluster Physics of Life Christmas Symposium, 15.12.2022

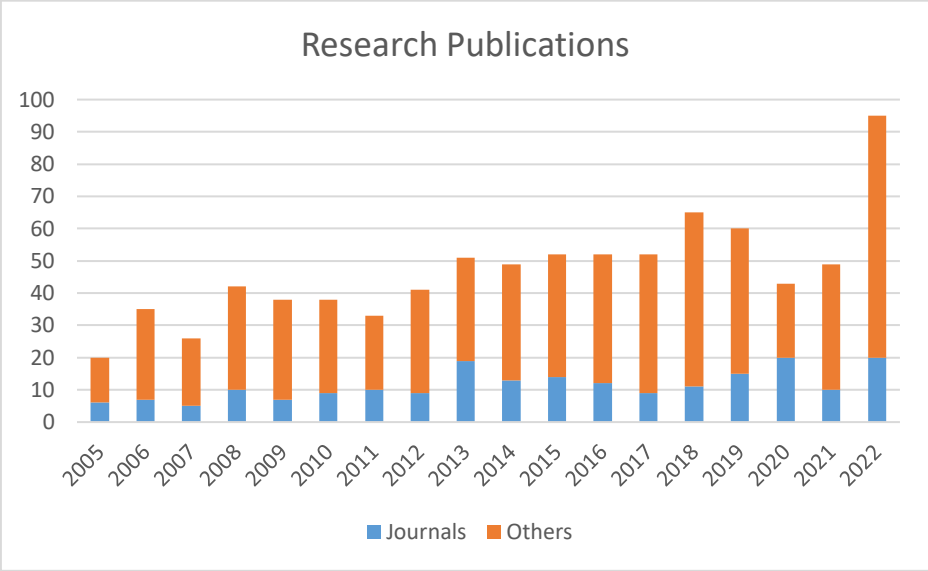
R Kuschmierz,…., J. Czarske, “Endoscopic 3D systems for analysis and manipulation”, Poster, Excellence Cluster Physics of Life Christmas Symposium, 15.12.2022

Patents and Patent Applications

U. Teicher, A. B. Achour, S. Ihlenfeldt, D. Weik, L. Büttner, R. Nauber, J. Czarske, T. Schröder, G. Lauer, „Ultraschallsystem und Verfahren zum Erstellen eines Ultraschallbildes“, German Patent Application DE10 2022 106 875, 2022.

Book Chapters and Books

J. Gürtler, 3D-Bildgebung mittels kamerabasierter Hochgeschwindigkeitsvelozimetrie und -interferometrie unter Nutzung tomografischer Rekonstruktion mit neuronalen Netzen - 3D imaging using camera-based high-speed velocimetry and interferometry using tomographic reconstruction with neural networks, Dissertation, Shaker-Verlag, Dresdner Berichte zur Messsystemtechnik Nr. 17, Aachen, 2021



ACTIVITIES

Prof. Czarske:

Program committees include (TPC, technical program committee):
TPC of OPTO / Sensor Conferences (AMA), Nürnberg
TPC of ITG / GMA-Fachtagung „Sensoren und Messsysteme“, Nürnberg
IMEKO Symp. Laser Metr. For Precision Meas. And Inspection in Industry
SPIE Photonics Europe, Photonics, Optics, Lasers, Micro- and Nanotechn., Optical Micro- and Nanometrology, Unconventional Imaging; Strasbourg, France
SPIE Photonics West, San Francisco
Conference of DGaO, Deutsche Gesellschaft für angewandte Optik e.V.
OSA conference on Optical Sensors, Barcelona, Spain
International Symposium on Optomechatronic Technologies, Seattle, USA
SPIE Opt. Meas. Syst. For Industr. Inspection,
icOPEN, Singapore,
European Optical Society Conferences
Organization of a conference in Dresden on all stages (financial issues, management with the agencies, advertisement for the congress, invitations with quality check points, generation of the program, orga for the venue, etc.): World Congress of Optics and Photonics of International Commission for Optics (ICO) and Optics Within Life Sciences (OWLS), Theme: Advancing Society with Light, ICO-25-OWLS-16-Dresden-Germany-5-9-Sep-2022, www.ico25.org
Co-chair of DIGITAL optical technologies, Munich, SPIE

Memberships include:
Fellow of International Society of Optical Engineering (SPIE), Washington USA
Fellow of European Optical Society (EOS), Finland
Fellow of Optical Society of America (OSA/Optica), DC USA
Fellow of IET (former IEE), London, UK
Fellow of IoP, London, UK
Society for Imaging Science and Technology, London
Member of Arbeitskreis der Hochschullehrer für Messtechnik eV. (AHMT);
Senior Member of IEEE;
Forschungsgesellschaft f. Messtechnik, Sensorik u. Medizintechnik e. V. (fms);
Member of Dechema
Board of Trustees of GALA (German Association of Laser Anemometry);
German Physical Society (DPG);
Verband der Elektrotechnik, Elektronik und Informationstechnik (VDE);
Board of German Society of Applied Optics (DGaO);
Fraunhofer IPMS: Curator
Member of Fraunhofer Society
Member of Excellence Cluster Physics of Life-PoL
Member of EKFZ for Digital Health
Elected Member of SAW – Saxon Academy of Sciences
Elected Vice President of ICO – International Commission for Optics, Paris, France and Miami, USA

