TECHNISCHE UNIVERSITÄT DRESDEN

MST
Chair of Measurement and Sensor System Technique

Faculty of Electrical and Computer Engineering

MST | Czarske Lab Annual Report 2024

BIOLAS
BIOMEDICAL COMPUTATIONAL LASER SYSTEMS

DRESDEN concept
SCIENCE AND INNOVATION CAMPUS

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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 20 years. We look back on an eventful year. It is a great pleasure, honor and privilege to report on our activities this year.
The Czarske Lab has successfully acquired projects in new research topics such as optogenetics exploiting human stem-cell-derived organoids. We started with a cooperation with the genetic laboratories at the CRTD, later a joint DFG project was carried out and now, together with our partners from the life sciences, we are gaining new insights into the optogenetics of human organoids, especially of neural networks and heart muscles towards desease modelling. The control of the light scattering processes in fibers or tissues with modern wavefront shaping techniques opens up further new directions. Projects were acquired on quantum technology of the second generation too. The United Nations (UN) proclaimed 2025 as the International Year of Quantum Science and Technology (IYQ), aimed at increasing public awareness of the importance of quantum science and applications. The year 2025 was chosen for this International Year of Quantum Science and Technology (IYQ) as it recognizes 100 years since the initial development of quantum mechanics. The quantum technology of second generation covers four areas that increasingly demonstrate a quantum unique selling point or advantage in applications such as quantum communication, quantum sensing, quantum imaging and quantum computer. On quantum communication with multimode fibers first results were achieved based on the running projects Quantum Internet of Things (QUIET) and 6G Life Hub/Quantum Communication. Together with Markus Gräfe (TU Darmstadt) the joint project "3D Quantum imaging with undetected light and wavefront control" was approved this year. We are happy to contribute our own contributions for IYQ.
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. Important funding from BMBF was achieved by projects such as ENOWA I, ENOWA II, KORONA, Quiet, 6GLife, GoBio.
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.
The students and staff members of the Czarske Lab have been awarded again. In total, the MST has received more than 125 honors, prizes and awards, including the Berta Benz award for PhD student Katrin Philip, donated with 10 000 Euro by Daimler and Benz Foundation. It is gratifying that an ERC grant was received from the alumni (Andreas Fischer, Bremen). Several new projects were acquired. The commercial success of the laser profile sensor for velocity and temperature measurements has to be highlighted, which was pushed mainly by Lars Buettner. This year, one patent on temperature profile measurements was transferred to company ILA R&D GmbH, Jülich. This successful innovation at the market was awarded with the Berthold Leibinger Innovation Award. One great news is that in December 2024 Jiawei Sun was appointed full Professor based at SIBET of CAS, we warmly congratulate him. With Prof Sun, over 8 former students and postdocs of Czarske Lab have now been appointed professor.
In 2017, the general congress ICO-24 was opened in Tokyo by the Japanese Emperor and at the General Assembly 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. 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 with the theme "Advancing Society with Light" can be found at the website https://www.ico25.org
Since 2019, the Czarske Lab offers the lecture “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 300 defenses of Bachelor, Master and PhD Theses (“Studienarbeiten”, “Diplomarbeiten”, “Doktorarbeiten”). 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. 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 students and team members for the committed research and teaching and our partners for the efficient and effective cooperation.

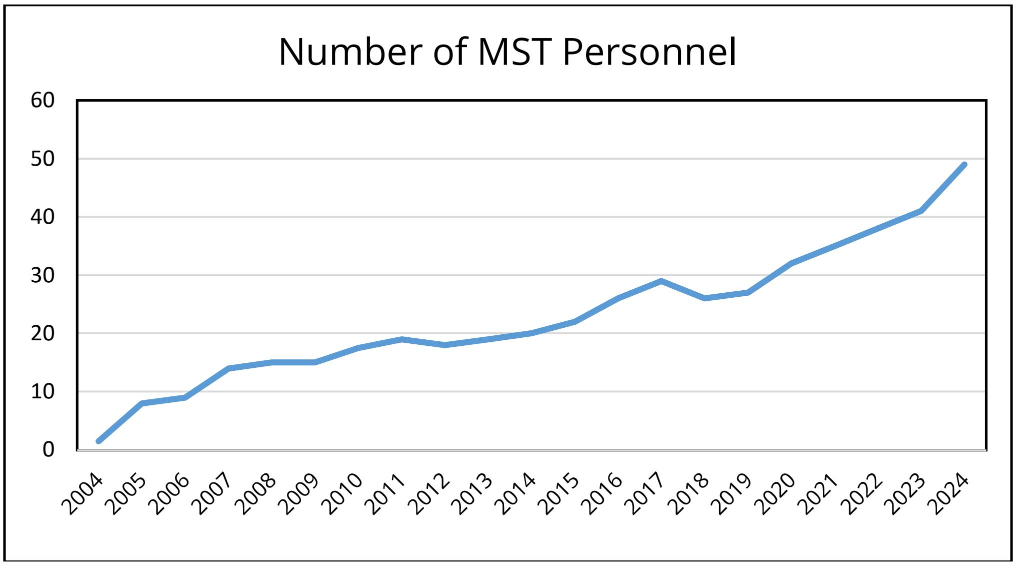
Best regards,

Prof Juergen Czarske

STAFF

No.	Name	Title	Position
1	Al-Khouri, Gabriel		Student Assistant
2	Ananth, Arjun		Research Assistant
3	Bilsing, Clemens	Dipl.-Ing.	PhD student
4	Bischoff, Hannes	M.Sc.	Research Assistant
5	Böhm, John		Student Assistant
6	Büttner, Lars	Dr. rer. nat.	Postdoc, Senior Research Fellow; Head of Department „Laser Measure-ment Systems“
7	Cai, Zixuan	Dipl.-Ing.	Research Assistant
8	Czarske, Jürgen	Prof. Dr.-Ing. habil.	Full Professor, Head of MST Director of the Czarske Lab Director of BIOLAS Center
9	Dou, Zehua	M. Sc.	PhD student
10	Dremel, Jakob	Dipl.-Ing.	PhD student
11	Eberling, Kerstin		Team Assistant, part-time
12	Emmerich, Hannes	Dipl.-Ing.	PhD student
13	Fleischmann, Jakob		Student Assistant
14	Glosemeyer, Tom	Dipl.-Ing.	PhD student
15	Gürtler, Johannes	Dr.-Ing.	Postdoc / Research Assistant
16	Hartl, Georg	M. Sc.	PhD student
17	Hoppe, Johanna		Student Assistant
18	Jose, Nidhin	B.Sc.	Student Assistant
19	Kirsch, Nele		Student Assistant
20	Koukourakis, Nektarios	Dr.-Ing.	Postdoc, Research Fellow, Head of De-partment “Bio-photonics and Laser Me-trology”, CEO of BIOLAS center
21	Krause, David	Dipl.-Ing.	PhD student
22	Kravets, Zhanna		Team Assistant, part-time

23	Krenkel, Justus		Student Assistant
24	Kuschmierz, Robert	Dr.-Ing.	Postdoc, Research Fellow, Head of Group “Laser Systems for Biomedicine”
25	Ließ, Konrad		Student Assistant
26	Lich, Julian	M. Sc.	Research Assistant
27	Linhsen, Luca Antonia		Student Assistant
28	Lu, Dangfeng	Dr.	Guest researcher
29	Ma, Wenhao		Student Assistant
30	Miao, Yu	Dipl. Ing.	Research Assistant
31	Nidhin, Jose		Research Assistant
32	Nütznadel, Erik		Research Assistant
33	Obersteiner, Antonia		Student Assistant
34	Othmani, Cherif	Dr.	Postdoctoral researcher
35	Otto, Solveig	B.A.	Project Manager
36	Pohle, Dennis	Dipl. -Ing.	PhD student
37	Rietmann, Piet		Student Assistant
38	Schmidt, Katharina	M. Sc.	PhD student
39	Schmieder, Felix	Dr.-Ing.	Postdoc / Research Assistant
40	Sun, Jiali	Dipl.-Ing.	Research Assistant
41	Tag, Martha		Student Assistant
42	Volkova, Veronika	B. Sc.	Research Assistant
43	Wang, Tijue	M. Sc.	PhD student
44	Wei, Zhiying		Student Assistant
45	Weik, David	Dipl.-Ing.	Research Fellow, Head of Group “Ultra-sound Imaging”
46	Wendland, Robert	Dipl.-Ing.	Research Assistant
47	Yang, Bin	Dipl. Ing.	Research Assistant
48	Zhang, Qian	Dipl.-Ing.	PhD student
49	Zolnacz, Kinga	Ph.D.	Research Assistant



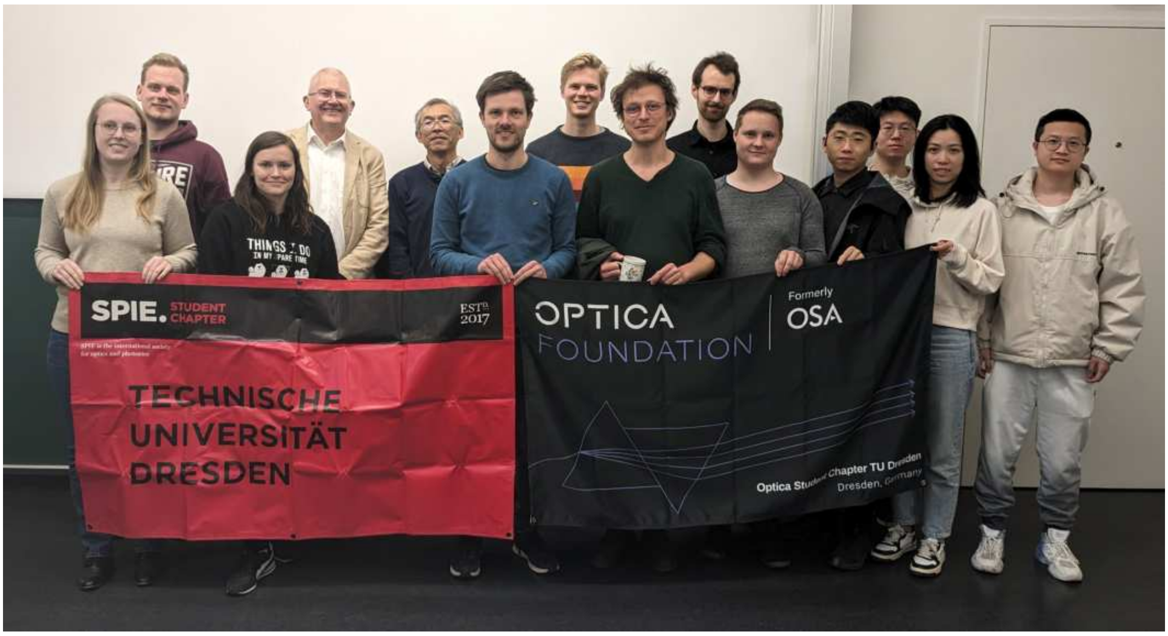
Number of staff members, excluding adminstration and technical members of the workshop etc.

SPIE. OPTICA Formerly OSA

Student Chapter TU Dresden

The SPIE+OPTICA 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 supported by OPTICA. 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 SPIE+OPTICA 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 excursion to Thorlabs in munich 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 2025.



The OPTICA-SPIE Student Chapter of TU Dresden with visiting lecturer
Prof. Charles Lin (Harvard University, Cambridge/Bosten, USA)

TEACHING

		WiSe 23/24	SoSe 2024
Grundzüge des Messens 4. Sem.	V: Prof. Czarske Ü: Dr. Gürtler, Dipl.-Ing. Emmerich	14	101
Mess- und Sensortechnik 5. Sem.	V: Prof. Czarske, Dipl.-Ing. Weik Ü: Dr. Gürtler, Dipl.-Ing. Emmerich	94	13
Praktikum Mess- und Sensortechnik 5.+6. Sem.	P: M. Sc. Lich, Dipl.-Ing. Dremel, Dipl.-Ing. Glosemeyer, et al. Prof. Czarske	90	10
Messsystemtechnik 6. Sem.	V: Prof. Czarske, Dr. Kuschmierz Ü: M. Sc. Schmidt, Dipl.-Ing. Bilsing	-	23
Lasermesstechnik 8. Sem.	V: Prof. Czarske Ü: Dr. Büttner	-	16
Mechatronische Lasersensoren 8. Sem.	V: Dr. Büttner, Prof. Czarske	-	16
Lasermesssysteme für die Fluidtechnik 9. Sem.	V: Dr. Büttner, Prof. Czarske	2	-
Digitale Holographie und Bildverarbei- tung 9. Sem.	V: Dr. Koukourakis, Prof. Czarske	6	-
Biomedizinische Laser-Systemtechnik und Optogenetik	V: Dr. Kuschmierz, Prof. Czarske, K. Schmidt, K. Zolnacz	6	-
Praktikum Lasersensorik	V: Prof. Czarske P: Dr. Zolnacz, M. Sc. Wang	-	3
Hauptseminar AMR	Dipl.-Ing. Scharf, Dr. Gürtler, Prof. Czarske	20	-
	Sub-Total:	**226**	**182**
	Total:	**408**	

Total number in 20 years: 18561

Modules at MST

Automatisierungs- und Messtechnik (3/2/0) (ET, MT)

Hauptseminar AMR (0/2/0) (ET)

Mess- und Sensortechnik (2/1/1) (ET, MT)

Prozessleittechnik (6/2/2) (ET)

Lasersensorik (4/1/1) ET

Oberseminar Messsystemtechnik (0/2/0) (ET, MT, PHY, NES, POL, CMS)

Photonische Messsystemtechnik (4/2/0) (ET)

Sensoren u. Messsysteme-Grundlagen (5/2/0) (MT)

Sensoren u. Messsysteme-Vertiefung (3/0/2)

Optische Prozessmesstechnik (4/2/0) (RES)

Non-Physics Supplement (7/2/0) (PHY)

Computational Laser Metrology – Fundamentals (1/3/1) (INF)

Computational Laser Metrology – Advances (6/4/0) (INF)

ET - Electrical engineering (Diplom/ Master)

MT - Mechatronics

RES - Regenerative Energiesysteme

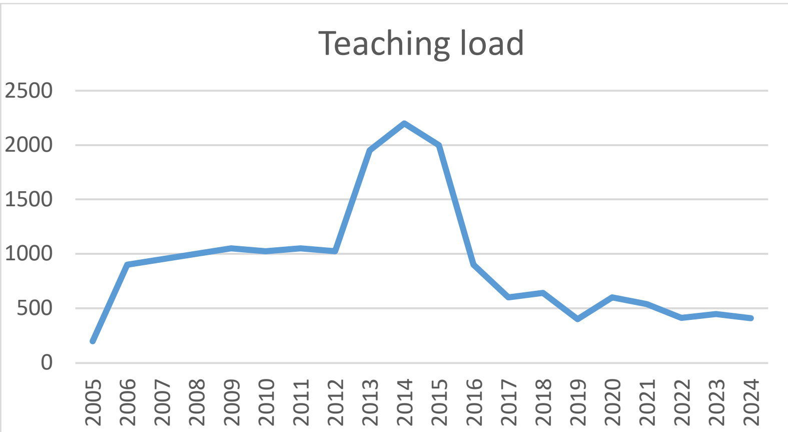
PHY - Physics

INF - Informatics

NES - Nanoelektronic Systems

POL - Physics of Life

CMS – Computational Modeling and Simulation



In total over 18 000

INVITED TALKS

Date	Guest Speaker	Topic
15 April 2024	Prof. Charles Lin, Center for Systems Biology, Massachusetts General Hospital, Boston	In vivo flow cytometry: blood cell analysis without drawing blood (Student chapter)
22 April 2024	Ingo Lanheinrich, polychip.ai, Dresden	Threshold methods versus deep learning - when it makes sense to use "AI" -algorithms in machine monitoring
13 May 2024	Yared Zena, Dr. Caspar Hopfmann; Institut für Festkörper- und Werkstoffforschung, Dresden	Highly efficient sources of entangled photon pairs for industrial environments using GaAs quantum dots
19 July 2024	Dr. Shwetadwip Chowdhury; University of Texas, USA	Computational Microscopy of Scattering Samples
28 October 2024	Prof. Jiawei Sun; Shanghai Pacific Energy Center, Shanghai, China	Artificial intelligencefor optical imaging and manipulation
13 December 2024	Dr. Wenfeng Xia; Kings College London, United Kingdom	Photoacoustic imaging for surgical guidance

Awards, Prizes, Honors and Elections

Jiawei Sun	Prize for Measurement and Sensor Technology of the Gisela and Erwin Sick Foundation, Freiburg, best dissertation on measurement systems at TU Dresden (5000 Euro donation): "Learning-based Three-Dimensional Optical Cell Rotation Tomography and Quantitative Phase", TU Dresden, 05/2024  Fltr: Uwe Hampel, Eric Starke, Mathias Panicke, Caroline Murawski, Karl Leo, Guiseppe Ciccone, Juergen Czarske, Wolfgang Bay, Gerald Gerlach. On the sreen, Jiawei Sun, Kai Geißdörfer, Yuan Sui
Jürgen Czarske	Distinguished Lecturer of IEEE Photonics Society 2024. The Photonics Society Distinguished Lecturers program was designed to honor excellent speakers who have made technical contributions of high quality and to enhance the technical programs of Photonics Society chapters.
Yuan Sui	Prize for Measurement and Sensor Technology of the Gisela and Erwin Sick Foundation, Freiburg, for young talents, best student thesis/Bachelor/Studienarbeit (500 Euro donation): "High-fidelity transmission through multimode fibers using deep learning", TU Dresden, 05/2024

