Annual Report 2023

Institute of Applied Physics

Friedrich-Schiller-Universität Jena

Imprint

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Cover: The newly appointed Professor of Experimental Quantum Information Prof. Dr. Fabian Steinlechner.

Content

VORWORT

Liebe Kolleginnen und Kollegen,

wenn ich auf das Jahr 2023 zurückblicke, erfüllt es mich mit Stolz, welche herausragenden Ergebnisse wir gemeinsam erzielt haben. Dies betrifft sowohl die Grundlagenforschung als auch die angewandte Forschung, und ich möchte einige der Höhepunkte mit Ihnen teilen.

Ein besonders anschauliches Beispiel für unsere Spitzenforschung mit herausragendem Anwendungsbezug über Fachgrenzen hinaus, ist die Entwicklung eines hochauflösenden linsenlosen Mikroskops, welches mit extrem ultraviolettem (EUV) Licht arbeitet. Damit war es z.B. möglich, den Spitzenkörper und die chemische Zusammensetzung der Zellwand von E. coli Bakterien in unterschiedlichen Stadien der Zellteilung zu identifizieren und gezieltere Heilmethoden für Krankheiten zu entwickeln. Nebenbei wurde dieses Setup als ein kompaktes EUV-Mikroskop im Labormaßstab realisiert und die Anwendungsmöglichkeiten durch die damit verbesserte Zugänglichkeit massiv erweitert. Die beteiligten Forschenden Prof. Limpert, Prof. Pertsch, Dr. Rothhardt sowie Dr. Hillmann vom Leibniz-Hans-Knöll-Institut wurden dafür mit dem erstmals vergebenen Preis für »Exzellente interdisziplinäre Kooperation 2023«hier am Beutenberg ausgezeichnet. Die Promotionsarbeit zur Entwicklung der EUV-Strahlquelle von Dr. Robert Klas wurde außerdem mit dem Hugo-Geiger-Preis der Fraunhofer-Gesellschaft geehrt.

Nicht weniger herausfordernd waren unsere Beiträge zu verschiedenen Raumfahrtmissionen. Reizvoll ist neben der entsprechenden Grundlagenforschung die Umsetzung der extremem Anforderungsbedingungen an die entsprechenden Mikro- und Nanostrukturen in weltraumtaugliche Instrumente, was unseren Kolleginnen und Kollegen am Fraunhofer IOF bisher jeweils erfolgreich gelungen ist. Ich denke hierbei insbesondere an die Mission JUICE der ESA zur Erkundung des Jupiters und seiner Monde mit dem ersten »Deep-Space-Laseraltimeter« GALA, dessen Grundlage eine nur wenige Millimeter dünne Hochleistungsspiegel-Optik ist. Damit soll auf Ganymed über eine hochpräzise Oberflächenvermessung mögliche Wasservorkommen aufgespürt werden.

Ebenso stellen die photonischen Quantentechnologien höchste Anforderungen an Komponenten und Systeme. Sie bieten umfassende Potentiale für innovative Anwendungen wie abhörsichere Kommunikation, hochempfindliche Sensorik und Bildgebung sowie leistungsfähiges Quantum-Computing. Demonstrieren konnten wir einen Quantenschlüssel-Austausch auf einer heterogenen Teststrecke aus Freistrahl- und Faserverbindungen als zweites Schlüsselexperiment der strategischen BMBF-Initiative QuNET, dem Kickoff zum BMBF-Projekt Q-NET-Q zum Ausbau von Quanten-Kommunikationsstrecken nach Frankfurt, Berlin und Nordhausen. Um unsere führende Rolle in der Quantentechnologie weiter auszubauen, haben wir mit Prof. Fabian Steinlechner eine neue Professur für »Experimentelle Quanteninformationstheorie« eingerichtet.
Zudem begrüßen wir Prof. Vladan Blahnik, der die wichtige Aufgabe im Bereich »Optisches Systemdesign« von Prof. Gross übernimmt.

Unser Institut hat in den letzten Jahren ein beeindruckendes Wachstum erlebt, was sich auch in der Vielfalt unserer Mitarbeiterinnen und Mitarbeiter widerspiegelt. Mit 38 vertretenen Nationen sind Diversität und interkulturelle Vielfalt fest in unserer Mission verankert. Als Teil der Initiative »Weltoffenes Thüringen« setzen wir uns für eine offene Gesellschaft und eine Kultur der Vielfalt ein.

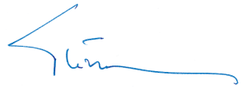
Die Ausbildung der nächsten Generation von Physikerinnen und Physikern liegt uns ebenfalls am Herzen: Knapp 50 Lehrformate – von der Vorlesung bis zum Praktikum - wurden geleistet und 20 Abschlussarbeiten erfolgreich betreut, sowie andere Formate wie das MINT-Festival mit Enthusiasmus bereichert. Auch unsere Beiträge auf inter/nationalen Konferenzen tragen dazu bei, unsere Sichtbarkeit zu steigern und somit Fachkräfte aus der ganzen Welt zu gewinnen.

Ein weiteres Highlight war die positive Evaluation der Exzellenz-Graduiertenschule Max Planck School of Photonics, die zeigt, dass unser Engagement für exzellente Bildung Früchte trägt. Gestartet in 2019 mit dem Ziel, themenbezogene und einrichtungsübergreifende Graduiertenprogramme zu schaffen, die mit den besten Universitäten und Institutionen weltweit konkurrieren können, zeigte sich das Gutachtergremium im 2023 beeindruckt von den exzellenten Studierenden, der Adressierung vielfältiger Karrierepfade durch die enge Vernetzung mit Wissenschaft und Wirtschaft sowie der Möglichkeit eines gemeinsamen Master-Abschluss an zwei Partneruniversitäten und den herausragende E-Learning-Methoden im »Digital Teaching Lab«. Das Gremium sprach sich ausdrücklich für eine Fortführung der »Max Planck School of Photonics« aus, welche wir mit großem Engagement gemeinsam mit unseren Partnern umsetzen wollen.

Ich möchte unseren Fördermittelgebern, kooperierenden Unternehmen und Partnereinrichtungen meinen herzlichen Dank aussprechen. Ihr Vertrauen und Ihre Unterstützung sind die Grundlage für unseren Erfolg. Mein besonderer Dank gilt allen Mitarbeiterinnen und Mitarbeitern des Instituts. Ihr Engagement und Ihre hervorragenden Leistungen sind die Pfeiler unseres Erfolgs.

Mit Zuversicht blicke ich auf das kommende Jahr, in dem wir gemeinsam weiterhin innovative Lösungen entwickeln werden, um die Herausforderungen von morgen zu meistern.

Ihr



Andreas Tünnermnann

PREFACE

Dear colleagues,

As I look back on 2023, I am proud of the outstanding results we have achieved together. This applies to both basic and applied research, and I would like to share some of the highlights with you.

A particularly vivid example of our cutting-edge research with outstanding application relevance beyond specialist boundaries is the development of a high-resolution lensless microscope that works with extreme ultraviolet (EUV) light. This made it possible, for example, to identify the tip body and the chemical composition of the cell wall of E. coli bacteria at different stages of cell division and to develop more targeted cures for diseases. In addition, this setup was realized as a compact EUV microscope on a laboratory scale and the application possibilities were massively expanded due to the improved accessibility. The researchers involved, Prof. Limpert, Prof. Pertsch, Dr. Rothhardt and Dr. Hillmann from the Leibniz Hans Knöll Institute, were awarded the first prize for "Excellent Interdisciplinary Cooperation 2023" here at Beutenberg. The doctoral thesis on the development of the EUV beam source by Dr. Robert Klas was also honored with the Hugo Geiger Prize of the Fraunhofer-Gesellschaft.