Service as Reviewer - Granting Agencies (partial list)
German Research Foundation (DFG: Individual Grants Programs, Priority Programs, Research Training Groups, Collaborative Research Centers, Core Facilities, Research Units, etc.), BMBF, AIF, The Nether-lands Organization for Scientific Research (NWO), Israel Science Foundation (ISF), King Faisal Foundation Saudi Arabia, National Science Foundation US

Service as Consultant and Advisor includes

Member Program Committee Sensor and Measurement Systems; Member Review Board System Engineering DFG (2012-2020); Member of review committee at Nanyang Technological University Singapore

Review of journal contributions (peer-review):
“Measurement Science and Technology”, “Applied Optics”, „Opt. Engineering“, „Pure Opt.“, „Opt. Letters”, “Opt. Express”, “Opt. Communications”, “Experiments in Fluids”, “Journal of Physics D: Applied Physics”, “Optics and Lasers in Engineering”, “Review of Scientific Instruments”, “Mechanical Systems and Signal Processing”, “Journal of the Optical Society of America A”, “IEEE Transactions on Instrumentation & Measurement”, „Flow Measurement and Instrumentation“, etc.

Member of the Editorial Board:
tm - Technisches Messen, Open Journal of Fluid Dynamics, Journal of the European Optical Society - Rapid publications, LAM of Nature Publishing, Applied Sciences, Photonics, etc.

“Akademische Selbstverwaltung” of TUD:
Member of the Senate, the Faculty Council, the PhD committee and the Study committee of the Faculty of Electrical Engineering and Information Technology, etc.

Co-opted Professor for Physics

Group Leaders

Dr. Lars Büttner:

- Studied Physics at Clausthal University of Technology, received a Ph.D. degree at Leibniz University Hanover
- Member of the German Association for Laser Anemometry – GALA e. V., the German Physical Society – DPG e.V., OPTICA (formerly OSA – The Optical Society)
- Supporting an MST key topic on computational metrology, especially the translation research in cooperation with renewable energy systems and magnetohydrodynamics.
- Reviewer activities include journals (Flow Measurement and Instrumentation, Optics and Lasers in Engineering, Optics and Laser Technology) and project proposals
- Co-Recipient of the 2008 Berthold Leibinger Innovation Award (3. Prize)
- Guest Editor of mdpi Appl. Sci. 2022 Special Issue "Computational Ultrasound Imaging and Applications"

Dr. Nektarios Koukourakis:

- Member of OPTICA (formerly OSA – The Optical Society), SPIE, DGaO, German Physical Society (DPG)
- Supporting an MST key topic on computational adaptive microscopy, translation research in cooperation with biomedical engineering, nanotechnology and microsystem engineering.
- Guest Editor of the journal Applied Sciences.
- Reviewer activities include journals such as Optics Express, Optics Letters, Applied Optics, Applied Physics Letters, Applied Physics B, Optics Communications
- Awarded by the OSA, Florida, USA
- Several invited talks

Dr. Robert Kuschmierz:

- Studied Mechatronics and received his Ph.D. in electrical engineering at TU Dresden
- Member of the German Physical Society (DPG), The Association of German Engineers (VDI), SPIE & OPTICA
- Current research interests include interferometry, holography and wavefront shaping for measurements at rotating machinery, sound-flow interaction, flame characterization and for lensless endoscopy
- Guest Editor of the journal Applied Sciences.
- Reviewer activities include Optics Express, Light: advanced manufacturing, Nature Communications, LSA
- Received awards for his Ph.D. thesis on *interferometric in-process metrology* by company SICK and Siegfried Werth Foundation and supervised multiple award-winning students in the field of computational endoscopy

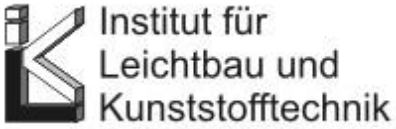
Dipl.-Ing. David Weik

- Studied electrical engineering at the TU Dresden and former staff member of the biomedical engineering group at the Fraunhofer Institute for Machine Tools and Forming Technology
- Member of IEEE Ultrasonics, Ferroelectrics and Frequency Control Society (UFFC)
- Current research interests include adaptive ultrasonic imaging for opaque fluids, aberration correction and super-resolution imaging in technology and biomedical engineering
- Cooperation partner of the Sick Engineering GmbH, the Helmholtz-Zentrum Dresden-Rossendorf and the hydrogen and fuel cell center ZBT GmbH

Dipl.-Ing. Stefan Rothe

- Studied electrical engineering at the TU Dresden
- Member of Optica, SPIE, etc
- Current research interests include physical layer security and quantum technology of the second generation of fewmode and multimode fibers, measurement-driven advances for optical data communication
- Awarded several times, e.g. by Gisela and Erwin Sick Foundation, Friends of Faculty Computer and Electrical Engineering of TUD, Best Paper Award of World General Congress ICO-25-OWLS-16-2022
- Lecturing on Deep Neural Networks (Virtual Labor for Students) and Measurement Technique (Excercises)

PARTNERS (SELECTION)

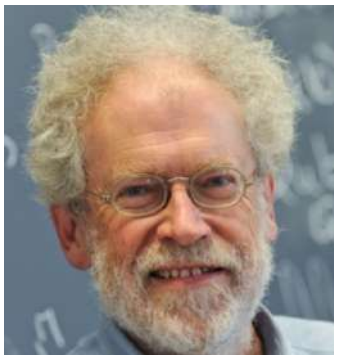


NEWSLETTER

COMMISSION INTERNATIONALE D'OPTIQUE · INTERNATIONAL COMMISSION FOR OPTICS

Nobel Prize for Entangled Photons

ICO celebrates 2022 Nobel Prize in Physics awarded for ground-breaking experiments in quantum optics



John Clauser (top) Alain Aspect (center) and Anton Zeilinger (bottom) received one-third each of the Nobel Prize in Physics 2022 for their experiments with entangled photons.