Jürgen Czarske	Outstanding reviewer award from Light: Science & Applications of Nature, Chinese Academy of Sciences, March 2024 
Jürgen Czarske	Honor of 7th BMEF Keling Academic Forum, SIBET, CAS, Hangzhou, June 2024
Stefan Rothe	Measurement Technique Prize of AHMT, Hall, Tirol, Austria, 19th September 2024 (AHMT is the society of Professors of Measurement and Sensor Systems)
Stefan Rothe	VDE ITG Dissertation Prize 2024 (2.000 Euro), awarded in Berlin (Hauptstadtforum), 26th November 2024
Dennis Pohle and Jürgen Czarske	BEST PAPER AWARD "Secret Key Generation in Multi-Mode Fiber Channels: Channel Measurements and Achievable Rates", P.-H. Lin, P. Nowitzki, E. Jorswieck, D. Pohle, Juergen Czarske, IEEE International Conference on Communications, IEEE ICC 2024, 9–13 June 2024, Denver, CO, USA
Jürgen Czarske	Promotion to Adjunct Professor for Optical Sciences, 2024 James C. Wyant College Optical Sciences, THE UNIVERSITY OF ARIZONA, Meinel Optical Sciences, 400N1 PO Box 210094|Tucson, AZ 85721
Stefan Rothe	2nd prize in 2024 German Thesis Award by Körber-Stiftung Hamburg (9 prizes of over 700 nominations), EUR 5000, 2024.12.03, Berlin
Tijue Wang	Student paper award, for the paper "Image restoration via learning on a digital twin for multi-core fiber endoscopy",Tijue Wang, J. Dremel, S. Richter, W. Polanski, O. Uckermann, I. Eyüpoglu, J. Czarske, R. Kuschmierz,, Optica Imaging Congress 15 – 19 July 2024 Toulouse, France.
Julian Lich	Award for Outstanding Dissertation titled " Parallel and spatially resolved measurement of the deformation, damage and modal behavior of fast rotating of rapidly rotating structures by using optical diffraction gratings " by the Dr.-Ing. Siegfried Werth Foundation
Jie Zhang	Price of the Dr.-Ing. Siegfried Werth Stiftung for especially good student thesis "Real-time quantitative phase imaging through an ultra-thin lensless microendoscope"
Jürgen Czarske	SPIE Dennis Gabor Award in diffractive optics for digital holography and related techniques for biomedicine, fiber communication, imaging, information processing, and laser metrology. 21 Sep. 2024, San Diego (SPIE is the international society of optics and photonics, USA)

	 Left: J. Czarske. Middle: with Jennifer Barton, 2024 SPIE President. Right: with Peter de Groot, 2024 SPIE President Elect
Jürgen Czarske	Elected as Vice President of International Commission for Optics (ICO), world umbrella organization for optics and photonics with over 50 member countries of all continents. The election process was accomplished at the congress ICO-25 in Lord Charles Hotel, Cape Town, South Africa, 24th October
Jürgen Czarske	Appointment for volunteering with Honorary Professor of the University of Shanghai for Science and Technology (USST)  Ceremony together the Vice President of Prof Zhang Zhong
Jürgen Czarske	Certificate of Appreciation of Tsinghua Shenzhen International Graduate School, Dec 4, 2024, Shenzhen
Wenting Geng	Prize on Digital Technology of BASF, Schwarzheide for best Diploma/Master Thesis with the title „High-dimensional Quantum Information Transmission using Few-mode Fibers“

Total number of elections, honors, prizes and awards: over 125

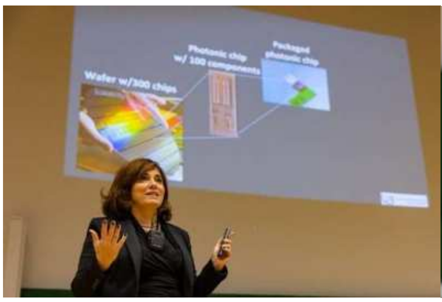
GENERAL CONGRESS ICO-25-OWLS-16

Looking back to the World Congress

Group photo of the SPIE STUDENT CHAPTER from Technische Universität Dresden - employees of the Chair of Measurement and Sensor Systems/Czarske Lab, including K. Schmidt, Dr. J. Sun, Dipl. Ing, G. Ning, from left: E. Scharf, Dr. J. Liech, Dr. J.Dremel, Q. Zhang, D. Pohle, D. Krause, Dr. S. Rothe, Dr. F. Bürkle, T. Glosemeyer.
The invitation was organiuzed by the SPIE-OPTICA Student Chapter President Katharina Schmidt

The Orga Team of ICO-25 | Opening of the congress | Prof A.P. (Allard) Mosk

Left: Program chair of OWLS, Prof Alex Heisterkamp. Right: Program chair of ICO, Prof Wolfgang Osten



Prof. Michal Lipson is the Eugene Higgins Professor of Electrical Engineering and Professor of Applied Physics at Columbia University

Juergen Czarske and Karsten Danzmann

Stefan Hell, Andrea Alù, Leszek Sirko

Carmiña Londoño, Yaseera Ismail, Humberto Michinel, Nabeel Riza

Left: Wilhelm Kaenders, Juergen Czarske, Gérard Mourou, Bernd Kleemann
Right: Gérard Mourou

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

Left: Photo of the participants of the Congress and General Assembly of ICO. Right: ICO Awarding, OPTCA Best Paper Prize for Stefan Rothe (middle), with 2023 President OPTICA Michal Lipson and CEO OPTICA Liz Rogan


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


Left: Nobel Laureate Stefan Hell and General Chair Juergen Czarske (from left). Right: Juergen Czarske, Sarun Sumriddetchkajorn (Thailand), Stefan Hell, Nabeel Riza (Ireland)


Left: Nobel Laureate Reinhard Genzel and General Chair Juergen Czarske (from right); Middle: Prof Genzel, Right: Leszek Sirko, Francesca Calegari, Reinhard Genzel

NEWS AND HIGHLIGHTS IN 2024

Visting of Photonics West. Left: Wall of Fame of SPIE at Moscone Center/San Francisco. Right: Group Meeting with a cooperation partner from Ohio

Quantum Communication Meeting with Charles Bennett and Gilles Brassard during the awarding of Eduard Rhein Foundation Prize in Technology in Munich. For the first Quantum Cryptography (BB84) they have won also the-Breakthrough Prize in Fundamental Physics, the world's largest science prize

Left: President Elect of OPTICA Jim Kafka. Middle: Podium discussion at IEEE Photonics Society Chapter. Right: Honoring as distinguished speaker at SIBET institute

Wall of Fame of SPIE Prizes in San Diego & Celebration with the team in the Air and Space Museum

Awarding of the Prizes of SPIE in Air and Space Museum. Left: Nobel Prizes Laureate 2023 with SPIE President Prof Barton. Middle and Right: Celebration of the Gabor Award, together with coopertation parters, e.g. Prof Jiawei Sun, former PhD student and postdoc at MST, now full professor at Suzhou Institute of Biomedical Engineering and Technology, SIBET

Left: Visit of former postdoc Stefan Rothe at Yale University, New . Middle: Visit ofLab for Multimode Fiber Endos-copy at Mice Brain at Boulder University, Colorado. Right: LAM Editors, J. Czarske, Siqiu Guo, Shuai Ding, W. Osten

Left and Middle: Advertisement for LAM on the top of Canton Tower, together with former Postdoc of MST, Prof Shengyu Shi, South China University of Technology, School of Mechanical and Automotive Engineering. Right: Meet-ing of Editors of LAM, Guangzhou (Host Editor-inChief Wolfgang Osten, in the middle)


Left and middle: After LAM Conference at Canton Tower: Meeting with former postdoc of MST, Shengyu Shi, Pro-fessor in Guangzhou. Right: Visit of Edge with OPTICA Student Chapter of CUNY, New York City


Left: Visit of Lab of Kishan Dholakia in Adelaide, Middle: Honored as distinguished speaker in Shenzhen, Right: Seminar of OPTICA-SPIE Student Chapter in New York City

Presentation of the demonstrator built by the AiF project “HoloScope” at the BMWK (Federal Ministry for Economic Affairs and Climate Action) 2024 Innovation Day for SMEs with a visit from federal Economics Minister Rober Habeck and the BMWK Head of the Innovation Policy Department Christina Decker.

The SAB Project “LiLoSkop” was presenting an demonstrator at the saxonian innovation conference with visits by Carsten Schneider (member of german parliament) and the saxonian Economics Minister Martin Dulig.

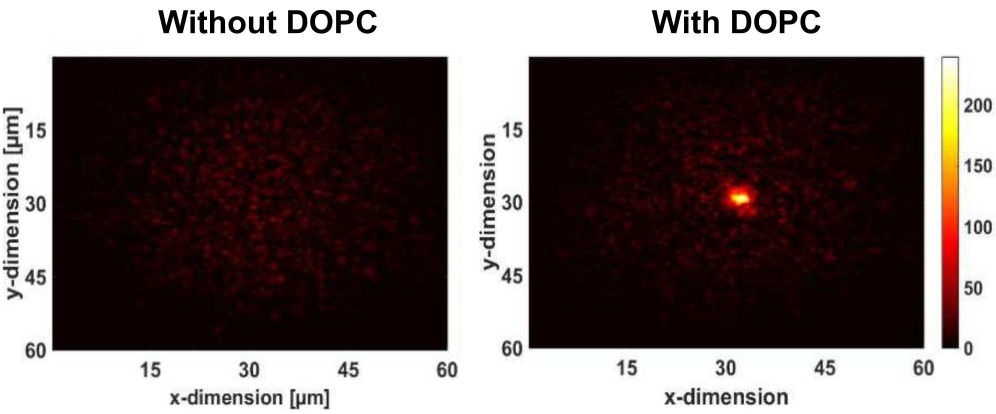
Left: Meeting in Dresden with partner of transcampus King’s College London, from left: Juergen Czarske, Wenfeng Xia, Feng He, Kinga Zolnacz, Jakob Dremel, Robert Kuschmierz. Middle: Meeting in London at 4th British and Irish Conference on Optics and Photonics, BICOP, 18th to 20th December 2024 at the IET London Savoy Place, from left: Juergen Czarske (Fellow of IET), Filipe Ferreira (UCL). Right: Ceremony with Vice President Zhang Zhong of USST

Christmas Party

DFG Focusing light through scattering tissue

Staff: J Böhm, N. Koukourakis, J. W. 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

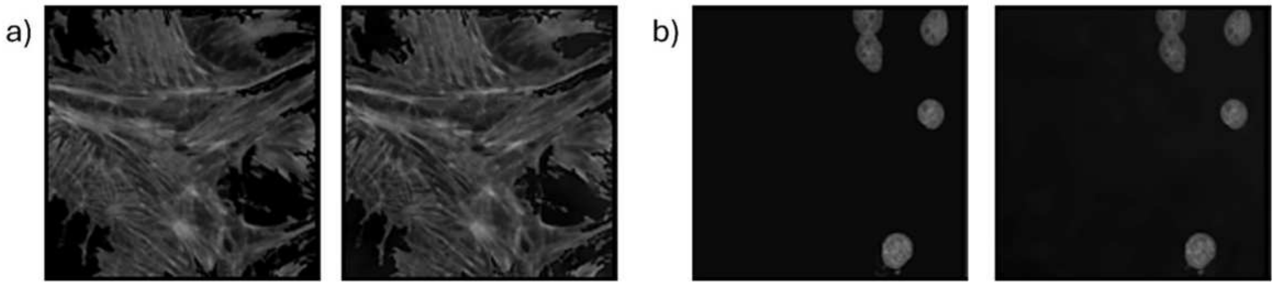
BIOLAS **Volumetric hybrid illumination microscopy using neural networks**

Staff: N. Koukourakis, K. Schmidt, J. W. 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. The reconstruction of the optically sectioned image is performed using a U-Net trained on images with structured and uniform illumination.

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



Examples from the HiLo-imaging Testdataset, a and b show different test images on the left side along with the corresponding network prediction on the right.

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**

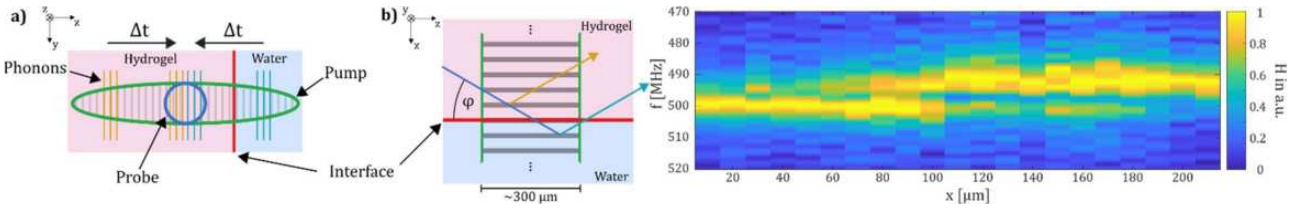
Staff: D. Krause, L. Liebig, N. Koukourakis, J. W. Czarske

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 – 04/2024

Partner: BIOTEC, Dresden, Prof. Jochen Guck



Left: ISBS excitation at interface. Right: Brillouin frequencies at the interface of water/hydrogel

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).

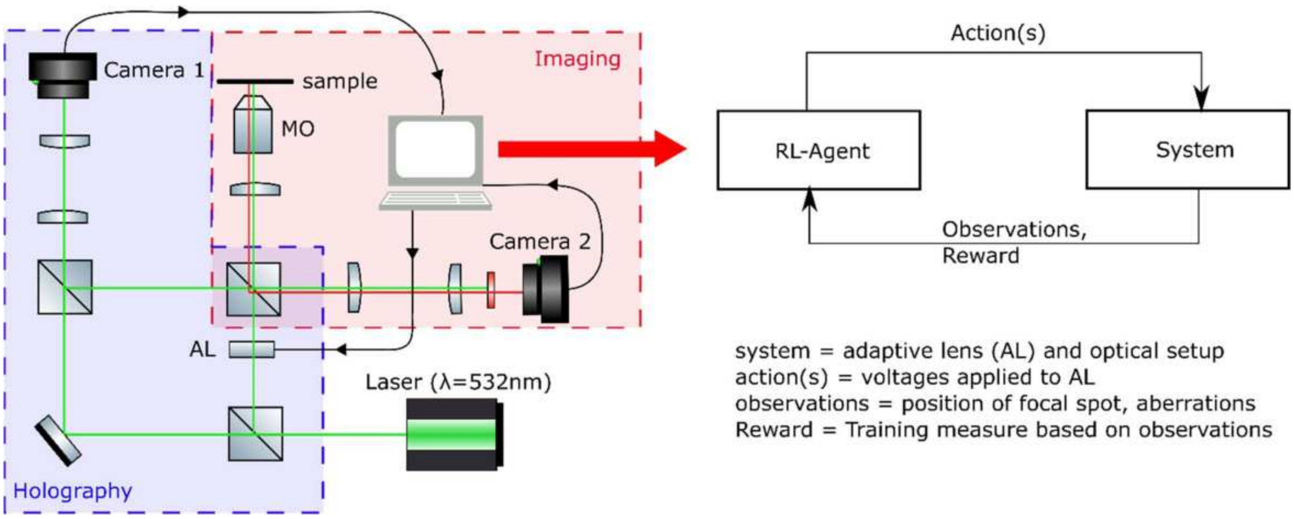
DFG **Aberration correction for real-time measurements in adaptive confocal microscope**

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

Aim: Microscopic techniques with high spatial and temporal resolution are required for measuring biological cells and tissues. For 3D measurments inside the sample deep imaging is required, which is realized by using confocal or two-photon microscopy. The sample tissue, which is in the imaging path of deep imaging will deform the wavefront and thereby intoduce aberrations to the measurement. Aberrations can be addressed by using adaptive optical elements. Furthermore, adaptive elements allow for fast scanning.
The aim of the project is to create a fully-adaptive two-photon microscope, which enables both fast scanning and high spatial resolution due to aberration correction. For this purpose, customized adaptive lenses from IMTEK (University of Freiburg) 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. 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 setup and to create a compact microscope.
However, including more adaptive elements driven by piezo-actors in the setup leads to a more complex control problem of the microscope components. To overcome this, machine learning methods such as neural networks and reinforcement learning agents are used to drive the adaptive optical elements for scanning and aberration correction.

Period: 10/2019 – 09/2025

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



Control of an adaptive lens (AL) using a reinforcement learning (RL) agent. The observations are made possible via digital holography and the calculated aberrations or the phase of the wavefront are transferred to the RL agent. The agent uses this to calculate the voltages to be applied next to the AL for aberration correction or a scan.