Our contributions to various space missions were no less challenging. In addition to the corresponding basic research, the implementation of the extreme requirements for the corresponding micro- and nanostructures in space-suitable instruments is exciting, which our colleagues at the Fraunhofer IOF have successfully achieved so far. I am thinking in particular of ESA's JUICE mission to explore Jupiter and its moons with the first "deep-space laser altimeter" GALA, which is based on high-performance mirror optics just a few millimetres thick. The aim is to detect possible water deposits on Ganymede using high-precision surface measurements.

Photonic quantum technologies also place the highest demands on components and systems. They offer extensive potential for innovative applications such as tap-proof communication, highly sensitive sensor technology and imaging as well as powerful quantum computing. We were able to demonstrate a quantum key exchange on a heterogeneous test track consisting of free beam and fiber links as the second key experiment of the strategic BMBF initiative QuNET, the kickoff to the BMBF project Q-NET-Q for the expansion of quantum communication links to Frankfurt, Berlin and Nordhausen. In order to further expand our leading role in quantum technology, we have established a new professorship for "Experimental Quantum Information Theory" with Prof. Fabian Steinlechner. We also welcome Prof. Vladan Blahnik, who is taking over Prof. Gross's important role in the field of "Optical System Design".

Our institute has experienced impressive growth in recent years, which is also reflected in the diversity of our staff. With 38 nations represented, diversity and intercultural diversity are firmly anchored in our mission. As part of the "Weltoffenes Thüringen" initiative, we are committed to an open society and a culture of diversity.

Educating the next generation of physicists is also close to our hearts: almost 50 teaching formats - from lectures to internships - were delivered and 20 theses successfully supervised, as well as other formats such as the MINT Festival enriched with enthusiasm. Our contributions at international/ national conferences also help to increase our visibility and thus attract specialists from all over the world.

Another highlight was the positive evaluation of the Max Planck School of Photonics Graduate School of Excellence, which shows that our commitment to excellent education is bearing fruit. Launched in 2019 with the aim of creating subject-related and cross-institutional graduate programs that can compete with the best universities and institutions worldwide, the panel of experts in 2023 was impressed by the excellent students, the addressing of diverse career paths through close networking with science and industry as well as the possibility of a joint Master's degree at two partner universities and the outstanding e-learning methods in the "Digital Teaching Lab". The committee expressly advocated the continuation of the "Max Planck School of Photonics", which we intend to implement with great commitment together with our partners.

I would like to express my sincere thanks to our funding bodies, cooperating companies and partner institutions. Your trust and support are the basis for our success. My special thanks go to all of the Institute's employees. Your commitment and outstanding performance are the pillars of our success.

I look forward with confidence to the coming year, in which we will continue to develop innovative solutions together in order to master the challenges of tomorrow.

Sincerely,

Andreas Tünnermnann

The Institute of Applied Physics (IAP) has a long-standing tradition and competence in design, fabrication and application of active and passive optical and photonic elements. It is also very well-known for its developments in the area of high power laser technology and nowadays also in quantum optics. Collaborative projects with companies ensure practical relevance and feasibility.

Research Profile

The institute conducts fundamental and applied research in the fields of micro-, nano- and quantum optics, fiber and waveguide optics, ultrafast optics as well as optical engineering. Our researchers develop novel optical materials, elements and concepts for information and communication technology, life science and medicine, environment and energy as well as process technology including material processing and optical measurement techniques.

Current research topics - investigated by over 150 scientists - concern function, design, fabrication and applications of micro- and nano-optical elements. Those are e.g. plasmonic resonant nanometric structures, polarizers from IR to DUV range, 3D nano-structuring of crystals with ion beam and Atomic Layer Deposition of optical coatings. Also light propagation and non-linear light-matter interaction in e.g. photonic nanomaterials, including metamaterials, photonic crystals, as well as effective media, quantum phenomena and integrated quantum optics, application of photonic nanomaterials and advanced photonic concepts for astronomical instruments are investigated.

Further research fields are the applications of femtosecond laser pulses, such as material processing and spectroscopic analyses, as well as micro- and nano-structuring, medical (laser) application and additive manufacturing usage of ultrashort laser pulses. For further aims, new concepts for solid-state lasers with focus on fiber laser technology are to be developed, such as novel large core diameter fibers, fiber optical amplification of ultra short laser pulses and Mid-IR up to soft x-ray laser sources. With those, absorption spectroscopy with ultrahigh spectral resolution, especially in the (extreme) ultraviolet (XUV) region can be realized.

Classical optical design as well as design of modern optical systems, like freeform optics, illumination systems, laser and delivery systems are considered in our research, as well as aberration theory, quality, performance and tolerancing evaluation of optical systems.

In quantum optics, principles of quantum mechanics are used to develop improved imaging and spectroscopy techniques. For these applications, photon pair sources are generated in structured media and on integrated quantum optics in lithium niobate insulators, with established expertise in related areas of modern photonics. Applications in areas such as remote sensing, long-range communication and complex quantum networks are also based on methods for generating and manipulating quantum states of light.

By investigating these fields of research, particularly in close cooperation with the Fraunhofer Institute of Applied Physics and Precision Engineering (IOF) as well as many partners in science and economy, the IAP covers numerous parts of the innovation chain - from interdisciplinary fundamental research to the demonstration of prototypes. This expertise offers remarkable contributions to solve issues in the mentioned before emerging fields.

Excellence in research is confirmed by the structural anchoring of the Competence Centre (ZIK) ultra optics into one of three key research areas of the Abbe Center of Photonics (ACP), four awarded ERC Grant -the latest about "High-flux Synchrotron alternatives driven by powerful long-wavelength fiber lasers - SALT" (2019), the International Research Training Group GRK 2101 (2015) as well as the pilot project "Max Planck School of Photonics" (2017). In recent years, expertise has also been built up in quantum research, and major projects have been successfully conducted, such as QuantIm4Life (2018), QUICK3 (2021) and PhoQuant (2022).

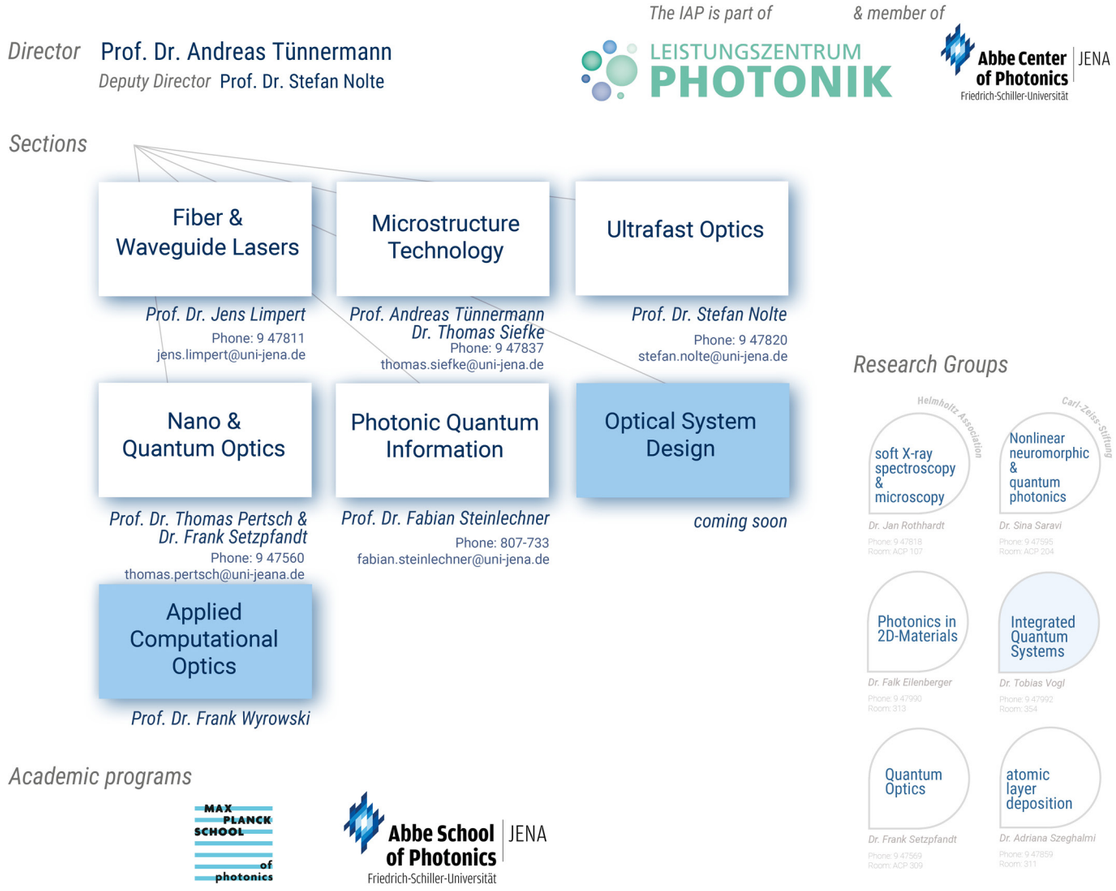
But not only excellent research makes the Institute splendid, also out-standing laboratory equipment, an excellent educated staff and an high commitment to the training of students and scientists in cooperation with the Abbe School of Photonics belongs to the self-understanding of the IAP.