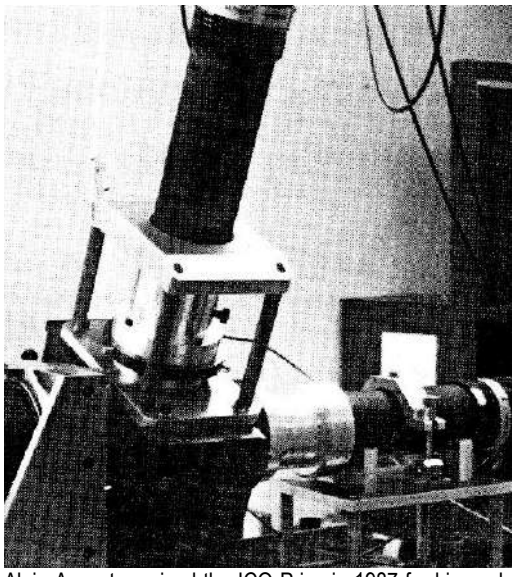
The Nobel Prize in Physics 2022 has been awarded to scientists belonging to the Optics and Photonics community "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science".

John Clauser, Alain Aspect (ICO award in 1987) and Anton Zeilinger, received one-third of the Prize each "*for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science*". The achievements provided an experimental answer to the so-called EPR paradox which had been proposed in the 30's by Albert Einstein (E), Boris Podolsky (P), and Nathan Rosen (R), who tried to prove that quantum mechanics was incomplete by envisioning an experiment in which a pair of particles in an initially entangled quantum state are then separated to an arbitrarily large distance. EPR argued that the particles exhibited correlations that would violate their understanding of locality because they would yield nonlocally conditional violations of the Heisenberg uncertainty principle. They therefore concluded that quantum mechanics, in its then-current form, must be incomplete. As time progressed, it was argued that the incompleteness must be a result of "hidden variables" unavailable to the observer.

John Stewart Bell deduced that, if measurements are performed independently on the two separated particles of an entangled pair and there is a dependence upon hidden variables within each half of the outcomes, their correlations must be mathematically constrained. This constraint would later be named the Bell inequality. He then showed that quantum physics predicts correlations that violate this inequality.

John Clauser (US) in collaboration with Horne, Shimony and Holt, developed an experimentally friendly version of Bell's inequalities[1]. Clauser and Freedman then demonstrated the first experimental violation of Bell's inequalities[2]. It is hard to overstate the importance of Clauser's work and heroism in going against the sentiments of the time.

Alain Aspect (France) addressed an important loop-hole in Bell's inequality experiments.



Alain Aspect received the ICO Prize in 1987 for his work on the confirmation by optical means of the violation of Bell's inequalities using the polarizers setup shown above.

Essentially, the analyzer settings were static in previous experiments. Perhaps, nature would conspire to yield the observed correlations based on knowing the slower-than-light settings of the analyzers. Aspect chose to switch the settings of the analyzers in a time fast compared to the transit time of the photons. He showed that Bell's inequalities still held. The important impact of his work[3] was quickly understood within the community. He was awarded the ICO Prize in 1987.

Anton Zeilinger (Austria) made a plethora of important impacts in the field of quantum informa-tion using entangled photons. The most famous of these is quantum teleportation [4] in which a quantum state is destroyed at one location and recreated in another.

[1] Physical Review Letters 23 (15), 880 (1969)
[2] Physical Review Letters 28 (14), 938 (1972)
[3] Physical Review Letters 49 (25), 1804 (1982)
[4] Nature 390 (6660), 575-579 (1997)

John Howell
President of the ICO

ICO25/OWLS16 took place in Dresden, Germany

It was a great honor for the ICO territorial committee of Germany to have hosted the General Congress in its country after 30+ years again

Nobel Laurate Gérard Mourou (left) with the General Chairman of the congress, Prof. Jürgen Czarske (right).

Among the topics offered in the congress were: · Optical Engineering & Design · Material Processing & Lithography · Display and Vision · Optical MEMS and Micro-Optics · Optical Sensing and Measurement · Computational Metrology · Optical Information Processing · Quantum and Nonlinear Optics · Ultrafast Optics & High Power Lasers · X-Ray and High-Energy Optics · Plasmonics and Metamaterials · Nanophotonics & Nanosensing · Fiber Optics & Communications · Terahertz and Silicon Photonics · Microscopy, Biomedical Spectroscopy · Biomechanics & Optical Elastography · Biomedical Optics · Nanobiophotonics & Optogenetics · Optics for Infectious Diseases

The General Congress for optics and photonics ICO-25-OWLS-16 of the International Commission for Optics (ICO) and the international society for Optics Within Life Sciences (OWLS) was in-person celebrated 5-9 September 2022 at the TU Dresden, Dresden, Germany. The General Congress was sponsored by the ICO, OWLS, and TU Dresden. We gratefully acknowledge the financial co-sponsoring by the DGaO - The German Branch of EOS, Carl Zeiss AG, OPTICA (The society advancing optics and photonic worldwide, formerly OSA), SPIE (The International Society for Optics and Photonics - Connect Minds and Advance Light), Photonics Society of IEEE (Institute of Electrical and Electronics Engineers), IUPAP (The International Union of Pure and Applied Physics) and the City of Dresden. The EOS (European Optical Society), LAM (African Laser, Atomic and Molecular Physics Network), and RIAO (The Iberian American Network on Optics) have technically co-sponsored the General Congress.