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, K. Schmidt, M.C. Wapler, U. Wallrabe, J.W. Czarske, N.Koukourakis, „Fully refractive telecentric f-theta microscope based on adaptive elements for raster scanning of biological tissues", *Opt. Express. Vol*(31), 29703-29715 (2023)
K. Schmidt, N. Guo, W. Wang, J.W. Czarske, N. Koukourakis, "Chromatic aberration correction employing reinforcement learning", *Optics Express. Vol* (10), 31 (2023)

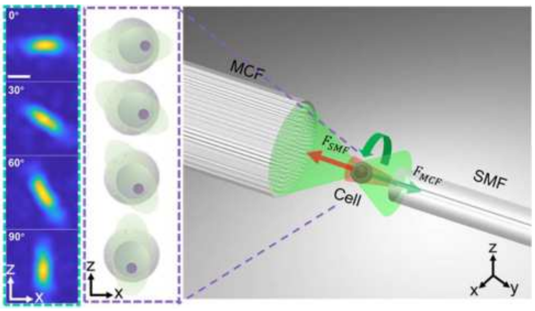
DFG **Tomographic refractive index measurement using Adaptive fiber-optical cell RO-Tation (TAROT)**

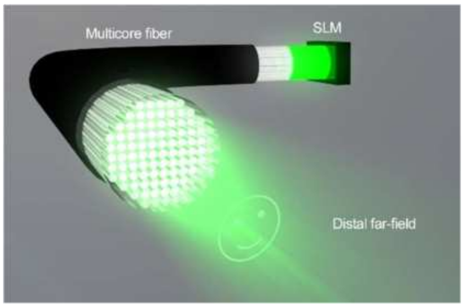
Staff: D. Krause, J. Sun, N. Koukourakis, J. W. Czarske

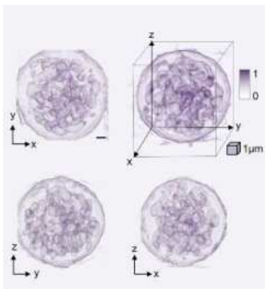
Aim: The three-dimensional refractive index (RI) distribution of biological cells contains rich information on the metabolism, health and on intracellular structure. An important biophysical parameter that can be accessed without invasive cell staining by quantitative phase imaging (QPI). As QPI techniques 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 – 02/2024







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

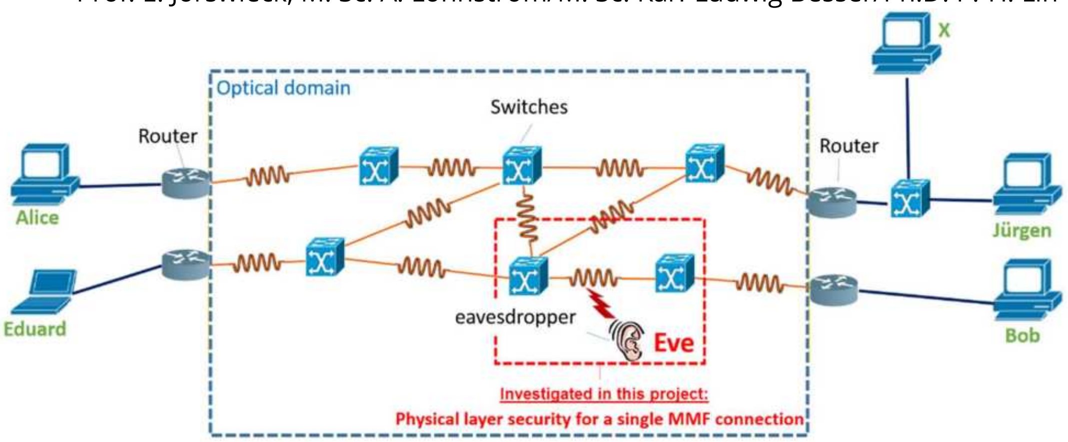
DFG **Physical Layer Security of Multimode Optical Fiber Transmission Systems**

Staff: D. Pohle, J. W. 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 – 11/2025

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



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, K. L. Besser, D. Krause, R. Kuschmierz, N. Koukourakis, E. Jorswieck, J. W. Czarske, „Securing data in multimode fibers by exploiting mode-dependent light propagation effects." Research, 6, 0065 (2023)

D. Pohle, S. Rothe, N. Koukourakis, J. Czarske, "Surveillance of few-mode fiber-communication channels with a single hidden layer neural network." Optics Letters, 47(5), 1275-1278 (2022)

P. H. Lin, P. Nowitzki, E. A. Jorswieck, D. Pohle, J. Czarske, J. "Secret Key Generation in Multi-Mode Fiber Channels: Channel Measurements and Achievable Rates." In ICC 2024-IEEE International Conference on Communications (pp. 4973-4978). IEEE. (2024)

BMBF **6G Life Hub**

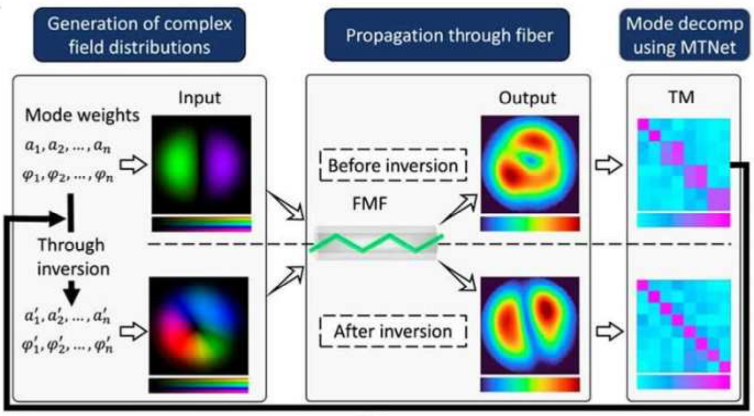
Staff: Q. Zhang, D. Pohle, Yu Miao, J. W. Czarske

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

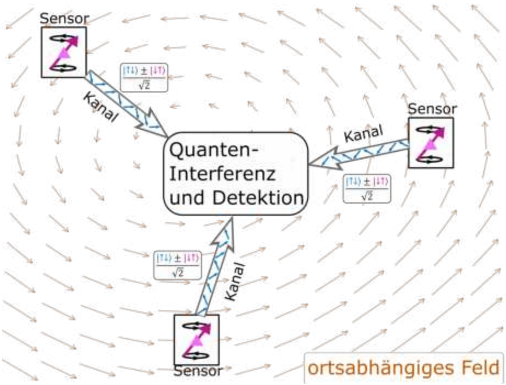
BMBF **Quantum Internet of Things (QUIET)**

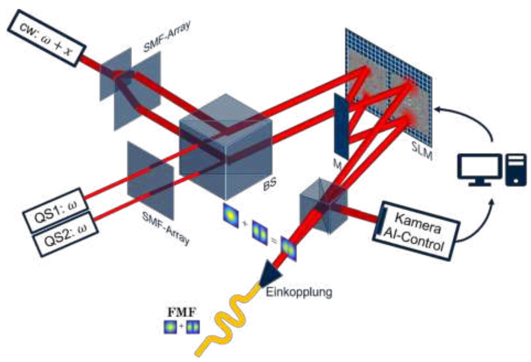
Staff: D. Pohle, Q Zhang, Jiali Sun, J. W. Czarske

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 signals provided by a sensor to a network node or central server via 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 Multiplane Light Conversion, a translation of distributed quantum signals towards a superposition of modes shall be achieved.

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

D. Pohle, F.A. Barbosa, F. M. Ferreira, J. Czarske, S. Rothe, "Intelligent self calibration tool for adaptive few-mode fiber multiplexers using multiplane light conversion." *Journal of the European Optical Society-Rapid Publications*, *19*(1), 29. (2023)

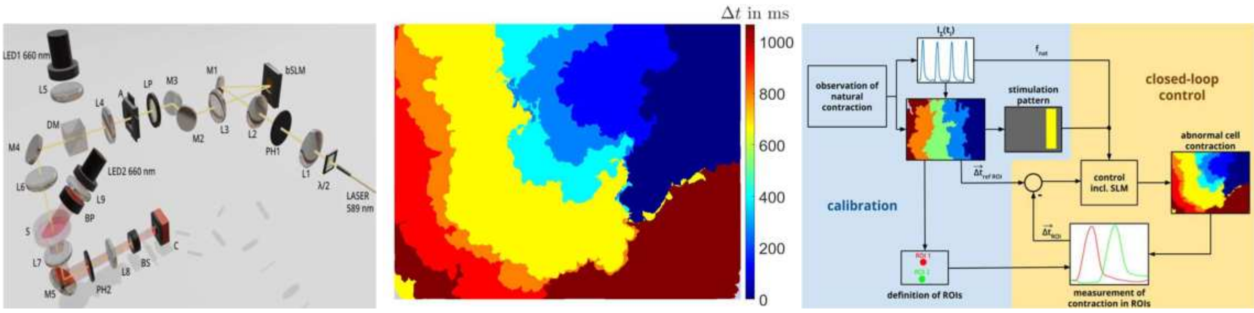
Leibinger Stiftung | **Optogenetic Stimulation and Cell Localisation in Three-Dimensional Cell Structures**

Staff: F. Schmieder, R. Wendland, L. Büttner, J. W. Czarske

Aim: Optogenetics is a set of methods for the control of the activity of genetically altered cells expressing light-sensitive membrane ion channels. Initiated by the discovery of light-sensitive membrane proteins, this exciting interdisciplinary reserach area has become a cornerstone instrument in biomedicine, promising great potential for applications ranging from fundamental research to clinical applications like the investigation of neurodegenerative diseases such as Alzheimer's or Parkinson's and the therapy of hearing impairment and the restoration of vision.
Here, this set of methods is targeted at the investigation of reentrant self-replicating contraction patterns in cardiac tissue called spiral waves. We set up an SLM-based holographic stimulation system for the optical stimulation of cardiac tissue contractions using the red-shifted membrane ion channel ChRimson. An all-optical video microscopy method for the speckle-based tracking of tissue contractions was implemented and employed to characterize optimal stimulation parameters regarding stimulation duration and power as well as to elucidate naturally occurring and stimulated contraction patterns, contraction propagation speed and direction.
Based on these methods, we conceptionalized a closed loop control as detailed in the right panel to track passing contraction wavefronts and thus adaptively react to aberrant tissue contractions. This paves the way for further research into cardiac malfunctions and future applications e.g. as an optical pacemaker.

Period: 11/22 – 10/24

Partner: Olaf Bergmann, Research Group Cell-based Model Systems, Department of Pharmacology and Toxicology, University Medical Center Goettingen



Left: Schematic of a holographic illumination setup for the stimulation and all-optical label-free recording of optogenetically excited contraction waves in genetically light-sensitized cells. Center: Temporal map of a spiral contraction wave starting at 0 ms (blue) and propagating to 1000 ms (deep red). Right: Concept for the all-optical control of human cardiomyocytes based on a calibration loop to elucidate contraction patterns and a closed control loop to react on aberrant contractions.

F. Schmieder, L. Büttner, A.T. Pierce, W. Derks, O. Bergmann, J.W. Czarske, "Single-cell investigation of excitation wavefront propagation in in vitro human induced cardiomyocytes using a digital holographic stimulation system", 27 January 2024, Part of SPIE BiOS, SPIE Photonics West, San Francisco, USA, 2024
F. Schmieder, M.A. Sikandar, R. Habibey, L. Büttner, O. Bergmann, V. Busskamp, J.W. Czarske, "Optogenetics with Human Stem-Cell-Derived Cardiomyocytes and Neuronal Networks", Optogen 2024, Prague, 16th April 2024

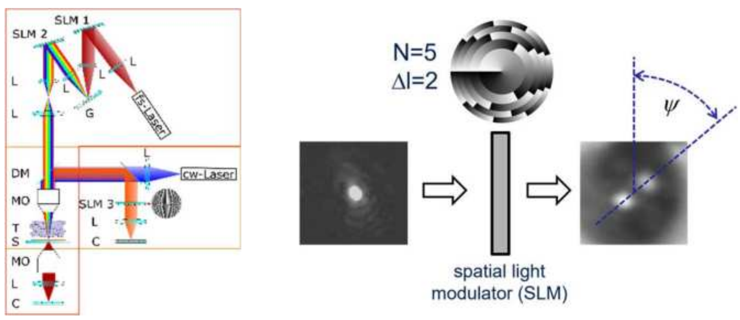
DFG **Optogenetic Stimulation and Cell Localisation in Three-Dimensional Cell Structures**

Staff: F. Schmieder, R. Wendland, L. Büttner, J. W. Czarske

Aim: Disturbances in the signal transmission are a main cause for heart arrhythmia and deadly ventricular fibrillation. However, the processes generating and interrupting these events are not fully understood yet. Optogenetics – a set of methods encompassing genetic and optical tools for the light-mediated control of cell characteristics – is a promising approach to induce, observe and control irregular signal transmission in in-vitro experiments in a spatially and temporally targeted manner for a deeper phenomenological understanding. The goal of this project is to provide the necessary tools for understanding signal transmission in three-dimensional in vitro cardiomyocyte cell structures. To this end, several approaches will be followed. First, three-dimensional optogenetic stimulation will be realized using non-linear two-photon processes to achieve cell-sized optical confinement in deep tissue (hundrets of microns). This approach will be extended using the method of temporal focusing to achieve a simultaneous stimulation of larger cell patches or volumes, guaranteeing the necessary temporal resolution for a 3d control of excitation waves in cardiac tissue.
To observe excited contraction waves in three dimensions without scanning for high temporal resolution, we will apply 3d localization microscopy and tracking of fluorescently labeled cell nuclei using the approach of point spread function engineering. Here, we will initially employ the method of the double helix point spread function, which is quite established in localization microscopy and flow measurement. Using deep neural networks for location deconvolution, we will investigate limitations regarding achievable observation depth in relation to scatter/fluorescent particle density.

Period: 10/2023 – 10/2026

Partner: Olaf Bergmann, Research Group Cell-based Model Systems, Department of Pharmacology and Toxicology, University Medical Center Goettingen



Left: Schematic of setup for simultaneous 3d targeted single cell stimulation and single shot 3d localization microscopy. Right: Principle of 3d localization microscopy with point spread function engineering. Single image points are converted to double spots using a special phase mask in fourier space. The depth of the light source can be estimated from the orientation angle ψ between the double spots which changes along the optical axis.

DFG **3D Quantum imaging with undetected light and wavefront control**

Staff: L. Büttner, J. W. Czarske

Aim: In the course of second-generation quantum technologies, quantum physical effects of light offer completely new methodological approaches also in optical imaging. The principle of induced coherence with entangled photon pairs of different wavelengths is particularly promising. The spectral separation of light illuminating the tissue and detected light represents a paradigm shift in optical imaging. Infrared photons interact with a biological sample, while the signal photons are detected with a camera. The measurement is performed with photons that never interact with the object. By detecting in the visual spectral range with silicon cameras, the signal quality is maximized. The aim of the project is to investigate the principles of wavefront manipulation and correction for the first time in quantum imaging with non-detected light in a non-linear interferometer and thus to enable gentle, marker-free 3D imaging of deep tissue with high contrast in the infrared spectral range.

However, the imaging of biological tissue exhibits some special features such as sample-induced aberrations or the three-dimensionality of the samples. For the first time, three-dimensional imaging and aberration correction with separate but entangled camera and object photons are being investigated. 3D single-shot imaging with single photons will be achieved modified point spread functions. System-related and sample-induced aberrations are corrected by the use of adaptive optical elements. The expected scientific progress lies in the gentle examination of tissue using sensitive, marker-free by means of sensitive, marker-free, chemical-selective 3D imaging with visual light.

Period: 2024 – 2027

Partner: Prof. Markus Gräfe, Technical University of Darmstadt

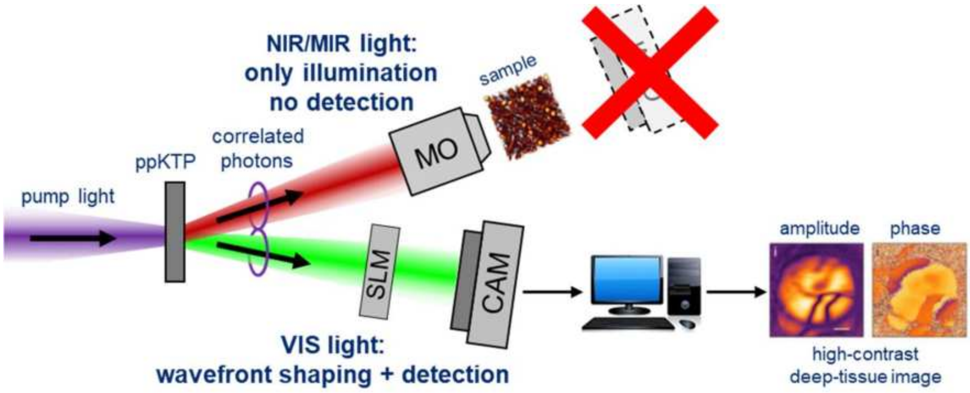


Illustration of Quantum Imaging with Undetected Light: A nonlinear crystal transforms pump light into correlated visible (VIS) and near-infrared (NIR) light beams by means of spontaneous parametric down-conversion. The NIR light illuminates the sample but remains undetected. The VIS light recorded by the camera never interacts with the sample but can reconstruct the image of the sample. Because the actual, more complicated setup is based on a non-linear Michelson interferometer, amplitude and phase of the sample can be recovered.