Research Facilities / Resources

Excellence in research requires high quality equipment for experimental questions and analysis. The state-of-the-art technical infrastructure is driven constantly forward by acquired adaptions for scientific questions, done by an experianced crew.

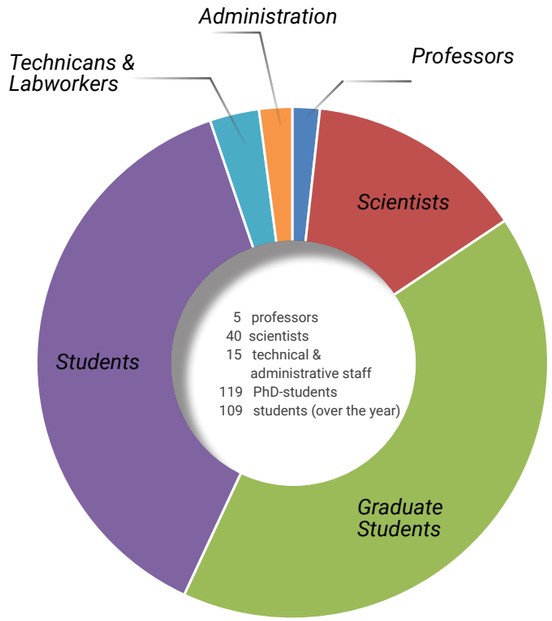
860 m² class 10,000 to 10 clean room area for:

- Electron beam lithography equipped with variable shaped beam and cell projection
- Laser lithography & Photolitography
- Coating technologies (sputtering, electron beam evaporation, ALD)
- Dry etching (RIE, RIBE, ICP)
- Cross beam, scanning electron microscopy, equipped with EDX and EBSD
- Helium ion microscopy
- Scanning nearfield optical microscopy
- Interference optical surface profilometry
- UV-VIS spectrometry & FTIR spectrometry
- Ellipsometry
- Nonlinear optical waveguide characterization
- High repetition rate ultrashort pulse laser systems (25fs to 20ps) including wavelength conversion covering the range from 4nm to 10µm
- High-precision positioning and laser scanning systems
- Laser micro-structuring and additive technology
- Rigorous optical simulation
- Field tracing techniques



Structure of the Institute 2023

Staff in 2023
(Key date 31.12.2023)



Abasifard, Mostafa
Abbe, Sylvia
Abdelaal, Mahmoud
Abtahi, Fatemeh Alsadat
Ackermann, Roland
Afsharnia, Mina
Ahmadi, Najme
Akshay Sunil, Bhadage
Alasgarzade, Namig
Alberucci , Alessandro
Almassarani, Mohammed
Arango Uribe, Juan José
Arumugam, Stree Vithya
Asghari, Bahar
Atzbach, Yannik
Augustine, Anukul Jovial
Baghdasaryan, Baghdasar
Bahri, Mehran
Barua, Sajib
Beer, Sebastian
Benner, Maximilian
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Elmanov, Ilia
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Jungnickel, Tom
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Karst, Maximilian
Kartashova, Anna
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Kleckner, Frederik
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Kohl, Hagen Peter
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Le, Thuy Dung
Lenski, Mathias
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Li, Yang-Teng
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Lyubin, Evgeny
Markogiannaki, Styliani
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Matthes, Tjorben
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Miculka, Martin
Mir, Umair Ashraf
Mishuk, Mohammad Nasimuzzaman
Mohanta, Jyotirmaya
Mollah, Sayonil
Moosavi, Wajihe
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Munser, Anne-Sophie
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Natarajan Rajkumar, Vishnoo
Nayak, Abani Shankar
Ngo, Gia Quyet
Nolte, Stefan
Notni, Lennart
Otto, Christiane
Paciorek , Karolina
Pal, Anupam
Palma Vega, Gonzalo
Parab, Tushar
Paul, Pritom
Penagos Molina, Daniel Santiago
Pertsch, Thomas
Pillot, Clotilde
Pimputkar, Vaishnavi
Porwol, Tatjana
Prabhakara, Nishitha
Rafi, Raihan
Rathi, Manish
Reents, Johannes
Reibe, Michael
Repp, Daniel
Richter, Daniel
Richter, Hannes
Ritter, Sebastian
Rockstroh, Sabine
Romashkina, Anastasia
Rosario Rodriguez, Grucheska
Saenz Perez, Andres
Safari Arabi, Masoud
Sanghvi, Rahul
Santos Suarez, Elkin Andres
Saravi, Sina
Sarvarzadeh, Seyedsaeid
Sauer, Gregor
Scheck, Niklas David
Schelle, Detlef
Schmelz, David
Schmidt, Holger
Schönberg, Alwin
Schrodt, Adriana
Schwartz , Georg
Sebak, Rana Khaled Hassan Mahmoud
Sergeev, Natali
Sevriukov, Denys
Seyfarth, Brian
Shinde, Saiya Rahul
Siefke, Thomas
Siems, Malte Per
Singhania, Vedika
Sperrhake, Jan
Spoerer, Jana
Sripathy , Kabilan
Stefanidi, Dmitrii
Steinberg, Carola
Steinert, Michael
Stelter, Daniel
Sushil, Sandhya
Tatlidil, Duygu
Teymori, Pouria
Tilloy, Lucile
Tischner, Katrin
Tiwari, Priyanshu
Tu, Yiming
Tünnermann, Andreas
Ugarte O., Idoia
Vafaeinezhad, Mohammadsadegh
Vavrečková, Šárka
Vetter, Julia
Vignesh, Subramaniyan
Vogl, Tobias
Voigt, Daniel
Vrckovnik, Trevor
Walther, Markus
Wang , Ziyao
Weißflog, Maximilian
Wiedemann, Tim
Winkler, Ira
Wyrowski, Frank
Xiao, Jianxing
Xu, Shuyun
Xu, Qian
Yildiz, Benjamin
Younesi, Mohammadreza
Zahedian, Majid
Zand, Ashkan
Zhang, Luosha
Zhang, Yuzhen
Zhang, Mingxuan
Zhang, Xiangyun
Zhang, Yueheng
Zhang, Zifei
Ziebell, Jobst
Zimmermann, Gil