The main theme was "**Advancing Society with Light**", emphasizing the importance of modern light technology for society. Light has the potential to recognize the origins of diseases to prevent them, or to cure them early and gently. This is one of the central topics of OWLS, which was founded at the ICO-15 Congress in Garmisch-Partenkirchen in 1990. Therefore, a special commemorative event of the 30+ years anniversary of the foundation of OWLS in Germany was organized. For the first time in the history of ICO, a joint General Congress was celebrated together with OWLS.

The General Congress is the most important scientific and technical meeting on all important topics of optics and photonics around the entire world. The General Congress presented insights into the almost limitless variety of application potentials of light technology, emphasizing crucial innovations such as optical networks for the internet, optical information technologies for advanced artificial intelligence, secure data transmission with quantum key distribution and the quantum computer. Great potential to solving issues on the environment and global energy were highlighted. Perspectives for the disposal of nuclear waste and space debris are opened up, techniques for monitoring air quality and water including detection of microplastics and energy-saving lighting by OLEDs were presented. Novel methods providing advanced tools for biomedicine were emphasized, such as optogenetics, Brillouin elastography, advanced smart microscopy as well as the transfer of modern laser and deep learning techniques to clinics. In addition, breakthroughs in fundamental science were presented at the congress, such as laser interferometers for the measurement of gravitation waves, galactic archeology of exoplanets and deformable mirrors for adaptive telescopes.

Memorable in-person talks by **three Nobel Laurates** were presented: Gérard Mourou, 2018 Nobel Laureate in Physics, inspired the audience with the plenary talk "Extreme Light for the Benefit of Science and Society". Sensational perspectives were outlined on the particle production in empty space to acquire an understanding how the mass of elementary particles is defined. Furthermore, the transfer to medicine was highlighted. An exciting plenary talk, titled "Optical Microscopy: The Resolution Revolution" was presented by Stefan W. Hell, winner of the 2014 Nobel Prize in Chemistry. Optical microscopy has attained single-digit nanometer imaging resolution in the far-field, enabling molecule motion tracking in vivo to elucidate the secrets of life. The 2020 Nobel Prize laureate in Physics, Reinhard Genzel, delivered the fantastic plenary talk, titled "A 40-Years Journey". The existence of mass singularity at the center our Milky Way with four million solar mass objects was observed beyond any reasonable doubt, which could only be achieved through the disruptive advances of optical telescopes using adaptive optics and fiber interferometers. In addition to the 3 Nobel Prize winners, two other outstanding plenary lectures were presented and discussed.

Dresden attracted well-known scientists.

Nobel Laureate Reinhard Genzel gave a talk about his personal 40-year journey to discover black holes.

In order to foster students, OPTICA-SPIE prizes were awarded. 17 best student papers prizes with a donation of 300 Euro each were supported by OPTICA, SPIE and TU Dresden. They were presented by Michal Lipson, President Elect of OPTICA and Kent Rochford, CEO of SPIE. The DGaO awarded 3 prizes for the best posters during the closing session of the General Congress. Furthermore, the OPTICA-SPIE student chapter Dresden has invited for an evening seminar.

Nobel Laureate and ICO Prize winner 2000 Stephan Hell, talked about optical microscopy frontiers.

Well-known researchers have presented excellent invited talks such as Alexander Gaeta, Jannick Rolland, Alan E. Willner, Jun Ye, Malgorzata Kujawinska, Pietro Ferraro, Karl Leo, Polina Bayvel, Aydogan Ozcan, Bahram Javidi, Tobias Kippenberg, Yongkeun Park, Allard Mosk, Elizabeth Hillman, Christoph Zaczek, Heidi Ottevaere, Chris Xu, Martin Booth, Cather Simpson, Juergen Popp, Pablo Artal, Caroline Murawski, Guohai Situ, Malte C. Gather, Elaine Wong, Michael Kempe, Wilhelm G. Kaenders, Sudipta Maiti, Adrian Podoleanu, Clara Saraceno, Georg Barbastathis, Colin J. R. Sheppard, Frederique Vanholsbeeck, Eugene Serabyn, Olav Solgaard, Lucia Kleint, Andrew G. White, Cornelia Denz, Jeffrey Kuhn, Michèle Heurs, Ori Katz, Yuzuru Takashima, Maria Vinas-Pena, Jörg-Peter Elbers, Monika Ritsch-Marte, Markus Graefe, Gerd Leuchs, Mona Jarrahi, Jun Tanida, Dana Cialla-May, Kai Wicker, Miguel A. Alonso, Jan Huisken, Kaoru Minoshima, Michel Meunier, Francesca Palombo, Michael Totzeck, Demetri Psaltis, and many others.