L. Büttner, J. Czarske, M. Gräfe, „Quantum Imaging with Undetected Light – A New IR Imaging Modality", Workshop "Optische in-Prozess Sensorik, Sensornetze und Sensorfusion, Quantensensorik", Bremer Institut für Angewandte Strahltechnik (BIAS), Bremen, 20.11.2024

AiF **Measurement methods and modeling spray cleaning – Development and application of an adaptive 3D camera measurement system for the semi-analytic modeling of spray cleaning processes.**

Staff: B. Yang, C. Bilsing, L. Büttner, J. W. Czarske

Aim: Spray cleaning is an essential process step in the manufacturing industry for food, beverages and pharmaceuticals. More efficient processes lead to increased efficiency, economics and decreased ecological impact. In this project, we want to analyze the process parameters and develop methods to acquire for the first time high-resolution data throughout the cleaning process, including the film flows and the dirt removal. A novel highspeed 3D camera based technique using engineered double-helix point spread function reveals the dynamics in the most relevant processes in spray cleaning. In the first step, the flow near the substrate is measured three-dimensionally. Secondly, we analyze the motion of dirt during removal with a spray cleaner. Following this, we measure the liquid flow and the dirt removal simultaneously. For this purpose, we develop an adaptive-optics based approch that enables optical imaging through the transparent but uneven dirt layer.

Period: 01/2022 – 09/2025

Partners: Dr. Hannes Köhler, Manuel Helbig,
Professur für Verarbeitungsmaschinen / Verarbeitungstechnik (VAT), TU Dresden

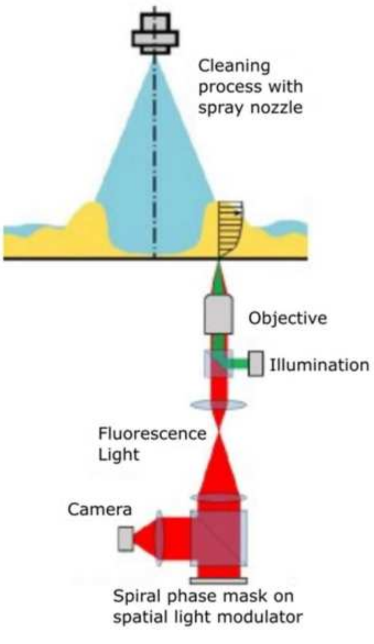


Fig. 1: Measurement setup for characterising the flow and the dirt removal at a spray cleaning process

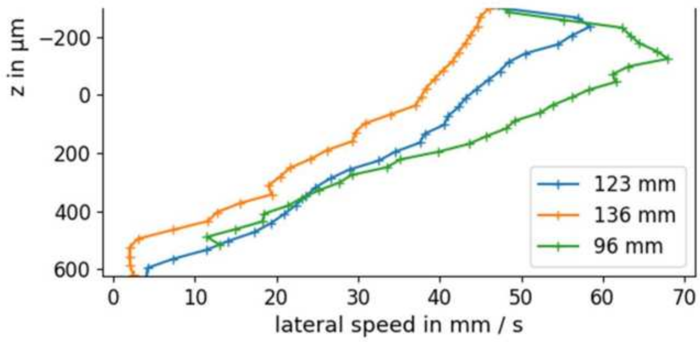


Fig. 2: Measured time-averaged flow profile of the film flow at different distances to the jet impact point.

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

Staff: C. Bilsing, L. Büttner, J. W. 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: 07/2022 – 09/2025

Partners: Rhandrey Maestri, Dr. Grégory Lecrivain, Prof. Uwe Hampel
Institute of Fluid Dynamics, Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

Fig 1: Taylor bubble in glas tube with constriction

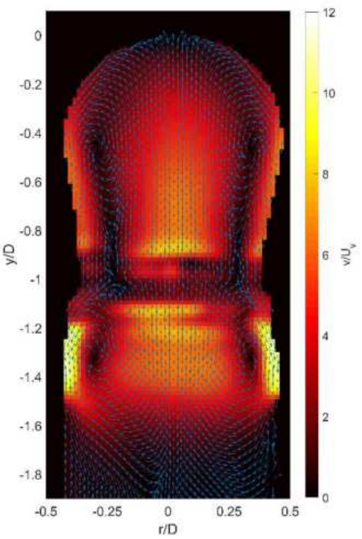


Fig. 2: Measured flow field in Taylor bubble

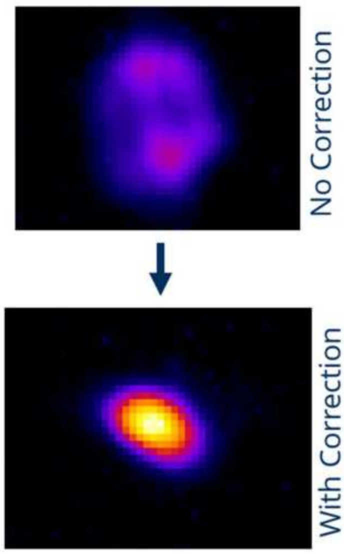


Fig. 3: Statical aberration correction with Spatial Light Modulator

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

Staff: J. Dremel, R. Kuschmierz, J. W. 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 – 12/2024

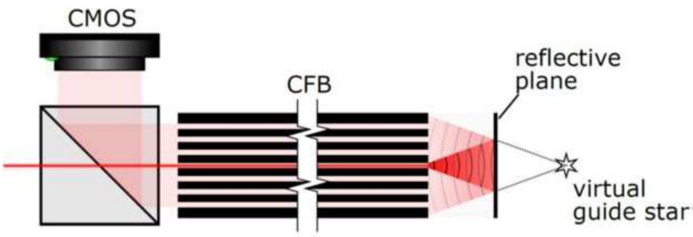


Fig. 1

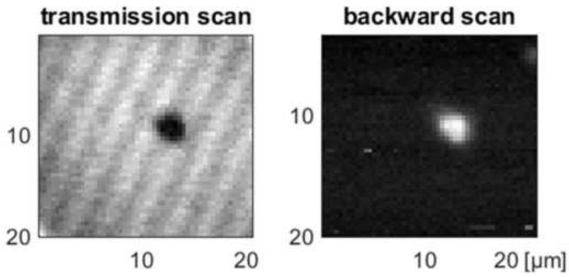


Fig. 2

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

Dremel, Jakob, Scharf, Elias, Kuschmierz, Robert and Czarske, Jürgen. "Minimal-invasive faseroptische Endomikroskopie für die Medizin" tm - Technisches Messen, vol. 89, no. s1, 2022, pp. 25-30. https://doi.org/10.1515/teme-2022-0068

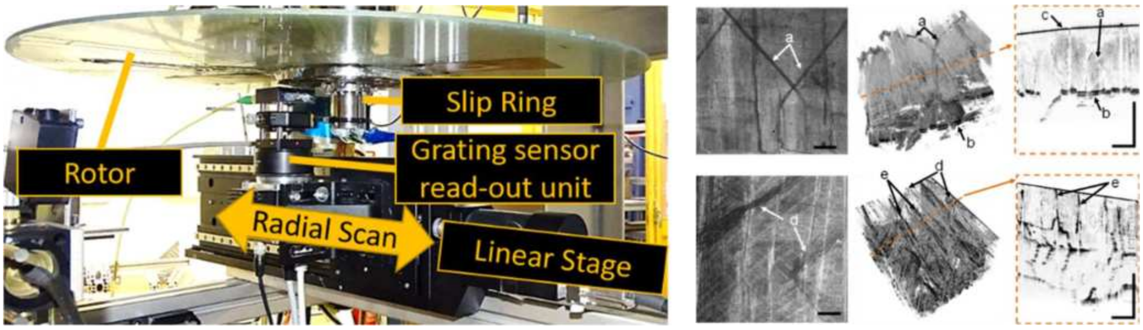
DFG **Investigation of damaged fibre-reinforced high-speed rotors using in-situ measurement systems**

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

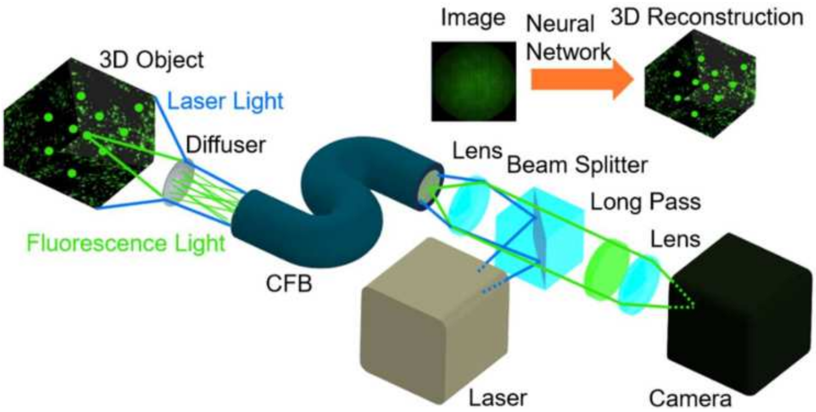
Lich, Julian, et al. "Spatially Resolved Experimental Modal Analysis on High-Speed Composite Rotors Using a Non-Contact, Non-Rotating Sensor." *Sensors* 21.14 (2021): 4705.
Filippatos, Angelos, et al. "Design and testing of polar-orthotropic multi-layered composites under rotational load." *Materials & 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**

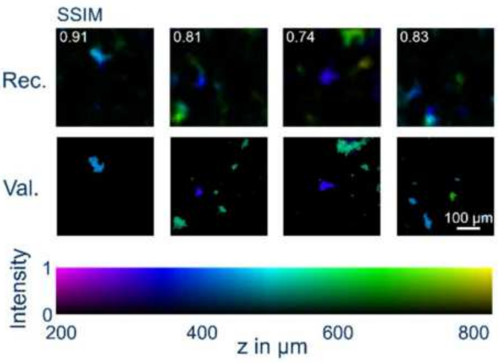
Staff: J. Lich, T. Glosemeyer, R. Kuschmierz, J. W. Czarske

Aim: Minimally invasive endoscopy offers a high potential for biomedical imaging applications. Many microscopic techniques can be transferred to endoscopy by using imaging waveguides. However, conventional fiberoptic endoscopes are based on the transmission of intensity patterns and require lens systems which are not suitable for real-time 3D imaging. In this project, a diffuser is utilized instead for passively encoding incoherent 3D objects into 2D speckle patterns. These patterns are then transmitted through imaging waveguides. Neural networks are employed for fast computational image reconstruction beyond the optical memory effect. By calibrating physics-informed network architectures with the varying point spread functions of the system, the reconstruction performance can be improved further. Illumination of fluorescent samples with a laser through the endoscope enables a paradigm shift towards single-shot 3D incoherent fiber imaging with keyhole access at video rate. Applying the diffuser fiber endoscope for fluorescence imaging is promising for in vivo deep brain diagnostics with cellular resolution, e.g. by calcium imaging.

Period: 05/2021-04/2025



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.



Fluorescence imaging with proximal laser illumination demonstrates application of diffuser endoscope for single-shot 3D incoherent imaging.

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)

J.Lich, T. Glosemeyer, J. Czarske. Single-shot 3D incoherent imaging with diffuser endoscopy, [J]. Light: Advanced Manufacturing. doi: 10.37188/lam.2024.015, (2024)

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

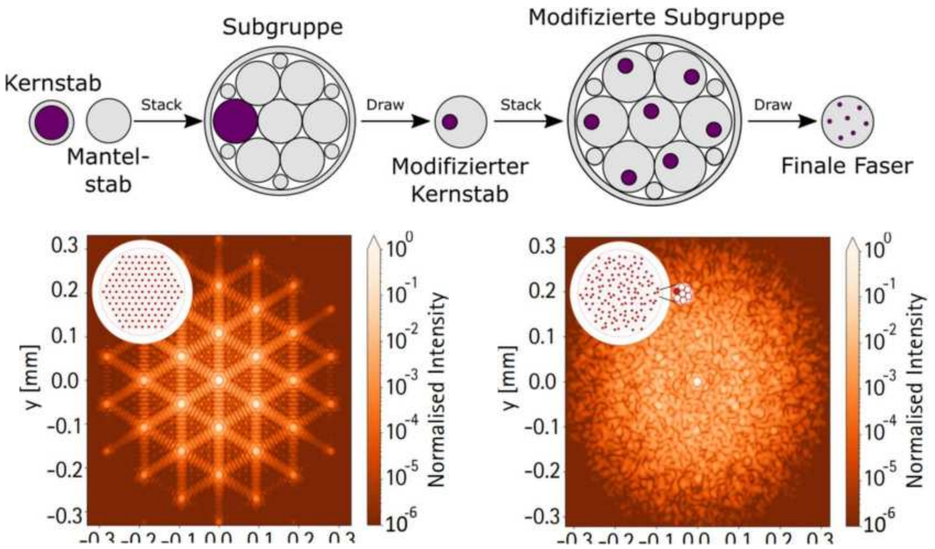
Staff: T Wang, R. Kuschmierz, J. W. Czarske

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.

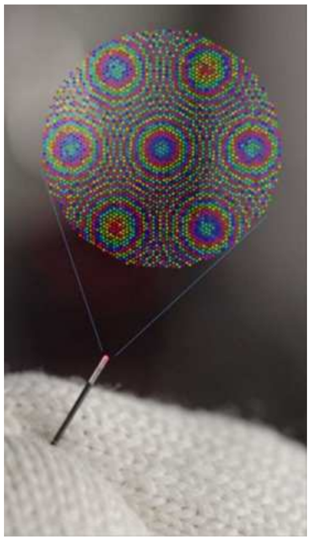
This project aims to overcome some of these issues, by implementing real time and in-situ calibration and closed loop control. Especially novel fiber designs are investigated in cooperation with Hannover Institute of Technology (HITec) of Leibniz-University Hannover, in order to achieve superior imaging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

Period: 08/2021-03/2024

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)**

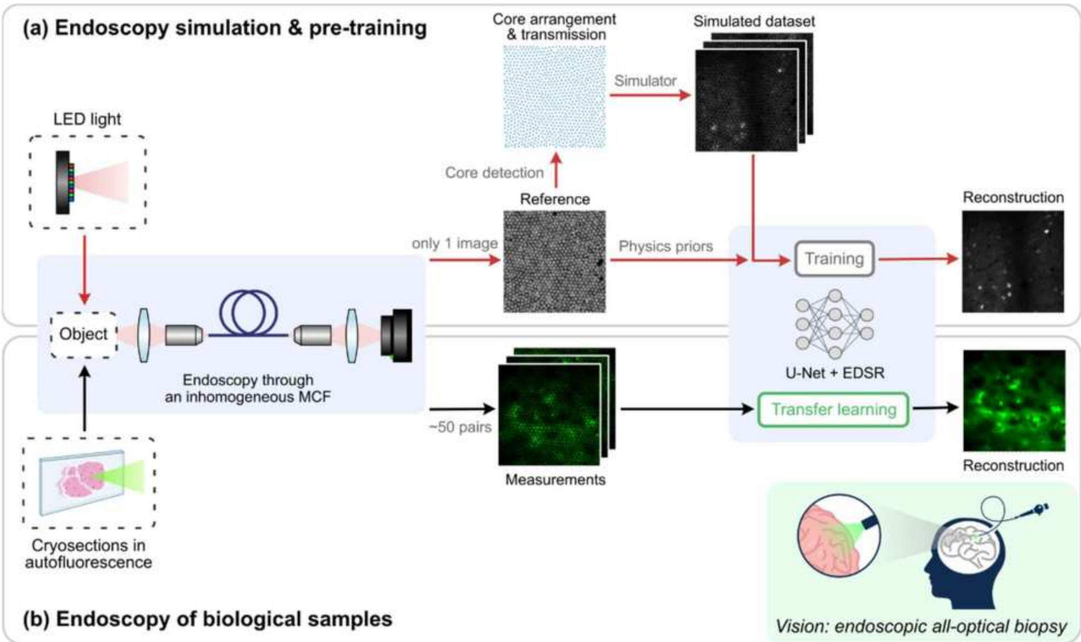
Staff: J. Dremel, T. Wang, R. Kuschmierz, J. W. Czarske

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 – 12/2024

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
Tijue Wang, J. Dremel J, S. Richter, et al. "Resolution-enhanced multi-core fiber imaging learned on a digital twin for cancer diagnosis". Neurophotonics, 2024, 11(S1): S11505-S11505.

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

Staff: H. Bischoff, Z. Dou, D. Weik, J. W. Czarske

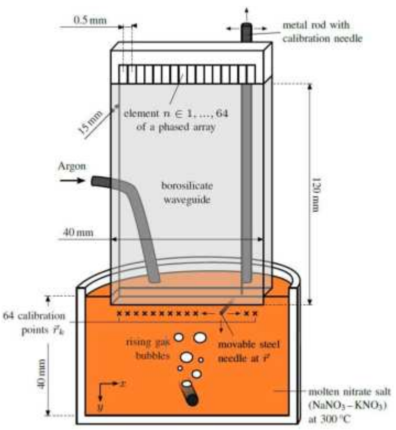
Aim: In industrial processes, such as continuous steel casting, the quality of the end pro-ducts depends on the melt flow and structure. Therefore, in situ imaging of opaque melts under harsh conditions is important. Conventional ultrasound measurement systems, which are usually suitable for imaging 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.