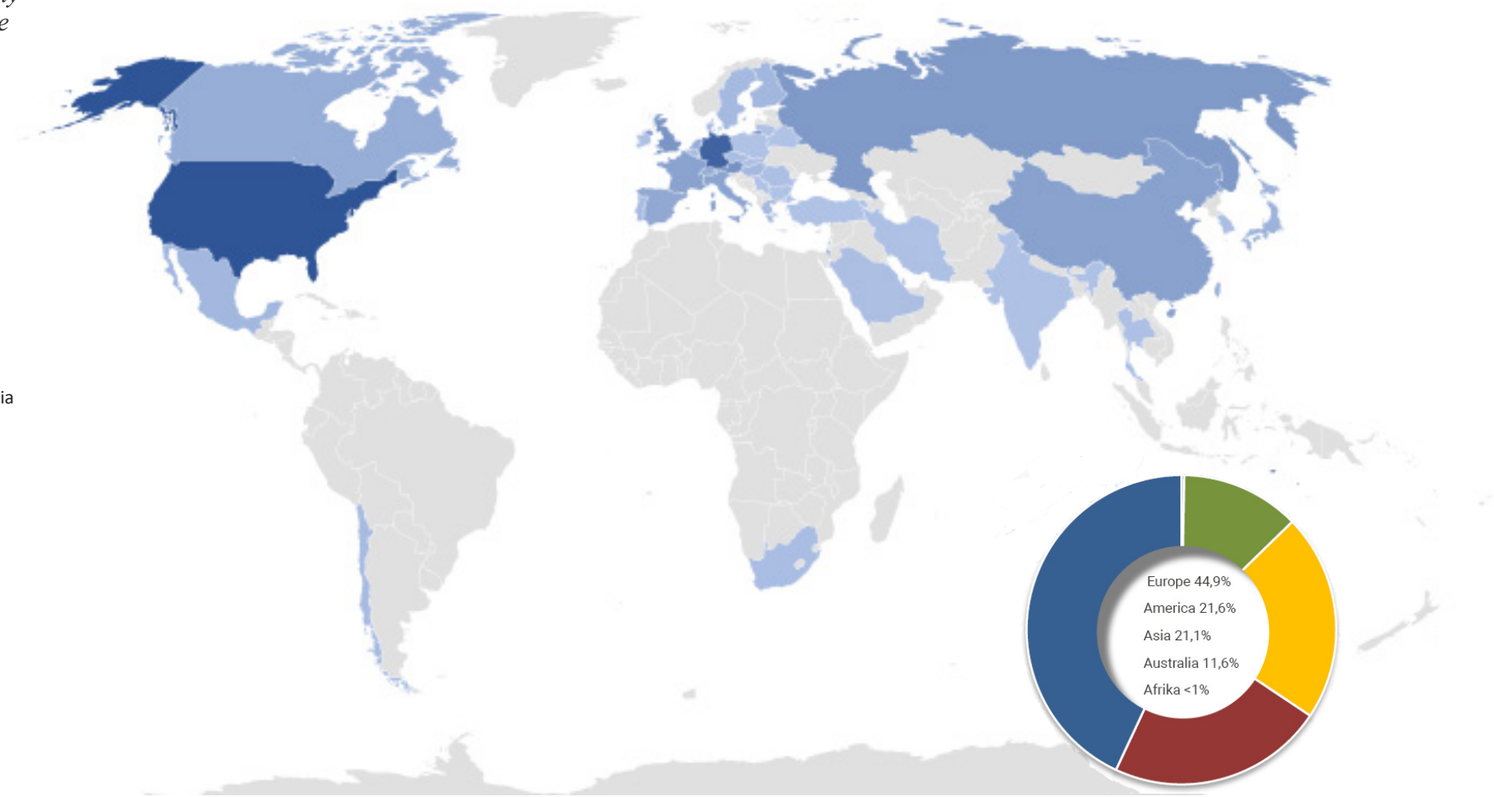
Guests & Visits

Guests indicate the national and international visibility of research results and enrich the structures of the Institute with new thinking and perspectives - not only in research and teaching, but also open eyes to other cultures and strengthen the network by personal relations.

Guests

BACHOR Hans	Australian National University, Canberra, Australia
BAILLY Elise	Universite Paris Saclay, Paris, France
BOES Andy	University of Adelaide, Australiaa
DE ANGELIS Constantino	University of Brescia, Italy
GOI Elena	Centre for Artificial-Intelligence Nanophotonics, University of Shanghai for Science and Technology, China
JELENKOVIC Brana	Institute of Physics, University of Belgrade, Serbia
KILDISHEV Alexander	Purdue University, West Lafayett, USA
STANKEVIČ Valdemar	Center for Physical Sciences and Technology, Vilnius, Lithuania
WESEMANN Luka	The University of Melbourne, Australia
WURDACK Matthias	Australian National University, Canberra, Australia

Cooperations in Publications



Quantitative figure of common publications in 2013-23.

EDUCATION

An essential part of the IAP is the training of young scientists on fundamental knowlegde and at the interface of physics, chemistry and material science. Together with our partner in education - the Abbe School of Photonics (ASP) - we offer an education in interdisciplinary international Master´s degree and graduation programs. Since 2017 the "Max Planck School of Photonics" (MPSP) is coordinated in Jena to qualify young scientists in pioneering research fields.

Lectures, seminars & tutorials

- Analytical Instrumentation
- Atome und Moleküle I & II
- Computational Photonics
- Computational Physics I
- Design and Correction of Optical Systems
- Experimental Quantum Technologies
- Fundamentals of Modern Optics
- Grundlagen der Laserphysik
- Imaging and Aberration Theory
- Innovation Methods in Photonics
- Integrated Quantum Photonics
- Introduction to Nanooptics
- Introduction to Optical Modeling
- Laser Physics
- Lasers in Medicine
- Lens Design I & II
- Mathematical Methods in Physics
- Micro / Nanotechnology
- Quantum Communication
- Quantum Computing
- Quantum Imaging and Sensing
- Quantum Optics
- Structure of Matter
- Thin Film Optics
- Ultrafast Optics
- Vakuum- und Dünnschichtphysik

Practical training / Internships

- Experimental Optics
- Grundpraktikum Biochemie
- Grundpraktikum Pharmazie
- Grundpraktikum Physik
- Grundpraktikum Physik für Humanmediziner
- Kursleiter Grundpraktikum Physik für Chemiker/Lehramt
- Kursleiter Grundpraktikum Physik für Humanmediziner
- Fortgeschrittenenpraktikum Physik

Bachelor Theses

Adrian Bohm
Einfluss von Nasschemie und Ionenbestrahlungsprozessen auf die Bildung zeitabhängiger nanoskaliger Partikelablagerungen an Siliziumoberflächen

Samuel Döpfner
Lifetime Characterization of Ultrashort Laser Pulse Written Fiber Bragg Gratings

Tom Kretzschmar
Erzeugung und Charakterisierung von Einzelphotonemission an Defektstellen in lösungmittel-exfoliertem hexagonalem Bornitrid

Moritz Lottmann
Surface Metrology using multi-wavelength Ptychography

Lennart Notni
Optisches Übersprechen in Aperture Multiplexing Polarimetern

Johannes Reents
Konzepte zur strukturierten Beleuchtung in der XUV-Bildgebung

Tim Wiedemann
Setup Development and Analysis-Thermal Characterization of LPBF manufactured Copper Components

Master Theses

Sajib Barua
High-temperature sensors based on ultrafast laser written fiber Bragg gratings