Michal Lipson spoke about „The Revolution of Silicon Photonics“, highlighting novel applications ranging from remote sensing to ultrahigh-bandwidth communications, which is crucial for advancing the internet. Karsten Danzmann presented a sensational talk, titled "Gravitational Wave Astronomy: Listening to the sounds of the dark universe!". Perspectives on understanding dark matter and hearing the Big Bang by laser interferometers on earth and in space were discussed. The General Congress planned to support expenses to the presenters or Bureau members from developing countries. Over 25 scholarships were granted based on the available budget of ICO, OWLS, OPTICA, SPIE, IEEE Photonics Society, and IUPAP. Elizabeth Rogan, CEO of OPTICA, spoke about the important topic “Diversity as a strategic driver”. Great efforts have been made to increase the number of female speakers with extraordinary commitment of the international Technical Program Committee (TPC), especially by Wolfgang Osten. The 5 awards for outstanding scientist were special highlights of the General Congress. Nobel laureates have handled the medals to the honored scientists.

Two ICO Prizes were presented to Francesca Calegari with the topic “Attosecond technology for the real-time tracking of electron dynamics in molecules” and Andrea Alu with the topic “Extreme Light-Matter Interactions in Polaritonic Metasurfaces”. Two IUPAP Young Scientist Prizes were awarded to Na Liu with the topic “Controlled multi-motion in high-order plasmonic architectures” and Can Bayram with the topic “Cubic-phase III-nitrides for Next Generation Quantum Devices”. The Galileo Galilei Medal was presented to Alexander I. Nosich, Laboratory of Micro and Nano Optics, Kharkiv, Ukraine, with the topic “Microcavity lasers and plasmonic nanolasers on threshold”. His outstanding contributions were achieved in unfavorable circumstances of Ukraine. His awarding at the General Congress was a special moment.

Immediately after the ICO-24 in 2017, the preparations for the General Congress already took place, but had to be stopped in 2020 due to the Covid-19 pandemic. The General Congress was postponed to 2021, but could not be held again. Fortunately, due a wise decision by ICO, no switch to digital presentation happens. However, there were **extraordinary circumstances** for the in-person General Congress by the war in Europe, shortcomings with flights and travel restrictions, supply chain limitations, etc. Most hurdles were taken together with the commitment of the worldwide network of sponsors and co-sponsors, the TPC especially the program chairs Wolfgang Osten and Alexander Heisterkamp, the fundraising chair Michael Pfeffer, adviser Bernd Kleemann and the unbelievable commitment of the local team, especially of Nektarios Koukourakis and Lars Buettner. The worldwide General Congress was celebrated with 5A (Africa, Asia, Australia, America and Amazing Europe). The total number of participants in ICO-25-OWLS-16 was around 400. For many participants it was the first face-to-face congress in two years.

The ICO as the umbrella organization with 54 territorial members and 7 scientific organizations has celebrated in Dresden the 75-years anniversary. The city hall of Dresden invited for a reception on Sunday, 4th September. The first mayor Detlef Sittel welcomed the international participants from 5A and highlighted science, industry and art in the capital of Saxony. On Monday, 5th September the General Congress was opened. The outstanding engagement of Frank Hoeller, Associate Secretary of ICO from 2017 to 2021, for the General Congress was highlighted. The ICO mourns his passing and the participants thought with a moment of silence. To commemorate of Frank Höller, the DGaO exhibited a poster.

John Howell, President of ICO, welcomed the participants and outlined the 75 years anniversary of the ICO, which was founded 2 years after second world war.

Top-quality contributions were presented from 55 countries of all continents

The 60+ years anniversary of LASER and 30+ years anniversary of OWLS were celebrated. The participants of the welcome reception enjoyed a fantastic organ concert in the Church of our Lady (Frauenkirche). A speech highlighted the unique construction, destruction and reconstruction of the Frauenkirche. On Tuesday, OPTICA organized a dinner. On Wednesday, the Rector of the TU Dresden, Ursula Staudinger has given a welcome address. The entire lecturing building could be used exclusively for the General Congress. We acknowledge this crucial support of TU Dresden. At the banquet in the Pulverturm, a historic (gun) powder tower, the exciting history of Dresden was lively demonstrated by jugglers with costumes of August the Strong and Countess Cosel. A guided tour around the Frauenkirche was a further highlight. The General Assembly (GA) debated and approved the strategic plans of ICO. Gilles Pauliat presented at the GA and the closing session the preparations for the next general congress ICO-26 in Dakar, Senegal. Humberto Michinel highlighted at the closing session that ICO became Category 1 Member of the International Science Council (ISC).

To conclude, we are pleased to have successfully celebrated the General Congress ICO-25-OWLS-16 in Dresden, thanks to the strong support by the ICO Bureau members and territorial committee, as well as international societies. It was the first postponed congress of ICO and the first merged congress of ICO and OWLS. We believe that ICO-25-OWLS-16 has become one of the most prestigious General Congresses in the whole history of the ICO with Three Nobel Laureates, well-known fantastic invited speakers and the highest quality of talks, posters, exhibition and discussions. Many invited speakers have won ICO Prizes before, such as the Nobel Laureate Stefan Hell. We express **our acknowledgements** to all committee members who contributed to the organization, the preparation, and the execution of the General Congress in Dresden, Germany. On behalf of ICO-25-OWLS-16 we hope everyone had an exciting and memorable time at this extraordinary General Congress.