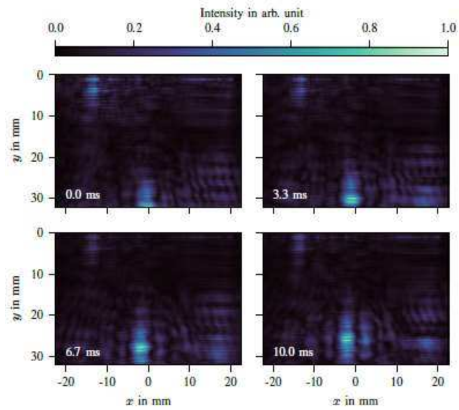
A reduced, non-invasive, ex situ calibration can be achieved by applying the time reversal virtual array method. Therefore only a limited set of precalibrated points at the waveguide-measurement volume interface are needed, which form the virtual array. The virtual array can be conceptually treated as 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: 12/2023 – 11/2026

Partner: Helmholtz-Zentrum Dresden-Rossendorf, Dr. S. 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.

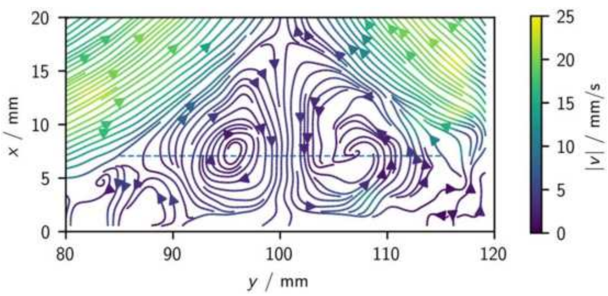
DFG **Investigation of thermal boundary layer dynamics in turbulent liquid metal convection by ultrasound localization microscopy of near-wall velocity fields and temperature measurements**

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

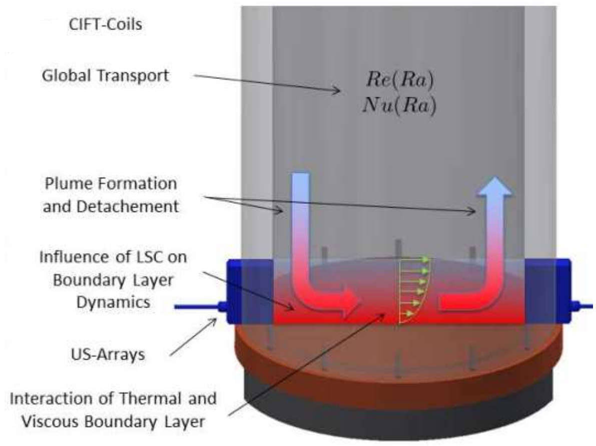
Aim: The dynamics and interaction of thermal and viscous boundary layers (BL's) will be studied experimentally in highly turbulent liquid metal convection at small Prandtl numbers using the ternary alloy GaInSn ($\mathrm{Pr} = 0.03$). Rayleigh-Bénard convection at large Rayleigh numbers of up to $\mathrm{Ra} \cong 5 \times 10^9$ 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: 04/2023 – 03/2026

Partner: Helmholtz-Zentrum Dresden-Rossendorf, Dr. S. Eckert, Dr. T. 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.

AIF **Monitoring the water content in polymer electrolyte membrane fuel cells using surface acoustic waves**

Staff: Z. Dou, D. Weik, J. W. Czarske

Aim: Optimizing water management is crucial for enhancing the lifespan and efficiency of low-temperature polymer electrolyte membrane fuel cells (NT-PEMFCs). Current methods for assessing water balance are expensive, complex, and lack real-time monitoring capabilities. In our research project, we're investigating a cost-effective method to detect water distribution with high temporal and spatial resolution during NT-PEMFC operation.

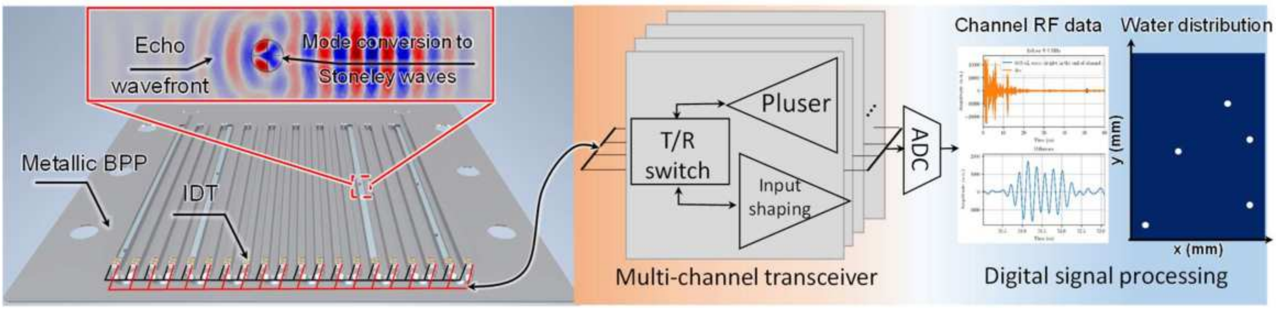
Our novel approach relies on measuring changes in the propagation properties of surface waves in the fuel cell when droplets are present in the channel. This enables us to detect the position and quantity of water droplets within the channel. By employing interdigital transducers across multiple transmission paths, we can deduce water distribution within the cell. This method has the potential to be cost-effective and widely applicable in NT-PEMFCs with metallic bipolar plates.

The collaborative project involves TU Dresden, ZBT, and IFW, aiming to develop a functional demonstratror for measuring water coverage on a fuel cell up to TRL 4. This includes the development of highly integrated ultrasonic transducers in the complex fuel cell system, along with validation and calibration processes. The practical relevance of the project will be demonstrated by applying the method in an operational fuel cell.

The diversity of companies in the project advisory committee highlights the project's promise for small and medium-sized enterprises. Significant advancements are expected in areas such as sensor technology, bipolar plate optimization, and fuel cell design. Given the high integration of components, close collaboration within the industry is essential, with the project advisory committee serving as an ideal platform for fostering partnerships and knowledge exchange.

Period: 12/2023 – 5/2026

Partner: ZBT Duisburg, Dr. L. Tropf, Dr. V. Lukasek
IFW Dresden, Dr. H. Schmidt



Schematic of the proposed measurement system. Pulse-echo-localization of water droplets is condected by means of surface acoustic waves and a transducer array.

Z. Dou, B. Fang, L. Tropf, H. Hoster, H. Schmidt, J. Czarske and D. Weik, "A Water Monitoring System for Proton Exchange Membrane Fuel cells Based on Ultrasonic Lamb Waves: An Ex-situ Proof of Concept", IEEE Transactions on Instrumentation and Measurement 72 (2023), 9601112

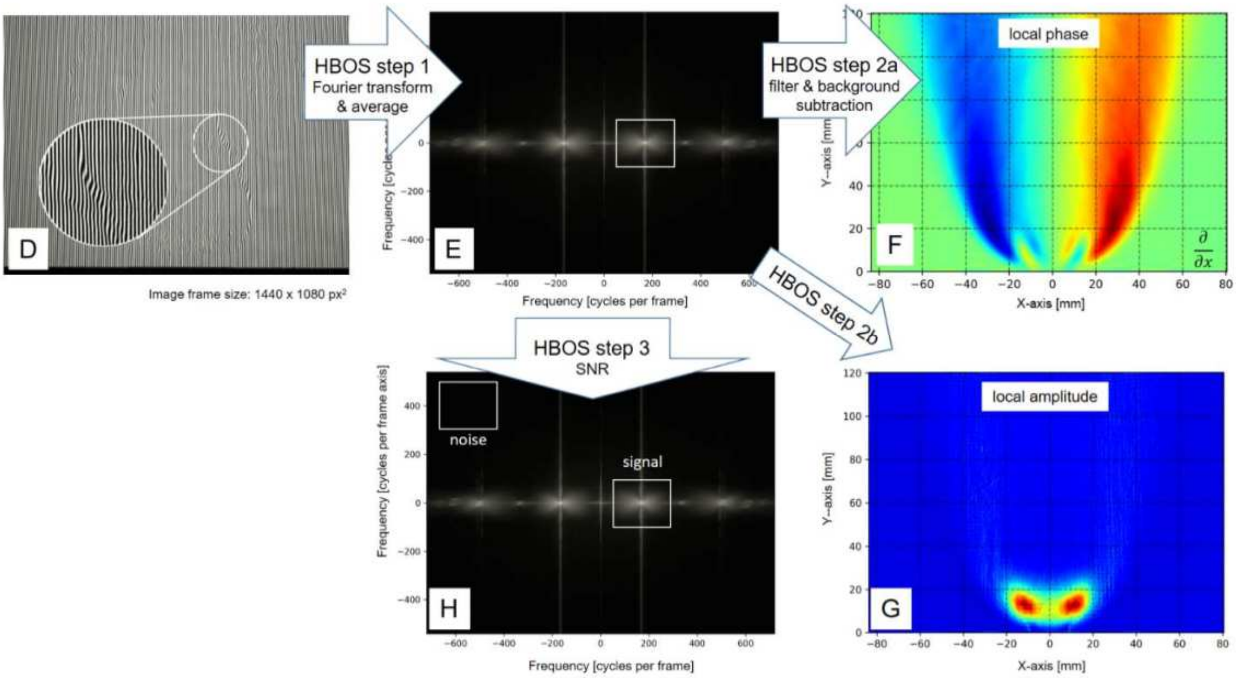
DFG **High-speed 4D measurement of thermoacoustic oscillations**

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



Heterodyne Background Oriented Schlieren measurement of a swirl stabilized flame based on Fourier domain.

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.

Tasmany, S., Kaiser, D., Woisetschläger, J., Gürtler, J., Kuschmierz, R., Czarske, J., "Heterodyne background-oriented schlieren for the measurement of thermoacoustic oscillations in flames." Exp Fluids 65, 151 (2024)

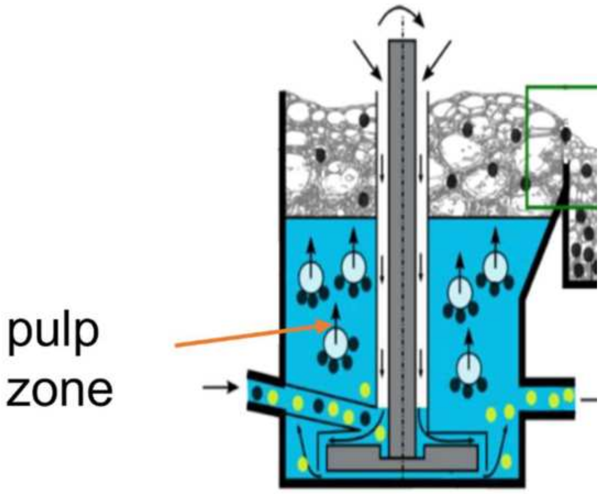
HZDR **In-process monitoring of phase fractions in multiphase processes using ultrasonic multi-frequency approaches**

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

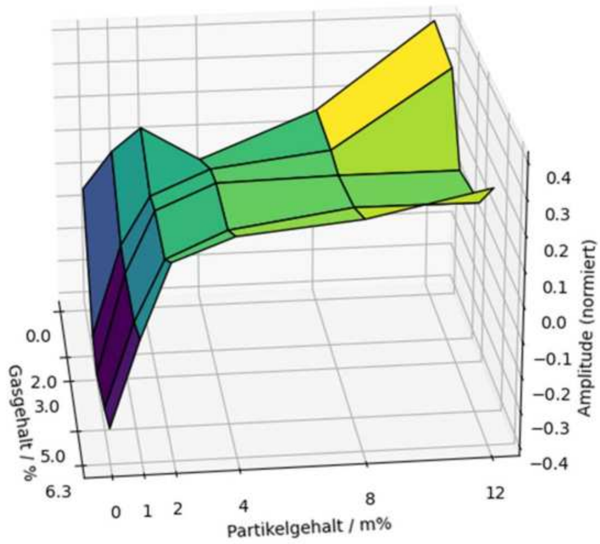
Aim: In 2016, about 20 billion liters of water were used, only to extract copper as a raw material. The process used is the froth flotation. Grained materials are being separated by the use of surfactant solutions. Ascending bubbles transport the hydrophobic materials to the surface, consisting of a 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 is to unambiguously characterize the material phase fractions within the pulp zone. Consisting of water, air and particles it represents a multiphase process, difficult to penetrate for various measurement systems. Using different ultrasonic frequencies, we can apply ultrasound-spectroscopy. Different wavelength get scatterd back and are attenuated differently from various material sizes (i.e. bubbles, particles). Using different signal processing techniques we can emphasise differences and similarities of the backscattered signals to solve the inverse problem of particle and air fraction. Thereby we are one step closer to a control loop that potentially increases the yield and saves energy and resources.

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

Period: Q4/2022 – Q4/2025



Scheme of a flotation cell



Heterodyne Background Oriented Schlieren measurement of a swirl stabilized flame based on Fourier domain evaluation with single pixel resolution.

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, 2023

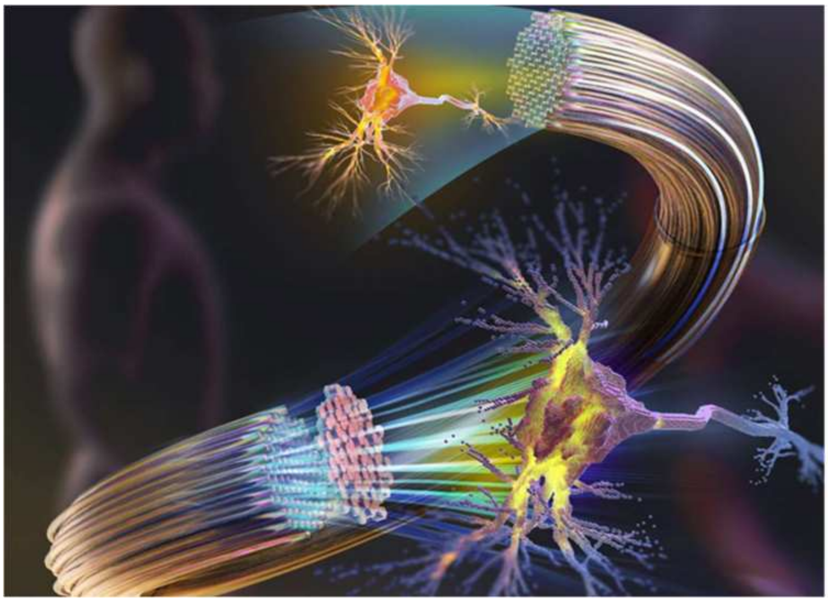
EFRE/SAB Minimally invasive fiber endoscopy using laser strcured waveguides

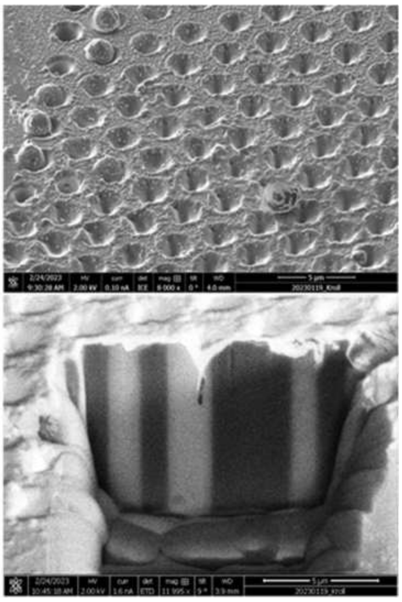
Staff: K. Zolnacz, R. Kuschmierz, J.W. Czarske

Aim: The thinnest and simplest endoscopes can be realized based on image waveguides (CFBs). Research is currently underway worldwide on CFB endoscopes without complex imaging optics in the measuring head. As a result, the endoscope diameter is only limited to <500 µm by the fiber diameter. However, strong and different aberrations (phase disturbances) occur for each CFB. Transmission of light through CFBs. With conventional endoscopes, only the light intensity can be controlled evaluated, the important phase information is lost. But this only includes 2D recordings fixed image plane and a few 1,000-100,000 pixels possible. The most studied approach for a unpixelated 3D imaging consists of measuring the aberrations of the CFB and their compensation (DOPC, digital optical phase conjugation) using programmable, digital, optical Area light modulators. This enabled impressive and relevant applications to be demonstrated will, among other things, Fluorescence microscopy, 2-photon microscopy, CARS, cell ablation, single cell rotation and -Tomography. However, the structures presented are extremely complex, expensive and sensitive compared to misalignment, so that they do not yet make their way out of the optics laboratory and into realistic ones Conditions of application have been found.

The aim is to expand commercial image waveguide components for the pure transmission of images (i.e. the light intensity) to components for the transmission of the complete light information from light intensity and light phase. For the first time, this should not be done with digital modulators, but with advances be used in optical manufacturing technology. The realized fibers are monolithic and therefore robust. They can therefore be used by a wide range of users and can be integrated into existing microscopes insert to expand their range of application from ex vitro to in vivo, for example for minimally invasive and label-free histopathology in the brain.