Tomi Getselev
Characterization of Photonic Filter Cavity Systems with Fourier-Transform Spectroscopy

Zhiqiang Lin
Phase-Shifted Fiber Bragg Gratings via Localized Femtosecond Photo-Treatment

Tom Lippoldt
Investigation of photocatalytic processes for greenhouse gas conversion using CARS spectroscopy

Tjorben Matthes
Irradiation-Induced Creation of Single Photon Emitters in hBN

Sixu Meng
Testing extended quantum theory withmulti-photon states

Raihan Rafi
Second Harmonic Generation in ALD Coated Guided Mode Resonant Gratings

Hannes Richter
Realization of dispersive characterization of ultrashort pulse written Bragg gratings

Alwin Schönberg
Wavelength dependence of the ablation of kidney stones using ultrashort laser pulses

Georg Schwartz
Polarization dependent characterization of femtosecond pulse written fiber Bragg gratings

Duygu Tatlidil
Laser induced Breakdown Spectroscopy (LIBS) of Laser Powder Bed Fusion Specimen

Shuyun Xu
Investigation of the transformation of global warming gases in valuable raw materials with the help of photocatalysts

Yuzhen Zhang

Theoretical and experimental determination of the tip temperature for thermal Scanning Probe Lithography

Doctoral Theses

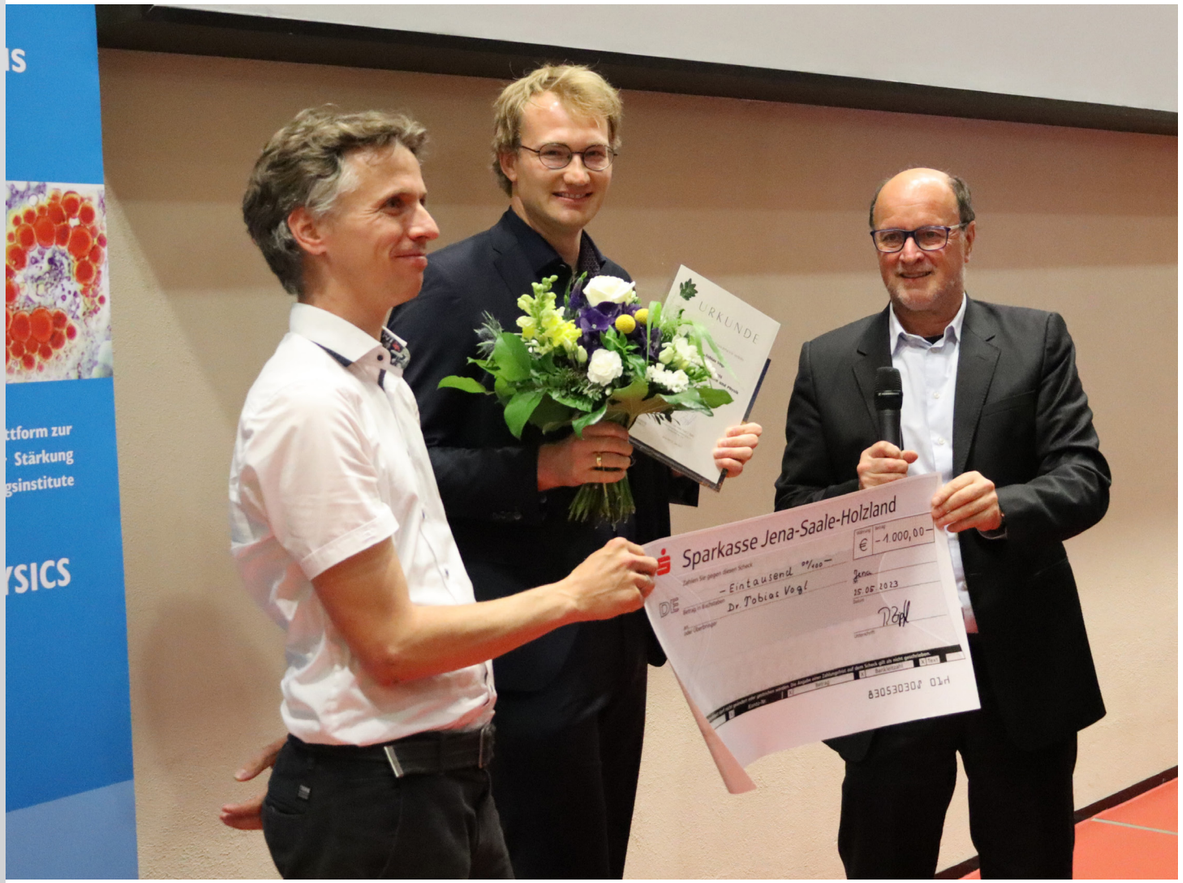
Thorsten Goebel
Multi-channel spectral filtering by femtosecond written fiber Bragg gratings

Matthias Heinzig
Diamantbasierte Raman-Oszillatoren

Pallabi Paul
Development and Properties of All-Dielectric and Metal-Dielectric Heterostructures at Atomic ScaleExterner Link

Andres Vega Perez
Quantum imaging and polarimetry with two-color photon pairs

RESEARCH
Achievements & Results



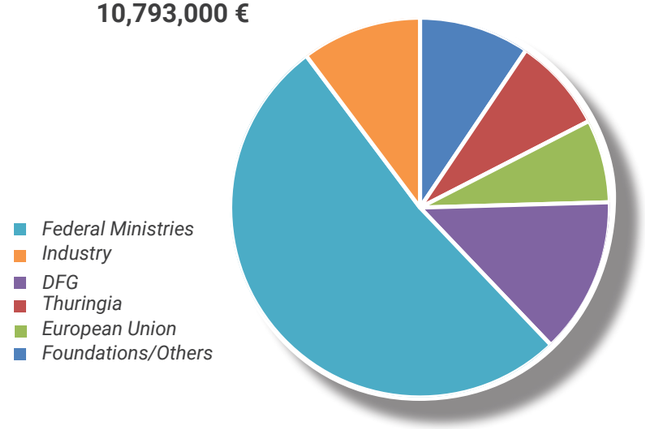
Dr. Tobias Vogl (middle) receives the Young Scientist Award of the Beutenberg-Campus Jena e.V., presented by Prof. Dr. Peter Zipfel (HKI Jena).
The laudatory speech was held by Dr. Falk Eilenberger (left).

Projects

"Applied Physics" is implemented in numerous projects in different application fields that contain fundamental research as well as application aspects. Accordingly, strong partners were explored and cooperation expanded. Thus, the IAP can continuously link the results and transfer those from basic research into innovative and novel demonstrators.