Prof. Jürgen Czarske
ICO25/OWLS16 General Chairman

European Optics gathered in Porto at EOSAM2022

EOSAM is the flagship event of the European Optical Society, EOS, one of international societies member of the ICO.

Prof. Manuel Costa (right) and Prof. Maite Flores (left) were the general co-chairs of EOSAM 2022.

The annual congress of the European Optical Society (EOS) took place in the beautiful city of Porto (Portugal) from 12 to 16 last September. EOSAM, is a major international scientific conference covering all aspects of optics and photonics, covered by the topical meetings and sessions. It is attended annually by over 500 top researchers, key leaders, students, and industry experts. Each year EOSAM moves into different optics hubs better serving the local communities and at each time creating a unique EOSAM experience for the attendees. EOSAM has been previously organized in France, Scotland, Germany, Netherlands and Italy. It was also planned for Portugal in 2020, but was held online due to the pandemic.

This year, EOSAM was celebrated in person at the Faculty of Engineering of the University of Porto, FEUP, in close collaboration with the Portuguese Society for Research and Development in Optics and Photonics, SPOF, and INESC TEC - Institute for Systems and Computer Engineering, Technology and Science. EOS also collaborated with Sedoptica, PhotonicsFinland, Promoptica, and the European Photonics Industry Consortium, EPIC, for the event.

The conference was organized by Manuel Filipe Costa, President of SPOF, and Maite Flores-Arias, Secretary of EOS as General chairs; Orlando Frazao and Susana Novais, from INESC-tec as Local Chairs; and Patricia Segonds, President-Elect of EOS and Gilles Pauliat, President of EOS as Program Chairs. The EOS Office coordinated and handled the organization led by the Executive Director, Elina Koistinen, together with Conference Manager Jussi Ahonen and Conference Assistant Tiina Romppanen.

EOSAM 2022 included high-quality program within the thirteen Topical meetings (TOMs), 3 special sessions and an exhibition. EOS once again provided tutorials on the topical meeting topics on Monday 12 September. This year there were nine. They were provided as an additional program, free of charge to all the EOSAM attendees. The tutorials were provided for the first time in 2014 and after a very successful start they have been included in the program ever since and have proved to be highly popular. Up to 140 attendees attended the parallel tutorials this year.

For the sixth time, EOS organized a special session for EU project partners to disseminate their goals and results to the conference audience. This year, nine projects were invited to join this session to present their goals and results.

The Early Stage Researcher Session is specially designed for participants in the first four years (full-time equivalent research experience) of their research careers and who have not been awarded a doctoral degree. PhD students were encouraged to express their ideas and describe

During EOSAM 2022, ICO Past-President Roberta Ramponi (right) received her EOS Fellow diploma from EOS past president and ICO Secretary General Humberto Michinel (left).

their scientific achievements to the conference audience. This year they were invited among those presenting a poster, and six students made very high-level presentations. The audience included mainly students but also many senior researchers.

Along the week there was a fantastic array of six plenary speakers on various topics, proposed and invited by Topical Meeting chairs .

During the week a two-day exhibition was held with Sphere, Thorlabs, Toptica, GloPhotonics , JEOS:RP and EDP Sciences, with a great buzzing at the booths all week. On Tuesday, an industrial optics podium session was held for the first time in co-operation with the European Optical Society, EOS, and the European Photonics Industry Consortium, EPIC. Challenges and solutions from companies were highlighted to researchers by Thorlabs, Toptica, Sphere, and GLOPhotonics. Afterwards, a very nice networking reception was enjoyed by all with live music from the faculty TUNA group, together with drinks and snacks.

The EOS Prize was given out to the best paper published in the Journal of the European Optical Society, JEOS:RP by Ines Fortmeier, Reyko Schachtschneider, Vit Ledl, Ondrej Matousek, Jens Siepmann, Antonia Harsch, Rolf Beisswanger, Youichi Bitou, Yohan Kondo, Michael Schulz and Clemens Elster. The purpose of the prize is to encourage a European dimension in research in pure or applied optics.

The newly elected EOS Executive Committee (Execom) started their work during EOSAM and is formed up by Patricia Segonds (President) Emiliano Descrovi (President-Elect), Gilles Pauliat (Past-President), Roelene Botha (Treasurer), Maite Flores-Arias (Secretary to the Board), Oliver Fähnle (Industrial Advisory Committee Chair9 and Thomas Südmeyer (Scientific Advisory Committee Chair).

Elina Koistinen
EOS General Director

Contacts

Forthcoming events with ICO participation

Below is a list of 2023 events with ICO participation. For further information, visit their official websites indicated for each meeting.

27-31 March 2023
RIAO/OPTILAS Iberoamerican Optics Meeting/XIV Latinamerican Meeting on Optics, Lasers and Applications
Costa Rica
Contact: Prof Manuel Costa
president@optica.pt
https://riao-optilas-2022.org

11-15 September 2023
EOSAM 2023. Annual Meeting of the European Optical Society

Dijon, France
Contact: Elina Koistinen
elina@europeanoptics.org
https://europeanoptics.org

Responsibility for the correctness of the information on this page rests with the International Commission for Optics http://www.e-ico.org/. *President:* Prof. John C Howell, Chapman University, USA; john.howell@mail.huji.ac.il *Treasurer:* Prof. Joseph Niemela, International Center for Theoretical Physics, Italy; niemela@ictp.it. *Secretary*: Prof. Humberto Michinel, Universidade de Vigo, Spain; secretariat@e-ico.org.