Period: 10/2023 – 12/2024





Left: Sketch of a Holographic 3D fiber bundle endoscope. A diffractive optical element is used to compensate the inherent phase scrambling of the fiber. Right: SEM image of an fiber facette after laserablation for DOE manufacturing.

K. Zolnacz, R. Stephan, J. Dremel, K. Hausmann, M. Liessmann, M. Steinke, J. Czarske, R. Kuschmierz, „Multicore fiber with thermally expanded cores for increased collection efficiency in endoscopic imaging," Light Advanced Manufacturing 49 (2024)

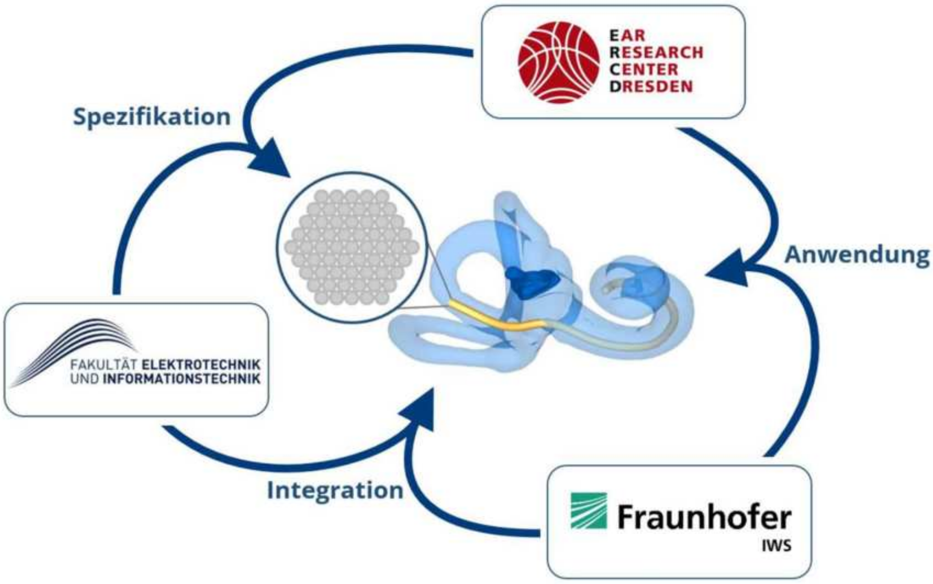
SAB **Optical inspection for the Scala Tympani for 3D real-time acquisition (OPTISCALA)**

Staff: J. Dremel, R. Kuschmierz, J. W. Czarske

Aim: The development of an innovative, optical, fiber-based procedure for minimally invasive 3D real-time detection of intracochlear structures. This procedure should enable automated CI-ET insertion into the Scala tympani under direct vision and with AI-supported real-time position correction of the electrode for the first time in the future. The sensitivity and specificity in the detection of cochlear trauma and ET malpositions should be significantly increased and their absolute occurrence significantly reduced. The proposed project aims to develop and test a multi-core fiber probe (10,000 cores, total diameter of the fiber bundle incl. attachment: 450µm) for support and 3D imaging during the insertion of implant insertion. Such small and flexible endoscopes are currently not available. The imaging probe is based on lenless holographic fiber imaging and to be tested in an additively manufactured model of the human cochlea as well as in a human temporal bone-

Partner: Prof. Dr. T. Zahnert & Dr. C. Müller, Ear Research Center Dresden
Prof. Dr. P. Hartmann & Dr. J. Golde, Fraunhofer AZOM Zwickau

Period: Q2/2024 – Q2/2027



Project volume based on fundamental research (DFG, etc), applied research (BMBF, SAB, AiF/ZIM) and industry projects

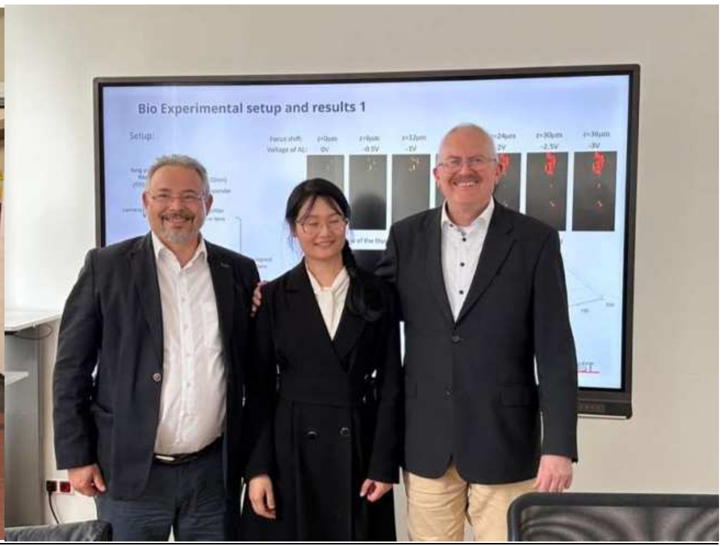
PhD Theses

Dr Wenjie Wang

Investigation of three-dimensional scanning microscope employing adaptive lenses and tunable prisms for zebrafish studies

Abstract:
Optical microscopy utilizing point-wise scanning techniques employs a laser focal spot to examine specimens, typically achieving a high lateral resolution of less than a micron.
To realize 3D scanning, additional scanning mechanisms are necessary to both axially and laterally control the position of the focus. However, conventional scanning mechanisms, such as mounting the detection objective lens on a motorized stage for displacement along the optical axis, often face speed limitations due to the inertia of the objective lens. Stability is another challenge due to the reliance on mechanical movement, which can introduce vibrations and artifacts, thereby affecting imaging quality. Conventional lateral scanning mechanisms mostly use reflective components such as galvo mirrors. However, these configurations result in longer optical beam paths, which lead to bulkier setups. This thesis introduces, for the first time, an additional scanning technique that combines adaptive lenses and tunable prisms to control the focal spot both axially and laterally. The adaptive lenses with two degrees of freedom allow for compensation of axial focus shift without mechanical movement and for the simultaneous correction of sample-induced aberrations, while the tunable prisms avoid the beam folding issues present in conventional lateral scanning mechanisms, enabling a compact lateral scanning system. With the advancement of adaptive lenses, multi-actuator lenses now enable not only axial scanning by tuning the shape of the lens surface but also the correction of rotationally symmetric aberrations simultaneously. However, the demands for monitoring adaptive lenses to achieve desired behavior, particularly for those with large tuning ranges or multiple degrees of freedom, can be high. In this thesis, partitioned aperture wavefront (PAW) sensing is successfully used to characterize a novel adaptive lens with a tuning range of -22 to 19 dpt, an aperture of 10 mm, and two actuators that allow for the tuning of focal length and spherical aberrations simultaneously through voltage pairs ranging from -30 V to +120 V. Using PAW sensing, the remaining relative defocus error is <1% while the error of targeted spherical aberration is <5%. This confirms that PAW sensing successfully validates the ability of novel adaptive lenses to manipulate spherical aberration. To verify the capabilities of adaptive lenses and tunable prisms to be combined with scan objectives, a designed telecentric f-theta scan objective provides a solution. It represents the first successful integration of adaptive lenses and tunable prisms in a compact system utilizing only a single 4F configuration, which minimizes the number of optical components while still achieving 3D scanning. Volumetric measurements of the transgenic fluorescence of the thyroid of a zebrafish embryo and mixed pollen grains provide evidence of the volumetric imaging capabilities of this approach. It highlights that this microscope is capable of performing flexible scanning with a uniform lateral resolution of 2.2 µm over a large tuning range of X=Y=6300µm and Z=480µm with only transmissive components in a compact system. Compared to commercial point-wise scanning techniques for 3D imaging, this method highlights unique advantages such as the ability to perform 3D scanning across substantially larger volumes of up to 19 mm^3, a transmissive compact design, the elimination of beam folding and mechanical movement, and integrated aberration correction. Electrically controlled elements enable stable real-time adjustments and eliminate vibrations and artifacts typically introduced by commercial 3D scanning techniques. Adaptive lenses capable of correcting spherical aberrations exhibit response times below 0.2 ms, making them ideal for high-speed axial adjustments. The trade-off is that the current resolution, at approximately 2.2 µm, has not yet reached the sub-micron levels achievable with commercial point-wise scanning techniques. Future work aims to scale the resolution down to sub-micron levels while preserving the system's unique benefits. In conclusion, the research based on the control of adaptive lenses and

tunable prisms provides a viable solution to improve large-range volumetric imaging in compact transmissive systems. This is also one of the key research focuses of the Biomedical Computational Laser Systems (BIOLAS), enabling flexible 3D scanning. These new adaptive elements also offer the potential to develop highly compact, even handheld microscopes, opening new possibilities in 3D biomedical imaging. Furthermore, this work aligns with the research priorities of Physics of Life (PoL). On one hand, the proposed approach demonstrates significant potential for developing 3D smart microscopes, and on the other hand, the electrically controlled adaptive elements provide precise and flexible control, supporting the study of biophysical mechanisms. In summary, this work represents a crucial first step toward the development of flexible, aberration-free, stable, and large-volume 3D smart microscopy for biomedical studies, laying the foundation for future advancements in volumetric imaging techniques based on adaptive elements.



Doctoral hat awarding Chair Andreas Richter, Wenjie Wang, Juergen Czarske

Dr Wenjie Wang during the extraordinary exam at the doctorial hat

Chair
Prof. Dr.-Ing. Andreas Richter
Reviewer
Prof. Juergen W. Czarske
Prof. Dr.-Ing. Ulrike Wallrabe
Prof. Dr. rer. nat. Stefan Sinzinger
Exam:
Prof. Dr.-Ing. Hubert Lakner
Prof. Juergen W. Czarske

Dr Ilenia Meloni

Adaptive light sources for optogenetic stimulation of Drosophila melanogaster


Caroline Murawski, Ilenia Meloni, Juergen Czarske, Hagen Malberg / Ilenia Maloni with doctorial hat

Abstract:
Optogenetics, a revolutionary technique that utilizes light-sensitive proteins called opsins to control neuronal activity, has transformed the field of neuroscience by providing unprecedented precision in the study of neural circuits and behavior. This thesis focuses on the application of optogenetics in Drosophila melanogaster research, aiming to advance our understanding of neural circuits and behavior through the development of adaptive light sources, and a set of homemade tools to simplify the design of optogenetic experiments, combining biology, engineering and computer science approaches. The first goal of this research was to find new, low-cost, and versatile ways to perform optogenetic experiments. This led us to the exploration and characterization of smart-phone displays as light sources for optogenetic stimulation. By utilizing smartphone displays, the activation and inhibition of various cell types, including motoneurons, muscles, sensory neurons, and multidendritic neurons, were achieved in Drosophila larvae and flies. This approach expands the possibilities of optogenetic research, making it accessible for students and researchers to easily perform experiments with small animals, at high temporal and spatial resolution, or even the light and spectral requirements of novel light-sensitive proteins. To facilitate optogenetic experiments, software tools were developed to accurately quantify light spatial distribution and analyze larval behavior. Spatial light distribution simulations provided insights into the emitted light from displays aiding us in the planning and understanding of the experimental results, tailored for light emitted by displays, and based on physical measurements rather than on simple assumptions on light spreading. Furthermore, an automatic feature
extraction tool enhanced the understanding of larval responses to light stimuli, capturing key behavioral events such as stops, sweeps, turns, and runs. This aids us in extracting a high number of behavioral characteristics, automatically, accurately and in less time compared to manual behavioral feature definition. The manipulation of complex light patterns using smartphone displays allowed us to design experiments for guiding larval movement. By integrating smartphone optogenetics, spatial light distribution simulations, and behavior feature extraction techniques, responses of larvae to dierent light profiles were elucidated, contributing to the understanding of larval behavior and its underlying mechanisms, particularly investigating the nociceptive adaptation of larvae in dierent gradients of light, showing similar adaptability in Drosophila larvae as in humans. Additionally, investigations into the control of larval feeding behavior using optogenetics shed light on the influence of non-neuronal cells, specifically the salivary

glands, on feeding regulation. Manipulating these glands through optogenetic techniques resulted in significant changes in larval feeding behavior, emphasizing the need to consider the contribution of other organs alongside neural control when studying animal behavior, and demonstrating for the first time optogenetically driven cannibalism in larvae. Moreover, the integration of bicolored Organic LEDs (OLEDs) with bidirectional optogenetics opens new avenues for studying neural circuits and developing therapeutic interventions for neurological disorders. The precise control of larval motoneurons and locomotor systems using these AC/DC OLEDs holds promise for investigating the role of single neurons in complex behaviors and potentially restoring locomotion in patients with spinal cord injuries. This thesis contributes to the field of optogenetics by advancing the understanding of larval behavior and its modulation through light stimulation. The novel adaptive light sources, tools for analysis, and insights gained from the experiments provide a framework for further exploration of neural circuits and behavior in Drosophila melanogaster and other small animal models.

Chair:
Prof. Dr.-Ing. Habil. Hagen Malberg
Review:
Prof. Dr.-Ing. habil. Jürgen W. Czarske
Prof. Dr. Malte C. Gather
Dr. Caroline Murawski

Diploma and Master Theses

Yuqi Xue „Characterization of polarization scattering of multi-mode fibers for space division multiplexing", 02/24

Wenting Geng "High-dimensional Quantum Information Transmission using Few-mode Fibers", 03/24

Jie Zhang "Illumination scanning tomography towards label-free 3D imaging of organoids", 03/25

Veronika Volkova "Characterization of thermally modified multicore fibers for applications in endoscopic imaging", 05/24

Hannes Bischoff „Compressive-Sensing zur Ultraschallbildgebung mit reduzierten Empfangskanälen" 06/24

Tobias Irrgang „Ultraschallbildgebung mit Einkanal-Ultraschallköpfen durch komprimierende Multimode-Wellenleiter", 07/24

Jonas Kreissl „Entwicklung und Validierung eines Software-Frameworks zur Modellierung medizinischer Roboter", 07/24

Yu Miao „Diffraction neural network for mode demultiplexing in multimode fibers", 08/24

Jiali Sun „Transfer learning-based physics-informed neural networks for phase retrieval of multimode fibers", 09/24

Johanna Hoppe „Ultrasound-Based Deep Learning-Assisted Real-Time Tracking of Microbots" 09/24

Ronghei Fu "Fiber-endoscopic imaging restoration using generative adversarial network", 10/24

John Böhm „Wavefront shaping with second harmonic generation based guidestars", 10/24

Robert Wendland “Optische Regelung der optogenetischen Aktivität humaner Kardiomyozyten“, 11/24

Erik Nützennadel “Charakterisierung der Messunsicherheitsreduktion durch adaptive Optik bei 3D-Mikroskopie“, 11/24

Chengxiao Wang „ Hardware-in-the-loop deep learning for imaging through the multimode optical fiber”, 12/24

Bachelor and Student Theses

Malte Weigelt “Untersuchung der akustischen Auswirkung von Schallkanal-geometrien für luftgekoppelte Phased-Arrays zur bildgebenden Messung von Flotationsschäumen“, 02/24

Ming Lin “Lernbasierte Optimierung einer Phasenmaske für endoskopische 3D-Bildgebung mit neuronalen Netzen“, 03/24

Luca Antonia Linhsen „Endoskopische, konfokale Fluoreszenzbildgebung durch phasenkorrigierte Mehrkernfaserbündel“, 04/24

Yuezhen Xu “Water monitoring in fuels cells using ultrasound reso-nance spectroscopy”, 04/24

Veronika Volkova „Establishment and characterization of a ablation procedure for phase compensation” 06/2024

Zhenyu Huang “Image based multi-basis fiber characterization for space division multiplexing”

Zixuan Cai “Ermittlung des Messunsicherheitsbudgets einer neuartigen Beugungsgittersensor-Ausleseeinheit durch Nutzung eines digitalen Zwillings“, 07/24

Daniel Hermann „Comparing Digital image Correlation and Diffraction gratings for Strain field Measurements“, 08/24

Arjun Ananth „Lamb Waves based Localization of Water Droplets for Fuel Cells – Analysis of Environmental and Operational Condition Effects”, 10/24

Fang Lyu „Ultraschallbasierte Messung des Gasgehaltes eines Mehrphasengemisches durch Nutzung eines Multiprocessor System-On-A-Chip zur Systemintegration”, 10/24