Third-party expenditure

Federal Ministries	5,599,000 €
DFG (German Research Society)	1,439,000 €
Contract Research	1,105,000 €
Foundations / Others	1,018,000 €
State of Thuringia	867,000 €
European Union	765,000 €
Total:	**10,793,000 €**

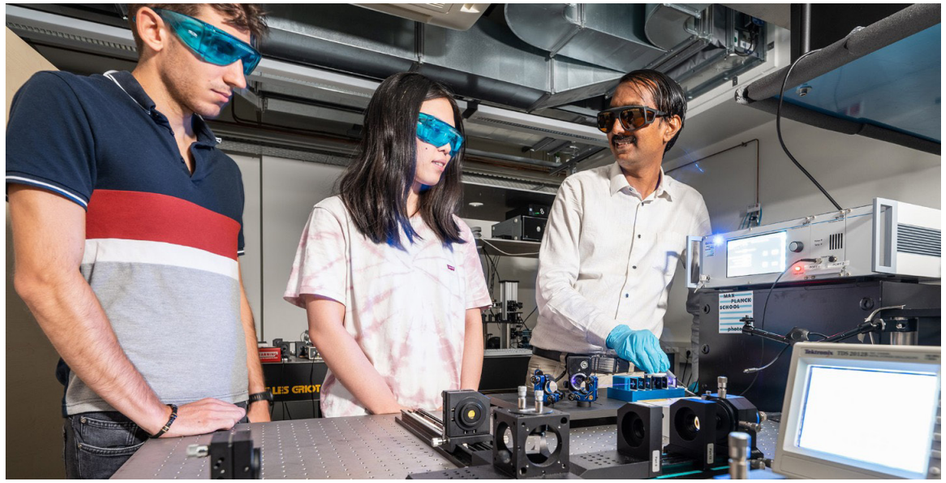


16.02.2023

Experiments on quantum computers even in education

New didactic terrain and important impulses for the University of Jena and the region

The beginnings of research in the field of quantum at our institute date back only about ten years - since then, some fundamental phenomena of quantum mechanics could be better understood and even applications could be developed together with the Fraunhofer IOF - as well as with other cooperation partners.
Such results by themselves mark a rapid development, which shows how much dynamism and potential there is in the new technology. It is therefore even more astonishing and at the same time highly relevant that experience can already be gained in university education through experiments with the world's first commercial quantum computers.
These developments were made possible by key funding from the German Federal Ministry of Education and Research (initiatives "digiPhoton" and "qp-tech.edu"). The social interest is not only in gaining knowledge and implementing it in the latest applications, e.g. to solve transmission and security problems in data communication. It is also important to have a lead in know-how in order to access international markets. This means that already now and in the future more and more experts are needed in industry and R&D who are well trained.
"Experimental quantum technologies should become an integral part of quantum education here in Jena in the future," resumes Prof. Dr. Andreas Tünnermann, Director of the Institute of Applied Physics at the University of Jena and the Fraunhofer IOF. The Lab Course "Experimental Quantum Technologies" led by Dr. Falk Eilenberger and Dr. Frank Setzpfandt, in which 18 students and PhD students performed complex quantum experiments on the Fraunhofer quantum computer "IBM QSystemOne", showed that this is already feasible.



Students experimenting in a laboratory at the Abbe Center of Photonics.

"Our goal was to make real state-of-the-art quantum experiments accessible hands-on," explains Dr. Falk Eilenberger. Via a cloud, participants were able to program the computer, which was physically located in Ehnringen (Baden-Würtemberg), read out results and display them in a meaningful way. "In the process, we solved problems in the field of simulation of quantum optical systems and on the so-called Grover algorithm," explains Dr. Falk Eilenberger. After easily comprehensible calculations, much more complex simulations were performed to exploit the advantages of quantum computing: "There we showed that entangled qubits, i.e. photons, allow much more precise interferometric measurements than classical photons." The researcher identifies concrete applications for this not only in improved optical metrology, but also for more precise clocks.
The students expressed great motivation - not only because of the deeper technical understanding they gained, but also because they were part of writing a small piece of physics history in Jena.

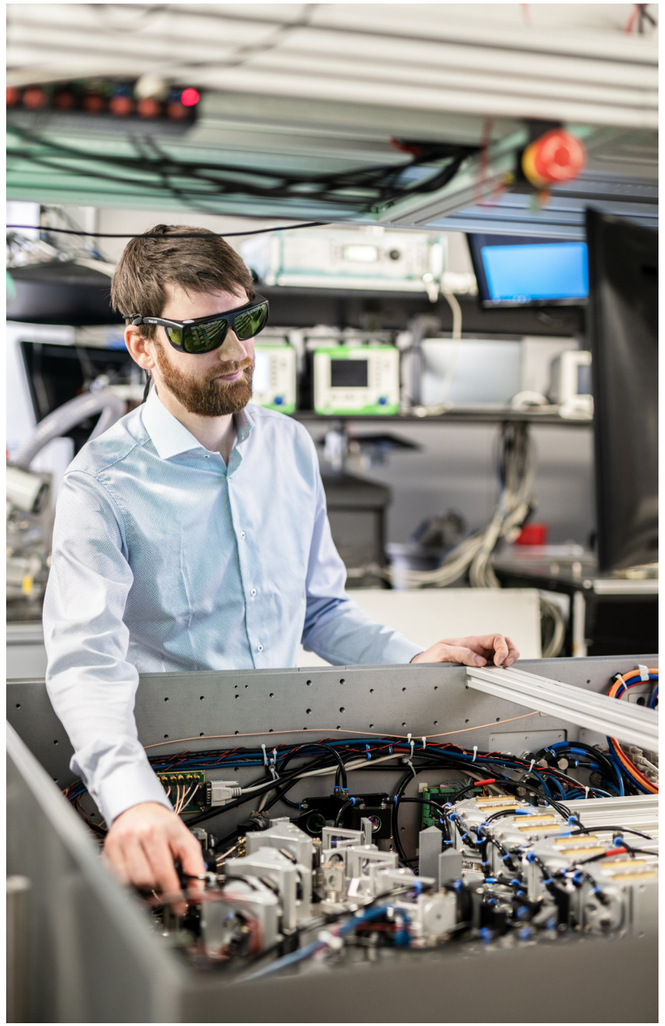
German version:

28.03.2023

Finding the needle in a haystack with EUV light

Hugo Geiger Award to Robert Klas

Perseverance and belief in himself have paid off handsomely for Robert Klas, a former doctoral student in Dr. Jan Rothhardt's research group "Soft X-Ray Spectroscopy and Microscopy". The six years of the doctorate were not only a great personal maturing process - the knowledge gained for further research is outstanding.
"In the second, third year, I went through a pretty big crisis: I simply could not prove my calculations in the lab, even though I was sure they were right! That cost me a lot of motivation to keep going and believe in myself. I received great support from my supervisors Dr. Jan Rothhardt and Prof. Jens Limpert. And then finally the breakthrough in the lab was achieved, setting an average power record in the EUV range of 10 milliwatts - that's a hundred times more power than similar systems at the beginning of my PhD!" reports Robert Klas. EUV (extreme ultraviolet) describes the spectral range of electromagnetic radiation between 10 nm and 121 nm wavelength, which characterizes a strongly short-wavelength range at the border of X-rays. "With this type of EUV source, experiments can now be performed on a laboratory scale that were only possible at synchrotrons a few years ago. Unlike synchrotrons, which are large-scale facilities with correspondingly high acquisition and operating costs, our setup fits on a lab bench," says Robert Klas, explaining the team's achievement. Thus, the compact setup costs only a fraction of such a large-scale research facility, so that the long waiting times at the large-scale facilities can be circumvented by the low acquisition costs and thus research results can be achieved more quickly."
The extremely small wavelength in EUV opens up many possibilities for the investigation of correspondingly small structures: Specifically, it is possible to inspect masks for EUV lithography for microchip fabrication with these light sources and thus prevent errors. These cutting-edge systems allow millions of transistors to be written onto a wafer the size of a fingernail. This gives an idea of how sustainability will be improved in terms of material savings in chip manufacturing.
This new technology also has a strong impact on the field of microscopy: Due to its wavelength in the nanometer range (one nanometer corresponds to one millionth of a millimeter), color images can be realized under an EUV microscope with a resolution of 18 nm - 10 times smaller compared to conventional light microscopes, which provide color images but only have a resolution of just under 500 nm. Scanning electron microscopes also achieve high image resolution, but again only have a black and white image of the object being imaged. In future, therefore, bacteria and cells can be examined much more precisely for their proportions of various substances such as carbon, lipids etc. "In the future, our technology will allow us to drive biological and medical studies and hopefully examine different types of viruses. Eventually, we hope to be able to image DNA with a diameter of about two nanometers using this technique," he said, describing the level of detail "In one experiment, we achieved a so-called field of view in the size of 100 x 100 micrometers. Figuratively speaking, this allows us to find a one-euro coin on the size of a soccer field."
This doctorate, which was produced in cooperation with the Helmholtz Institute Jena and the Fraunhofer Institute for Applied Optics and Precision Engineering IOF, was awarded 3rd place in the Hugo Geiger Prize on March 21, 2023. During the "Symposium Netzwert", the largest internal event for Fraunhofer researchers, the prize donated by the Bavarian State Ministry of Economic Affairs, Regional Development and Energy was handed over by the State Secretary Roland Weigert: "With their visionary ideas, the prize winners have achieved top performances in very different fields of research. [...] The award-winning work is not only characterized by scientific excellence, but also offers great potential for application and thus for economic success."