NEWSLETTER

COMMISSION INTERNATIONALE D'OPTIQUE · INTERNATIONAL COMMISSION FOR OPTICS

Next ICO-25/OWLS-16 in Dresden, Germany

World Congress for Optics and Photonics ICO-25 – OWLS-16

Dresden – Germany

30+ Years Anniversary OWLS

ICO-25 • 5 – 9 September 2022 • OWLS-16

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

"We hope everyone will have a fascinating and memorable time at this general meeting."

The motto of the Congress is "Advancing Society with Light", emphasizing the importance of modern light technology for society. More information is available in the official website: https://ico25.org

From 5th September till 9th September 2022 the General Congress for Optics and Photonics of the International Commission for Optics (ICO) and the international society on Optics Within Life Sciences (OWLS) will be celebrated in Dresden (Germany), emphasizing the importance of modern light technology for society. Light has the potential to recognize the origins of diseases, to prevent them, or to cure them early and gently. This is one of the central topics of OWLS, founded at the ICO-15 Congress in 1990.

Therefore, a special commemorative event of the 30+ years anniversary of the foundation of OWLS in Germany will be organized. The General Congress is the most important scientific and technical meeting on all important topics of optics and photonics around the entire world. After 30+ years and continuing the success of the recent previous general congresses, it is our great honor to host the General Congress in our country again. Due to the outbreak of the COVID-19 pandemic and the worldwide restrictions accompanied by it, the World Congress was postponed twice. The general congress, with participants from all over the world will advance the diffusion of knowledge in the fields of optics and photonics and will be celebrated in-person. The paper submission **deadline was extended to April 24, 2022**. Among the topics offered are:

- Optical Engineering & Design
- Material Processing & Lithography
- Display and Vision
- Optical MEMS and Micro-Optics
- Optical Sensing and Measurement
- Computational Metrology
- Optical Information Processing
- Quantum and Nonlinear Optics
- Ultrafast Optics & High Power Lasers
- X-Ray and High-Energy Optics
- Plasmonics and Meta-materials
- Nanophotonics & Nanosensig
- Fiber Optics & Communications
- Terahertz and Silicon Photonics
- Microscopy, Biomedical Spectroscopy
- Biomechanics & Optical Elastography
- Biomedical Optics
- Nanobiophotonics & Optogenetics
- Optics for Infectious Diseases

Prof. Dr. Jürgen Czarske
ICO V.P. & Chair of ICO-25/OWLS-16
https://ico25.org

NEWSLETTER

COMMISSION INTERNATIONALE D'OPTIQUE · INTERNATIONAL COMMISSION FOR OPTICS

ICO-25 World Congress moved to 2022

The ICO-25/OWLS-16 Congress will take place 5-9 September 2022 in Dresden (Germany)

Prof. J. Czarske is the General Chair of ICO-25 to be celebrated in Dresden (Germany).

The ICO bureau, during its last meeting celebrated 14th January 2021, approved a change in the dates of the next World Congress of the International Commission for Optics (ICO-25). The congress will not take place during 2021 as initially planned and it has been moved to 5-9 September 2022 to guarantee a face-to-face meeting. The 16th Conference of the International Society on Optics Within Life Sciences (OWLS) and its 30th anniversary will be also celebrated in parallel merging to the world congress ICO-25/OWLS-16. The resolution has been motivated by the situation generated by the covid-19 pandemic and adds another year of extension to the celebration of the mentioned event, which had already been postponed before for another year. It is a difficult decision, which has been unanimously approved by the members of the ICO bureau and that aims on the one hand to ensure the success of the meeting with the maximum participation of delegates from different countries, and on the other side to guarantee health security, given the uncertainty about the possibility of vaccination worldwide during 2021. It is expected as an advantage to the whole world congress that by the delay newest research results on optics and photonics technologies against the covid-19 pandemic will extent and actualize.

Another agreement approved unanimously during the ICO bureau meeting was to hold the ICO General Meeting (also known as the General Assembly, where the delegates from all over the world meet) in September 2021, adopting an online format. Therefore, the assembly will not coincide for the first time in its history with the celebration of the ICO World Congress. The reason for this decision is to dedicate this meeting of all the delegates from the different ICO territories exclusively to the election of the new ICO bureau, given that the current one has been in office for the last year, as it was not possible to hold the general assembly in 2020. An extraordinary General Meeting in person will be held alongside ICO-25/OWLS-16 world congress in Dresden, Germany in 2022 to discuss all other topics normally included in the agenda that cannot be considered in the online meeting format. In the next weeks, detailed instructions on the election process will be sent to all the ICO delegations by the ICO Secretariat as well as by the ICO Past President who chairs the Nomination Committee.

Prof. Humberto Michinel
ICO Secretary General

Photo of the last ICO World Congress celebrated in Tokyo (Japan) in 2017 with the attendance of the emperors of Japan.