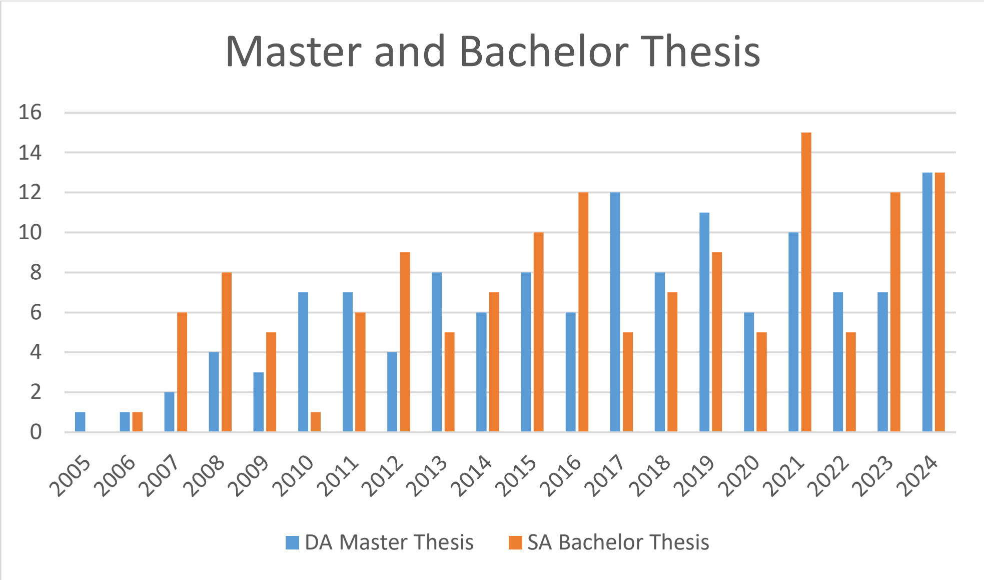
Chuan Shi „Optical diffractive neural network for multiplexing and demultiplexing orbital angular momen-tum modes”, 10/24

Nhidhin Jose „Design and commissioning of a highly integrated ultrasound measurement device and its characterization”, 12/24

Yuedi Zhang “Development of smart FPGA-based mode demultiplexer for multimode fiber”, 06/24

Niklas Weise “Konzeptionierung und Implementierung der Prozesskette zur Fertigung von phasenkorrigierten kohärenten Faserbündeln mittels Ablation“, 11/24

Wenhao Ma “3D-Lokalisierungsmikroskopie mit Hilfe von Deep Learning“, 12/24



Total in 20 years, 272: 131 Bachelor Theses (SA) and 141 Master Theses (DA)

SCI-Publications in journals with peer review process

J. Dremel, et al., "Lensless single-shot multicore fiber endomicroscopy using a single multispectral hologram" Light: Advanced Manufacturing, 2024

J. Sun, B. Yang, N. Koukourakis, J. Guck, J.W. Czarske, “AI-driven projection tomography with multicore fibre-optic cell rotation.”, Nature Communications 15, 147 (2024)

C. Bilsing, E. Nützenadel, S. Burgmann, J. Czarske, L. Büttner, “Adaptive-optical 3D microscopy for microfluidic multiphase flows”, Light: Advanced Manufacturing 5:37 (2024)

J. Lich, T. Glosemeyer, J. Czarske, R. Kuschmierz, “Single-shot 3D incoherent imaging with diffuser endoscopy”, Light: Advanced Manufacturing 5(15), (2024).

J. Sun, B. Zhao, D.W. Zhigang Wang, J. Zhang, N., J. W. Czarske, X. Li, “Calibration-free quantitative phase imaging in multi-core fiber endoscopes using end-to-end deep learning”, Optics Letters, 2024 - opg.optica.org

F. Bürkle, R. Maestri, G. Lecrivain, U. Hampel, L. Büttner, J. Czarske, “Investigation of the gas and film flow of Taylor bubble in a tube with a short constriction employing 3D particle tracking”, Experimental and Computational Multiphase Flow (2024)

Z. Gao, X. Ge, L. Zhu, S. Ma, A. Li, L. Büttner, J. Czarske, P. Yang, “Flow field estimation with distortion correction based on multiple input deep convolutional neural networks and Hartmann-Shack wavefront sensing”, Photonics 11(5), 452 (2024)

T. Wang, J. Dremel, , S. Richter, W. Polanski, O. Uckermann, I. Eyüpoglu, J.W. Czarske, R. Kuschmierz, “Resolution-enhanced multi-core fiber imaging learned on a digital twin for cancer diagnosis.”, Neurophotonics, 2024, 11(S1): S11505-S11505

R. Maestri, S. Radhakrishnakumar, F. Bürkle, W. Ding, L. Büttner, J. Czarske, U. Hampel, G. Lecrivain, “Equilibrium Taylor bubble in a narrow vertical tube with constriction”, Physics of Fluids 36, 032108 (2024).

J. Sun, R. Kuschmierz, O. Katz, N. Koukourakis, J.W. Czarske, “Lensless fiber endomicroscopy in biomedicine”, PhotoniX, Perspective review, volume 5, Article number: 18 (2024)

K. Zolnacz, R. Stephan, J. Dremel, K. Hausmann, M. Liessmann, M. Steinke, J. Czarske, R. Kuschmierz, “Multicore fiber with thermally expanded cores for increased collection efficiency in endoscopic imaging,” Light Advanced Manufacturing 49 (2024)

S. Tasmany, D. Kaiser, J. Woisetschläger, J. Gürtler, R. Kuschmierz, J.W. Czarske, “Heterodyne background-oriented schlieren for the measurement of thermoacoustic oscillations in flames.” Exp Fluids 65, 151 (2024)

S. Rothe, F.A. Barbosa, J.W. Czarske, F.M. Ferreira, “Unlocking mode programming with multi-plane light conversion using computer-generated hologram optimisation", JPPHOTON-100637.R1, Journal of Physics: Photonics, 2024

Invited talks at conferences (with proceedings) and seminars (without proceedings)

J Czarske, Q Zhang, D Pohle, Yu Miao, Jiali Sun, Fiber-optical Sensing and Communication exploiting physics-informed deep learning and quantum technology, invited by Filipe Ferraro, UCL, OPTICA, Optica British and Irish Conference on Optics and Photonics, IET London: Savoy Place, London, United Kingdom, 18 - 20 December 2024

J.W. Czarske, Q. Zhang, D. Krause, R. Kuschmierz, T. Glosemeyer, J. Dremel, J. Sun, K. Koukourakis, Multimode Fiber Communication and Multicore Fiber Endoscopy Exploiting Physics-informed Deep Neural Networks, Hong Kong, 5 Dec. 2024

J.W. Czarske, Q. Zhang, D. Krause, R. Kuschmierz, T. Glosemeyer, J. Dremel, J. Sun, Biomedical Imaging, Sensing and Communication with Multicore and Multimode Fibers Exploiting Physics-Informed Deep Neural Networks, Shenzhen, 4 Dec 2024

J.W. Czarske, F Schmieder, R Wendland, L Buettner, R. Kuschmierz, T. Glosemeyer, J. Dremel, J. Sun, N Koukourakis, Lensless multicore fiber endoscopy and holographic optogenetics with organoids towards advancing biomedicine, Melbourne, Monash, 2 Dec 2024

J.W. Czarske, K Żołnacz, R. Kuschmierz, J. Dremel, M. Steinke, R. Stephan, "Lensless 3D imaging using multicore fiber endoscopy and Two-Photon Polymerization (2PP)-printed holograms towards advancing biomedicine, Workshop on 3D printing of Photonics Components-Session 3: 3D printing of polymer, invited by Jiawen Li and Heike Ebendorff-Heidepriem, Melbourne, RMIT, Dec 1, 2024

J.W. Czarske, D. Krause, R. Kuschmierz, T. Glosemeyer, J. Dremel, J. Sun, K. Koukourakis Lensless 3D imaging using multicore fibers exploiting physics-informed deep neural networks towards biomedicine, invited by Jiawen Li, Adelaide, 29 Nov 2024

J.W. Czarske, Q. Zhang, D Pohle, R. Kuschmierz, T. Glosemeyer, J. Dremel, J. Sun, Optical Fiber Technology for Biomedical Imaging and Communication Exploiting Physics-informed Deep Neural Networks, Singapore, 27 Nov 2024

J.W. Czarske, Q. Zhang, D. Pohle, S. Rothe, N. Koukourakis, R. Kuschmierz, J. Dremel, L. Buettner, Physics-informed deep neural networks for multicore and multimode fibers towards advancing biomedicine and quantum communication, Shanghai, SIOM, invited by Situ Guohai, 25 Nov 2024

J.W. Czarske, Q. Zhan, J. Sun, S. Rothe, Physics-informed deep neural networks for mode decomposition in quantum and classical communication, Shanghai, Conference on Neuromorphic Photonics, 24 Nov 2024

J.W. Czarske, K Żołnacz, R. Kuschmierz, J. Dremel, Lensless 3D imaging using multicore fibers with holograms by additive and subtractive manufacturing, invited from Wolfgang Osten, Conference of Light Advanced Manufacturing, Guangzhou, 21 Nov 2024

J.W. Czarske, F. Schmieder, R. Wendland, L. Buettner, Human induced pluripotent stem cell-derived neurons and cardiomyocytes investigated by holographic closed-loop optogenetics, OWLS-17, Mumbai (invited by Prof. Sudipta Maiti (Professor and Chair, Department of Chemical Sciences, TIFR Mumbai) appointed as the new President of International Society on Optics Within Life Sciences-OWLS), India, 19 Nov 2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, Q. Zhang, L. Buettner, Physics-informed deep neural networks for multicore and multimode fiber sensors towards biomedicine and communication, invited by

Prof Azizur Rahman, Professor of Photonics at City University, Seminar of Student Chapter of IEEE Photonics Society, City University London, 1 Oct 2024

J.W. Czarske, D. Pohle, T. Glosemeyer, R. Kuschmierz, Q. Zhang, L. Buettner, Multimode fiber communication exploiting physics-informed deep neural networks towards physical layer security and entangled photon teleportation, invited by Dr Filipe Marques Ferreira and Prof Polina Bayvel, University College London, United Kingdom, Seminar of Student Chapter of OPTICA and IEEE Photonics Society, University College London, 31 Sep. 2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, C. Bilsing, L. Buettner, Lensless multicore fiber endoscopy and double-helix point spread function-based imaging towards advancing biomedicine, University of Boulder, Seminar, invited by Prof Rafael Piestun, 26 Sep. 2024

T. Glosemeyer, J. Lich, R. Kuschmierz, J. Czarske, 3D Diffuser Encoded Imaging and Physics-Informed Neural Network Reconstruction, invited by FiO1, Conference OPTICA FiO and LS, Denver, 25 Sep 2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, L. Buettner, Single-shot imaging exploiting physics-informed deep learning and second-generation quantum technology, Seminar, invited by Prof F. Willomitzer, Tucson, 26 Aug 2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, N. Koukourakis, Lensless single-shot 3D imaging towards biomedicine, invited by Optica Student Chapter and Prof Robert Alfano, 29 Aug 2024, City College of New York

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, J. Dremel, T. Wang, N. Koukourakis, Physics-informed deep neural networks for multicore and multimode fiber information transmission towards biomedicine and communication, invited by Prof Hui Cao, 30 Aug 2024, Yale University

J.W. Czarske, T. Glosemeyer, J. Dremel, T. Wang, R. Kuschmierz, L. Buettner, Paradigm shifts with physics-informed deep neural networks for lensless single-shot imaging towards biomedicine, invited by Aydogan Ozcan, Samueli Electrical and Computer Engineering, Chancellor's Professor and HHMI Professor at UCLA, Los Angeles, 16 Aug 2024

T. Glosemeyer, J. Lich, J. W. Czarske, R. Kuschmierz, Diffuser endoscopy for single-shot fluorescence imaging using physics-informed deep learning, 19 August 2024, Part of Nanoscience + Engineering, Conference 13112, Optical Trapping and Optical Micromanipulation XXI, SPIE San Diego, invited

J. Sun, Z. Chen, Y. Tang, B. Yang, Z. Wang, G.Huang, B. Zhao, X. Li, J.W. Czarske, AI-driven multicore fiber-optic cell rotation, 19 August 2024, Part of Nanoscience + Engineering, Conference 13112, Optical Trapping and Optical Micromanipulation XXI, SPIE San Diego, invited

J.W. Czarske, J. Zhang, N. Koukourakis, Optical Measurement and Sensor Systems for Advancements in Manufacturing, virtual conference Taiwan-Germany, TSMC, invited talk, 4 July 2024

J.W. Czarske, N. Koukourakis, J. Sun, Optical diffraction tomography of rotated cancer cells using lensless fiber endoscopy and deep neural networks, 28 January 2024, Invited by YongKeun (Paul) Park (KAIST, Korea), Part of SPIE BiOS, SPIE Photonics West, San Francisco, USA, 2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, L. Buettner, Q. Zhang, "Lensless fiber imaging using deep neural networks and quantum technology", 10 April 2024, SPIE Photonics Europe, Strasbourg, 2024 (invited by Irene Georgakoudi; Marc P. Georges; Nicolas Verrier)

L. Buettner, C. Bilsing, F. Bürkle, J.W. Czarske, „Adaptive Optics for Studying Fluid Mechanics at Interfaces", Center of Interface Studies (CIS) Kick-off Event, Helmholtz-Zentrum Dresden-Rossendorf, 03.05.2024

J.W. Czarske, T. Glosemeyer, R. Kuschmierz, Q. Zhang, Keynote: Single-shot 3D Imaging Exploiting Holography and Physics-informed Neural Network Reconstruction, OPTICA, Digital Holography, invited by Pietro Ferraro, Paestum, Italy, 5 June 2024 (Keynote)

J.W. Czarske, T. Glosemeyer, J. Sun, Q. Zhang, R. Kuschmierz, N. Koukourakis, Fiber communication and biophotonics, exploiting deep learning and structured light, Changchun, invited by student chapter of IEEE Photonics Society (and OPTICA and SPIE Student Chapters), 17 June 2024

Q. Zhang, J.W. Czarske, AI-based Mode Decomposition for classical and quantum communication through multimode fibers as MIMO channels, Changchun, invited by student chapter of IEEE Photonics Society (and OPTICA and SPIE Student Chapters), 17 June 2024

J. W. Czarske, T. Glosemeyer, R. Kuschmierz, L. Buettner, "Lensless 3D imaging using deep neural networks and quantum technology using entangled photons towards biomedicine", Light Conference, Track 2 Biophotonics, Changchun, China, 19th June, 2024 (Keynote talk)

J.W. Czarske, T. Glosemeyer, Q. Zhang, R. Kuschmierz, L. Buettner, Computational imaging using holography and physics-informed deep learning for biomedicine and quantum technology of second generation, seminar talk, Shanghai Institute of Optics and Fine Mechanics, SIOM, invited by Guohai Situ, Shanghai, 21 June 2024

J.W. Czarske, T. Glosemeyer, Q. Zhang, R. Kuschmierz, L. Buettner, Computational imaging using holography, physics-informed deep learning and optical signal processing for biomedicine and fiber communication, Shanghai, Jiao Tong University, Invited by Chapter of IEEE Photonics Society, 24 June 2024

J.W. Czarske, T. Glosemeyer, Q. Zhang, R. Kuschmierz, J. Sun, L. Buettner, Computational imaging using physics-informed deep learning for biomedicine and quantum technology, invited, Zhejiang University, College of Optical Science and Engineering (COSE), invited, Hangzhou, 25 June 2024

J.W. Czarske, T. Glosemeyer, J. Dremel, T Wang, R. Kuschmierz, J. Sun, Computational imaging using digital holography and deep learning for biomedicine, invited talk, Suzhou Institute of Biomedical Engineering and Technology (SIBET), 26 June 2024

J.W. Czarske, T. Glosemeyer, Q. Zhang, R. Kuschmierz, J. Sun, L. Buettner, Computational imaging using physics-informed deep learning for biomedicine and fiber communication, June 26, 2024, invitation from Prof Min Gu, Seminar at University of Shanghai for Science & Technology, Shanghai

D. Weik, Z. Dou, H. Emmerich, H. Bischoff, L. Buettner, J.W. Czarske, „Multimodale Ultraschallbildgebung: Wellenfrontkorrektur für neue Zugänge der Diagnostik", UltrasounDD – Ultrasonic Interdisciplinary Symposium Dresden, EKFZ AI & Electronics, September 11 2024

J.W. Czarske, T. Glosemeyer, Q. Zhang, R. Kuschmierz, L. Buettner, Minimally invasive laser-based endoscopy with optical fibers for biomedicine and quantum technology, Leipzig, SAW- Sächsischen Akademie der Wissenschaften zu Leipzig, invited plenary presentation, 9 Feb 2024

K. Schmidt, N. Koukourakis, U. Wallrabe, J.W. Czarske, „Smart Scanning Microscopy with Adaptive Lenses and Prisms", Optica Imaging Congress, Toulouse, France, July 2024, invited talk

R. Kuschmierz, J. Dremel, K. Zolnacz, T. Glosemeyer, J.W. Czarske, „Measuring and compensating the optical transfer functions of flexible imaging waveguides for lensless endoscopy", EOSAM European optical society annual meeting, Naples, Italy, September 2024, invited talk

R. Kuschmierz, J. Dremel, T. Glosemeyer, K. Zolnacz, R. Stephan, M. Steinke, J.W. Czarske, "Building a mechanical flexible and ultrathin lens for minimally invasive endoscopy", 23rd Slovak-Czech-Polish Optical Conference, Štrbské pleso, Slovakia, September 2024, invited talk

Conferences (reviewed)

International Conference Presentations

Q. Zhan, J. Sun, S. Rothe, J.W. Czarske, Physics-informed neural networks for classical and quantum communication with multimode fibers, Frontiers in Optics (FiO) -Annual Meeting of OPTICA, Denver, 23 Sep 2024