Dr. Robert Klas shows the EUV source.
He is a laureate of the Hugo Geiger Award 2023.
Image: Walter Oppel (Fraunhofer IOF)

German version:

25.05.2023

"Photonic Ecosystem" – From Jena to the World

Young Scientist Award of the Beutenberg Campus e.V. honors Dr. Tobias Vogl

This year's Young Scientist Award of the Beutenberg Campus e.V. honors Dr. Tobias Vogl, who joined the University of Jena as a postdoctoral researcher in 2019 after completing his Ph.D. at the Australian National University. The award criteria, including the quality and scientific rigor of the work reflected in the number and significance of publications, the relevance of the work to the campus's motto "Life Science meets Physics," and the mobility/internationality of the candidates, are exceptionally fulfilled by the leader of the research group "Integrated Quantum Systems."

Quality and scientific rigor of the work considering the age of the researcher

During his Ph.D., Mr. Vogl introduced a new topic to his former research group under Prof. Ping Koy Lam: the utilization of 2D materials for quantum optical experiments. This led to a series of first-author publications in renowned scientific journals. With his results and dissertation, Dr. Vogl also completed the best Ph.D. in Physics at the Australian National University in 2019, and he was nominated for the Bragg Gold Medal by the Australian Institute of Physics as one of the top ten physics Ph.D. candidates in Australia that year.

Basis of his scientific success

During his Ph.D., Mr. Vogl developed, optimized, and prepared room-temperature quantum emitters from the 2D material hexagonal boron nitride for use in modern quantum technologies. He initially developed and optimized a fabrication process for these emitters, which exhibited exceptional photophysical properties. The precise atomic structure of these emitters was unknown (and still partially is), but Tobias Vogl succeeded in developing and describing a model for the different emitters through fundamental experiments. Additionally, Mr. Vogl investigated their potential applications, including the direct coupling of emitters to optical fibers (e.g., for quantum networks). One of the most significant achievements was the coupling of an emitter to a microresonator, a success that had been pursued by

The Young Scientist Award 2023 of the Beutenberg Campus e.V. honors Dr. Tobias Vogl.

scientific groups worldwide before and after. He integrated this resonator-coupled light source into a prototype small satellite and qualified it for space. This study was featured as a Condensed Matter Highlight of the Month in the journal Nature Communications (March 2019). The research explored not only the radiation tolerance of quantum emitters for satellite-based quantum communication, which had not been previously investigated, but also qualified 2D materials in general for space applications. "This includes, for example, atomically thin field-effect transistors that could make future satellite electronics more efficient and lighter. We were particularly surprised by a novel defect healing mechanism that we observed in the experiments, where gamma rays can permanently improve a material (respectively its optical properties). With further experiments and theoretical simulations, we were able to fully elucidate the mechanism behind this effect," explains Dr. Tobias Vogl.

Time in Jena and internationality

In his first year as a postdoc at IAP, Tobias Vogl received a research project from the German Research Foundation (DFG), which was the first and very early step toward scientific independence. In this project, he developed a novel excitation mechanism for single-photon sources and explored their use in quantum cryptography. Despite the COVID-19 pandemic, he managed to maintain intensive collaboration with the Cavendish Laboratory through a joint postdoctoral fellowship with

Dr. Falk Eilenberger and Dr. Tobias Vogl are working together at the quantum light source.

the University of Cambridge. In the same year, he started building an international research consortium aimed at advancing single-photon sources for a global quantum internet. Due to the lack of efficient quantum repeaters, such a quantum network can only be established through satellite connections, as quantum information is exponentially attenuated in glass fibers and can only be transmitted over very long distances through the atmosphere. "Dr. Vogl and his consortium successfully aquired a project funding from the BMWK for the development of a quantum light source and the evaluation of its performance in space on a small satellite. He serves as the local project leader as well as the spokesperson and coordinator of the research consortium, which includes researchers from the University of Jena, the Ferdinand-Braun-Institute, the Leibniz Institute for High-Frequency Technology, the Technical University of Berlin, and associated partners at Fraunhofer IOF, the University of Cambridge, the National University of Singapore, and the Polytechnic University of Milan. Acquiring and coordinating such a research network at a young stage of his career is an accomplishment typically reserved for senior researchers with extensive experience," emphasized Prof. Stefan Nolte, who supports the research work with infrastructure.

"Life Science meets Physics"

"This space project not only tests the quantum light source as a central component for a global quantum network but also carries a quantum interferometer on board the satellite, which seeks to explore extended physical theories beyond the standard model in microgravity. This experiment could confirm or falsify certain quantum gravity theories," explained Dr. Tobias Vogl. While no deviations from the predictions of standard quantum mechanics have been found in terrestrial experiments conducted on the ground, this experiment is of great importance for fundamental physics. It achieved measurement accuracy increased by an order of magnitude compared to the state-of-the-art, making it the most precise test for this class of extended quantum theories beyond the standard model. "Experiments of this kind are extremely important for fundamental physics as they contribute to better understanding the coupling of gravity at the quantum level. Significant advances in the natural sciences have often been made when researchers pursued the unknown," Professor Nolte added.

Tobias Vogl has further developed this groundbreaking concept of optical quantum logic on a satellite and received the INNOspace Masters Award in 2021, endowed with €400,000, from the German Aerospace Center. This prize, resulting from an ideas competition, promotes innovations between the space and non-space sectors.

In the following year, 2022, Mr. Vogl successfully obtained a junior research group funded by the BMBF. The group combines single-photon emitters in 2D materials with integrated optics. "This enables us to miniaturize complete quantum optical setups that were previously realized in laboratories into small quantum photonic chips. At the same time, this technology enables highly precise interferometric measurements, as outlined for tests beyond the standard model," Tobias Vogl expressed his excitement.

"This laid the foundation for the development of nanoscale quantum sensors. We found that the quantum emitters respond sensitively to various environmental properties such as temperature, currents, and magnetic fields and can be used for super-resolution imaging. As a result, not only can a single property of a sample be measured, but even all the aforementioned characteristics simultaneously with a resolution of approximately 1 nm."

These nanoscale quantum sensors are highly compact yet more precise than currently available solutions, making them extremely promising for applications in the field of life sciences. The magnetic field sensors could enhance the precision and resolution of medical magnetic resonance imaging (MRI) scanners. The compactness even opens up the possibility of using mobile devices in an ambulance during major natural disasters," outlines Stefan Nolte, describing the potential application areas of this technology. "Mr. Vogl has been at the forefront of the development of room-temperature quantum emitters since their discovery, rapidly advancing them to a stage where they can be utilized in modern quantum technologies, including space-based applications and nanoscale quantum sensors in medical diagnostics and super-resolution imaging."

In addition to acquiring over €7.5 million in third-party funding, publishing a significant number of articles in prestigious scientific journals such as Nature Physics and Nature Communications, and receiving invitations to international conferences and colloquia, Tobias Vogl supervises eight doctoral students, three master's theses, and leads two postdoctoral researchers. Furthermore, he is actively involved in teaching at the university.