CALL FOR PAPERS

SPIE. DIGITAL OPTICAL TECHNOLOGIES

26–29 June 2023
ICM—International Congress Center Messe
München, Germany

Astract Due Date: 1 MARCH 2023

Digital Optical Technologies 2023 (DOT101)

Conference Chairs: **Bernard C. Kress,** Google (United States); **Jürgen W. Czarske,** TU Dresden (Germany)

Program Committee: **Giorgio Anania,** Aledia (France); **Christian Bosshard,** Ctr. Suisse d'Electronique et de Microtechnique SA (Switzerland); **Federico Capasso,** Harvard School of Engineering and Applied Sciences (United States); **Oliver Cossairt,** Northwestern Univ. (United States); **I Jan Chen,** Southport Co. (Taiwan); **Arie den Boef,** ASML Netherlands B.V. (Netherlands); **Andrew Forbes,** Univ. of the Witwatersrand, Johannesburg (South Africa); **Yoshio Hayasaki,** Utsunomiya Univ. (Japan); **Andreas Hermerschmidt,** HOLOEYE Photonics AG (Germany); **Nicolaus Hettler,** CDA GmbH (Germany); **Ulrich Hofmann,** OQmented GmbH (Germany); **Hong Hua,** College of Optical Sciences, The Univ. of Arizona (United States); **Bahram Javidi,** Univ. of Connecticut (United States); **Sabina Jeschke,** RWTH Aachen Univ. (Germany); **Norbert Kerwien,** Carl Zeiss AG (Germany); **Douglas R. Lanman,** Facebook Technologies, LLC (United States); **Scott McEldowney,** Meta (United States); **Ilmars Osmanis,** Lightspace Technologies, SIA (Latvia); **Aydogan Ozcan,** UCLA Samueli School of Engineering (United States); **Igino Padovani,** Robert Bosch LLC (United States); **Silvania F. Pereira,** Technische Univ. Delft (Netherlands); **Christophe Peroz,** Sony Corp. (Japan); **Pascal Picart,** Univ. du Maine (France); **Ting-Chung Poon,** Virginia Polytechnic Institute and State Univ. (United States); **Demetri Psaltis,** Ecole Polytechnique Fédérale de Lausanne (Switzerland); **Monika Ritsch-Marte,** Medizinische Univ. Innsbruck (Austria); **Jannick P. Rolland-Thompson,** The Ctr. for Freeform Optics (United States); **Markus Rossi,** ams-OSRAM (Switzerland); **Peter Schelkens,** Vrije Univ. Brussel (Belgium); **Ruediger Sprengard,** SCHOTT AG (Germany); **Robert E. Stevens,** Adlens Ltd. (United Kingdom); **Hagen Stolle,** SeeReal Technologies GmbH (Germany); **Eleonora Storace,** imec (Belgium); **Yuzuru Takashima,** Wyant College of Optical Sciences (United States); **Michael Totzeck,** Carl Zeiss AG (Germany); **Reinhard Voelkel,** SUSS MicroOptics SA (Switzerland); **Uwe Vogel,** Fraunhofer-Institut für Organische Elektronik, Elektronenstrahl-und Plasmatechnik FEP (Germany); **Gordon Wetzstein,** Stanford Univ. (United States); **Angus Wu,** Goertec Electronics, Inc. (United States); **Frank Wyrowski,** LightTrans International UG (Germany); **Zeev Zalevsky,** Bar-Ilan Univ. (Israel); **Michael Zeuner,** scia Systems GmbH (Germany); **Leander Zickler,** Meta (United States)

Take this opportunity to share your research at SPIE Digital Optical Technologies, a conference dedicated to emerging digital trends and perspectives in optics and photonics. Come to Munich to meet with users and researchers to discuss the latest developments in the field of digital optics.

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- topological optimization algorithms
- AI- and DNN-aided design techniques

DIGITAL IN FABRICATION
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- diamond turning / techniques for injection molding, pressure molding, casting,...
- additive/subtractive manufacturing techniques and technologies
- digital 3D printing by two photon polymerization.

DIGITAL IN OPERATION
- dynamic digital optics for switching, tuning or functionality reconfiguring
- computational techniques to enhance imaging, display and sensing functionality.

DIGITAL OPTICS BUILDING BLOCKS CAN BE GROUPED IN THREE CATEGORIES
- macro-optics: refractive freeform optics, hybrid refractive/diffractive optics, graded index optics...
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- nanophotonics (metasurfaces, photonic crystals, plasmonics,...).

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EXAMPLES OF APPLICATION FIELDS USING DIGITAL OPTICS
- display, imaging and sensing using digital optics
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SPIE. DIGITAL OPTICAL TECHNOLOGIES

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Learn about recent advances in using digital technologies to enhance the performance of optical imaging, display and sensing. Find out about new approaches that push digital principles at the macro-, micro- and nanoscales to the forefront of optics. Exchange new ideas, address your shared concerns, and get access to information not yet published in the mentioned topical areas. Share your research with other engineers, scientists and researchers.

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Authors notified	12 April 2023
Program online	12 April 2023
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Manuscripts due	7 June 2023

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- Title
- Author(s) information
- 250-word abstract for technical review
- 100-word summary for the programme
- Keywords used in search for your paper (optional)
- Your decision on publishing your presentation recording to the SPIE Digital Library
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- Ensure that all clearances, including government and company clearance, have been obtained to present and publish. If you are a DoD contractor in the USA, allow at least 60 days for clearance
- Attend the meeting
- Present at the scheduled time

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