K. Schmidt, N. Koukourakis, J.W. Czarske, Towards label-free imaging and analysis of 3D tissues using deep neural networks, 20 August 2024, Part of Nanoscience + Engineering, Conference 13112, Optical Trapping and Optical Micromanipulation XXI, SPIE San Diego

Q. Zhang, Y. Sui, S. Rothe, J.W. Czarske, Learning to decompose multimode fibers using a physics-informed neural network, 22 August 2024, Part of Nanoscience + Engineering, Conference 13112, Optical Trapping and Optical Micromanipulation XXI, SPIE San Diego

J. Wu, J.W. Czarske, L. Cao, Diffraction model-driven network for light field generation through a coherent fiber bundle, 19 August 2024, Part of Nanoscience + Engineering, Conference 13112, Optical Trapping and Optical Micromanipulation XXI, SPIE San Diego

T. Glosemeyer, J. Lich, R. Kuschmierz, J.W. Czarske, „3D fluorescence imaging with diffuser endoscopy and physics-informed deep learning", SPIE Photonics West, San Francisco, USA, 27th January 2024

J.W. Czarske, R. Kuschmierz, J. Dremel, M. Kroll, E. Scharf„ Lensless endoscopy via wavefront shaping for fluorescence imaging", SPIE Photonics West, San Francisco, USA, 29th January 2024

J. Dremel, M. Kroll, T. Thiele, E. Scharf, R. Stephan, M. Steinke, J.W. Czarske, R. Kuschmierz, „Fabrication of holograms on optical fibers via femto-second laser techniques", SPIE Photonics West, San Francisco, USA, 1st February 2024

J. Dremel, T. Wang, S. Richter, O. Uckermann, W. Polanski, I. Eyüpoglu, J.W. Czarske, R. Kuschmierz, „ In vivo brain tumor classification using fiber endoscopy", SPIE Photonics West, San Francisco, USA, 27th January 2024

F. Schmieder, L. Büttner, A.T. Pierce, W. Derks, O. Bergmann, J.W. Czarske, "Single-cell investigation of excitation wavefront propagation in in vitro human induced cardiomyocytes using a digital holographic stimulation system", 27 January 2024, Part of SPIE BiOS, SPIE Photonics West, San Francisco, USA, 2024

F. Schmieder, A.T. Pierce, L. Büttner, W. Derks, O. Bergmann, J.W. Czarske, "Optogenetic stimulation and fast label-free wide field video microscopy for the investigation of excitation wavefronts in in vitro cardiac tissue", 28 January 2024, Poster at SPIE BiOS, SPIE Photonics West, San Francisco, USA, 2024

D. Krause, J. Böhm, L. Liebig, N. Koukourakis, J. Czarske, Investigation on impulsive stimulated Brillouin microscopy for high-speed elastography in hydrogel, 27 January 2024, SPIE BiOS, SPIE Photonics West, San Francisco, USA, 2024

D. Krause, J. Sun, L. Liebig, N. Koukourakis, J. Czarske, "Full-angle projection tomography with AI-enhanced fibre optics rotation: from cells to organoids", 20 August 2024, Optical Trapping and Optical Micromanipulation XXI, SPIE Optics + Photonics, San Diego, USA, 2024

L. Büttner, Z. Gao, P. Yang, C. Bilsing, J. Czarske, „Multiple-input deep neural network aberration correction for measurements in microfluidics through fluctuating phase boundaries", SPIE Optics + Photonics, paper 13149-34, San Diego, USA, 18.-22. Aug. 2024

J. Boehm, D. Krause, N. Koukourakis, J.W. Czarske, Correction quality criterion for DOPC guide-stars, 10 April 2024, SPIE Photonics Europe, Strasbourg, 2024

B. Yang, J. Sun, N. Koukourakis, J.W. Czarske, Learning-based optical diffraction tomography for label-free 3D cell imaging, 10 April 2024, SPIE Photonics Europe, Strasbourg, 2024

D. Pohle, P. Carniello, N. Hanik, J.W. Czarske, Characterization and modelling of multimode fibers using holographic transmission matrix measurements. 10 April 2024, SPIE Photonics Europe, Strasbourg, 2024

K. Schmidt, N. Guo, N. Koukourakis, M. von Witzleben, M. Gelinsky, J.W. Czarske, Virtual staining on unlabeled tissue samples, 11 April 2024, SPIE Photonics Europe, Strasbourg, 2024

Y. Sui, Q. Zhang, S. Rothe, J.W. Czarske, Reference-free phase retrieval of multimode fibers enhanced by physics-driven neural network, 8 April 2024, SPIE Photonics Europe, Strasbourg, 2024

J. Zhang, J. Sun, N. Koukourakis, J.W. Czarske, Lensless microendoscope for quantitative phase imaging with flexible working distance, 8 April 2024, SPIE Photonics Europe, Strasbourg, 2024

F. Schmieder, M.A. Sikandar, R. Habibey, L. Büttner, O. Bergmann, V. Busskamp, J.W. Czarske, "Optogenetics with Human Stem-Cell-Derived Cardiomyocytes and Neuronal Networks", Optogen 2024, Prague, 16th April 2024

R. Kuschmierz, E. Scharf, R. Stephan, L. Linhsen, K. Zolnacz, T. Glosemeyer, M. Steinke, J.W. Czarske, „High resolution lensless fiber endoscopy for optogenetics and neurophotonics", Optogen 2024, Prague, 16th April 2024

S. Richter, J. Dremel, T. Wang, I. Eyüpoglu, J.W. Czarske, K. Kirsche, R. Kuschmierz, W. Polanski, O. Uckermann, „Autofluorescence based recognition of brain tumors with a convolutional neural network", Deutsche Gesellschaft für Neurochirurgie, Göttingen, Germany, 9th June 2024

J. Hoppe, R. Nauber, D. Castellanos Robles, J.W. Czarske, M. Medina-Sánchez, Influence of hyperparameters on the performance of deep learning-based microrobotic localization under phantom tissue, MARSS, Delft, NL, 2024

H. Emmerich, V. Tholan, C. Zhang, S. Heitkam, K. Eckert, Z. Dou, J.W. Czarske, D. Weik, "Selective bubble detection in a multi-phase flow using non-linear acoustics", Ultrasonic Industry Association Annual Symposium UIA52, Dublin, Ireland, 2024.

H. Emmerich, L. Knüpfer, D. Weik, J.W. Czarske, P. Trtik, K. Eckert, S. Heitkam, „Ultrasonic measurement to determine temporally and spatially resolved liquid fraction of foam", 15th European Foam Conference (EUFOAM), Dresden, 2024

Q. Zhang, Y. Sui, S. Rothe, J.W. Czarske, "Learning to decompose highly multimode fiber system over 1000 modes using physics-informed mode decomposition neural network", Light Conference, Track 7: Optical Imaging and Metrology, Changchun, China, 20th June, 2024

T. Wang, J. Dremel, S. Richter, W. Polanski, O. Uckermann, I. Eyüpoglu, J. Czarske, R. Kuschmierz, "Image restoration via learning on a digital twin for multi-core fiber endoscopy", Optica Imaging Congress, Toulouse, France, July 2024-BEST PAPER Award of OPTICA

C. Bilsing, L. Büttner, A. Metzmacher, U. Janoske, J. Czarske, S. Burgmann, Analysis of the Flow Structure inside an Oscillating Sessile Drops in a Shear Flow Using Double-Helix 3D Particle Tracking Velocimetry and Adaptive Optics, 10 July 2024, 21st International Symposium on Application of Laser and Imaging Techniques to Fluid Mechanics, Lisbon, Portugal, 2024

S. Tasmany, D. Kaiser, J. Woisetschläger, J. Gürtler, R. Kuschmierz, J.W. Czarske, Background-Oriented Schlieren for the Detection of Thermoacoustic Oscillations in Flames, 21st International Symposium on the Appli-cation of Laser and Imaging Techniques to Fluid Mechanics, Lisbon, Portugal, 2024

J. Gürtler, S. Tasmany, J. Woisetschläger, R. Kuschmierz, J.W. Czarske, Tomographic reconstruction of combustion flow fields from density measurements based on physics-informed neural networks, 21st International Symposium on the Application of Laser and Imaging Techniques to Fluid Mechanics, Lisbon, Portugal, 2024

K. Zolnacz, R. Stephan, J. Dremel, K. Hausmann, M. Liessmann, M. Steinke, J.W. Czarske, R. Kuschmierz, „Lensless multicore fiber endoscope with expanded cores for improved light collection," Frontiers in Optics (FiO) -Annual Meeting of OPTICA, Denver, USA, 26 September 2024

National conferences (reviewed) and Talks (no review, seminar/workshop)

D. Weik, D. Räbiger, T. Vogt, S. Eckert, L. Büttner, J. Czarske, „Ultrasound Localization Microscopy for Super-Resolved Flow Fields in Liquid Metal Experiments", 4th International Workshop on Measuring Techniques for Liquid Metal Flows (MTLM2024), Dresden, 2024

H. Emmerich, Z. Dou, D. Weik, J.W. Czarske, V. Tholan, S. Heitkam, K. Eckert, "Determination of the bubble size in bubbly liquids using non-linear acoustic interaction", Jahrestreffen Dechema Fachgruppen 2024, Bremen, 2024

L. Büttner, J.W. Czarske, M. Gräfe, „Quantum Imaging with Undetected Light –
A New IR Imaging Modality", Workshop "Optische in-Prozess Sensorik, Sensornetze und Sensorfusion, Quantensensorik", Bremer Institut für Angewandte Strahltechnik (BIAS), Bremen, 20.11.2024

Book Chapters, Books, Editorials

R. Nauber, L. Büttner, J.W. Czarske, Special Issue on Computational Ultrasound Imaging and Applications - Applied Sciences, 2024 - mdpi.com

Patents and Patent Applications

J Czarske, Q Zhang, Optical propagation mode or multimode fiber demultiplexer, communication system, method for training a simulated optical diffractive neural network and method for training a simulated physics-informed neural network, Patent, 10 2024 132 327.2, 2024

P. Warkusz, R. Kuschmierz, J. Lich, J. Czarske, „Bore inspection device", DE Patent, submitted and transferred to JENOPTIK Industrial Metrology Germany GmbH

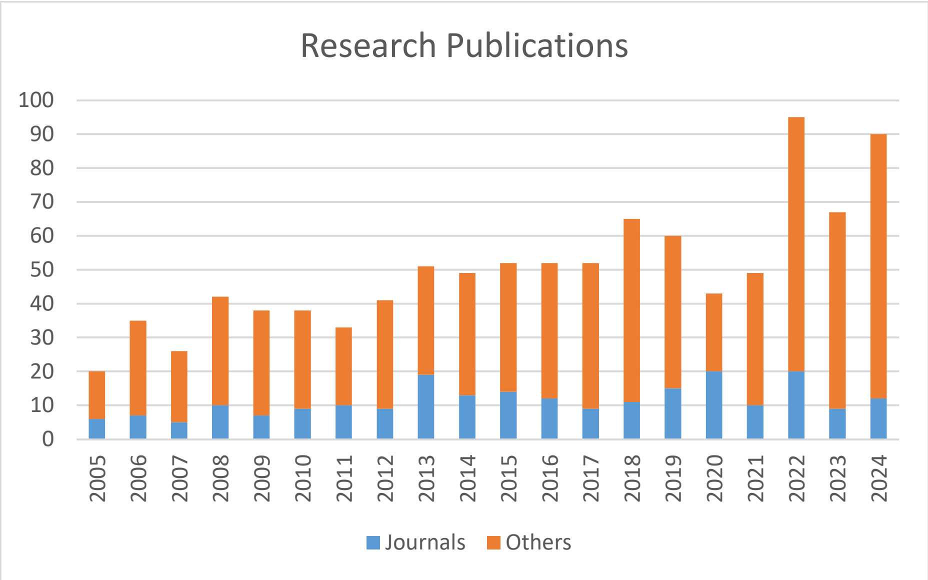
R. Kuschmierz, J.W. Czarske, „Method and arrangement for adaptive illumination of an object with light", European Patent, granted

R. Kuschmierz, M. Kroll, E. Scharf, J.W. Czarske, „Method for compensating the dispersion in image waveguides", European Patent, filed

R. Kuschmierz, J. Dremel, E. Scharf, J.W. Czarske, „Method and device for compensating phase interference of multiple wavelengths of image waveguides", DE & US Patent, filed

T. Glosemeyer, R. Kuschmierz, J.W. Czarske, „Method for the transmission of high-resolution image information through image waveguides", DE Patent, filed

The Patent of L. Büttner, J. Czarske, "Method for determining the fluid temperature" (filed 2022) has been transferred to ILA R&D GmbH, Rudolf-Schulten-Straße 3, 52428 Jülich as a supplement to the MST invention "Laser Doppler velocity profile sensor": https://ila-rnd.com/ldv-profile-sensor/



ACTIVITIES

<u>Prof. Czarske</u>:

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 Netherlands 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), SPIE – The International Society for Optics and Photonics
- Supporting an MST key topic on computational metrology, quantum imaging, biophotonics and the translation research in cooperation
- 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
- 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 and by BIOLAS @ TU Dresden
- Several invited talks

Dr. Robert Kuschmierz:

- Member of SPIE & OPTICA
- Supporting an MST key topic on computational and adaptive microendoscopy for biomedical imaging
- 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

OUR PARTNERS (SELECTION)

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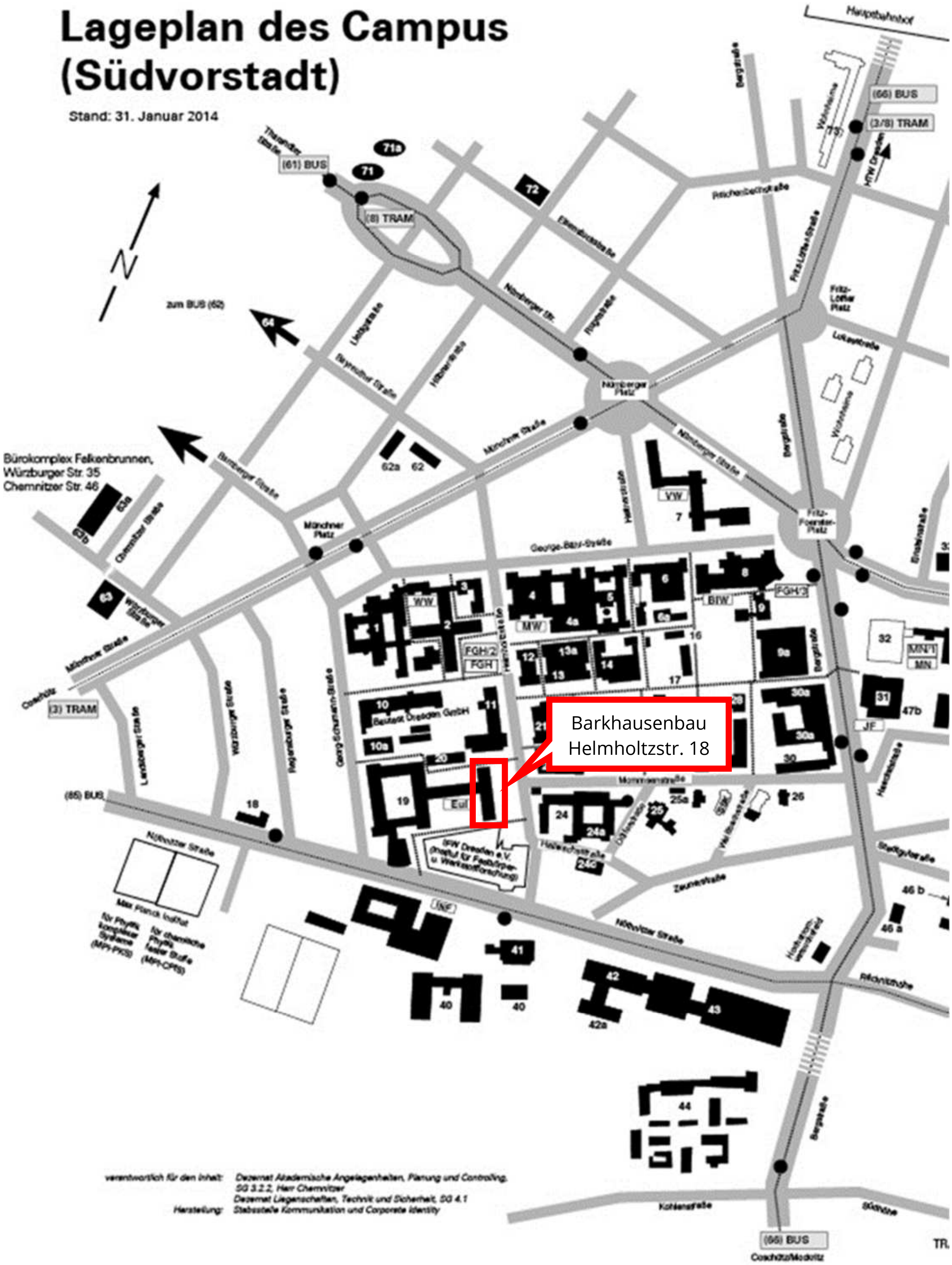

Laboratory of Measurement and Sensor System Technique (MST) / Czarske Lab

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