When asked about the spice behind these remarkable achievements, Tobias Vogl responds, "The 'Photonic Ecosystem' in Jena, particularly here at the Beutenberg campus, has facilitated these research accomplishments for me and my team. It is a special place with fertile ground."

German article:

01.06.2023

UKPiño - A Grand Endeavor

BMBF-funded RUBIN consortium sets out with ambitious goals

When 14 highly specialized and market-leading companies in the field of optical and photonics technologies join forces with two research institutions in a traditional hotspot, exciting and forward-thinking developments, as well as innovative products, can be expected. This alliance has set out to do nothing less than revolutionize international markets with cutting-edge applications. To achieve this ambitious endeavor, additional seven associated partners have been recruited as multipliers or pilot customers. This potential of ideas, expertise, and resources has also been recognized by the Federal Ministry of Education and Research (BMBF), which has provided €13 million in funding through the "RUBIN - Regional Entrepreneurial Alliances for Innovation" program starting from June 1, 2023. An additional €7 million comes from the stakeholders.

The techology

The alliance goes by the name "UKPiño" and places Ultrashort Pulse (UKP) laser technology at the center of its activities. "The fascinating aspect of this technology is that it offers a contactless processing method that is not only highly precise but also efficient and low maintenance. This enables the production of products that meet the highest quality requirements, particularly in terms of durability. The resource-efficient use of materials plays a significant role in achieving economic and ecological goals," explains Prof. Stefan Nolte, whose research group has been successfully working with UKP lasers in materials processing and was awarded the Deutschen Zukunftspreis in 2013. "In our alliance, the focus is on unlocking the 2µm wavelength range as a key component for exploring new application fields. This allows for the processing of previously inaccessible materials. High-tech materials such as silicon, ceramics, crystals, high-performance plastics, and composite materials are of great interest. Many semiconductor compounds are transparent in this spectral range, enabling the expansion of current UKP processing techniques for volume processing of glasses to this material range," explains the researcher the core idea.

ukpiño

RUBIN
Regionale unternehmerische Bündnisse für Innovation

As it involves a completely new technology platform, new approaches are required along the entire value chain. From applied basic research to the development of new optical components and device development for the production of supplier and end-user products, completely new paths need to be found and tested. The partners complement each other with their core competencies in optics, optical systems, system integration of high-tech laser systems and equipment, as well as application expertise.

The potential

Dr. Tino Eidam, coordinator of the alliance, outlines the concept's potential: "With UKPiño, we venture into highly dynamic fields characterized by stable and disproportionate growth rates. With this new technology, it may be possible to design silicon semiconductor structures that enable the integration of electronics and photonics on a single chip ('Silicon-Photonics'). We see further application fields in medical technology, battery manufacturing, 'Smart Wearables,' 'Additive Manufacturing,' as well as for scientific laser systems, quantum technology, and nonlinear frequency conversion into the soft X-ray range, enabling novel metrological applications, for example."

Roots

The UKPiño consortium emerged from the research group 'UKPflex,' which was funded by the Thuringian Ministry of Economics and strategically utilized funds from the state, federal government, and EU - an example of the positive effects of targeted support on sustainable technological development.

German article:

October 2023

Fabian Steinlechner - the new professor for "Experimental Quantum Information"

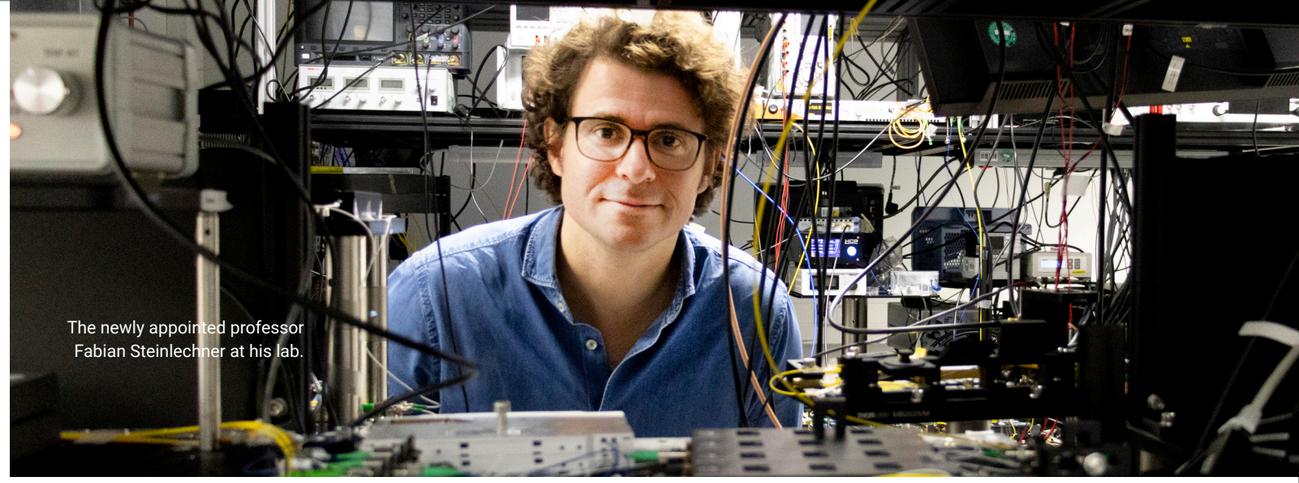
From the Hofburg cellars in Vienna via the Canary Islands to the Beutenberg in Jena

Following his appointment, we spoke to Fabian Steinlechner about his career to date and his goals as a professor here at the Institute. You can read an excerpt here:

For those who don't know you yet, could you please give us a brief overview of your academic career?

"... I completed my degree in technical physics in Vienna in 2009, where I also wrote my diploma thesis at the Institute for Quantum Optics & Quantum Information (IQOQI) under the supervision of Anton Zeilinger. I then did my doctorate in the optoelectronics group at the Institute of Photonic Science ICFO in Barcelona under the supervision of Valerio Pruneri. My research topic was the development of quantum light sources for space applications. After my PhD in 2015, I returned to the Academy of Sciences in Vienna as a postdoctoral researcher to join the group of Rupert Ursin and work on a series of experiments on quantum communication and fundamental aspects of quantum nonlocality. In August 2018, I was appointed as a junior research group leader at Fraunhofer IOF through the Fraunhofer Attract program with my research program "Photonic Technologies for Quantum Communication". Thanks to the unique framework conditions in Jena and the rapid growth in application-oriented quantum photonics in Germany, the group is well positioned within the Fraunhofer IOF. Thanks to the unique framework conditions in Jena and the rapid growth in application-oriented quantum photonics in Germany, the group has grown to 30 employees in just 5 years."
...

complete interview:



The newly appointed professor Fabian Steinlechner at his lab.

How do you see the importance of experimental quantum information for future technologies and applications? And what potential impact could it have on society?

"I think that quantum information has a special place in society in many areas. On the one hand, it enables practical applications in the medium future, which I hope will become state-of-the-art solutions. Then this fascinating and initially unfamiliar technology will become part of everyday life for many people. When terms such as quantum entanglement and quantum superposition enter common language, new perspectives and completely different application possibilities will be opened up. We are currently only scratching the surface of what is possible.
However, such future perspectives should be approached with a realistic timeline and expectations. In addition to many conceptual challenges, quantum technology also places immense demands on the underlying technological basis - in order to gain new insights and carry out revolutionary experiments, numerous highly developed components are required. And this also shows very clearly how theory and experiment are intertwined: only when I can build the corresponding experimental setups and new experimental devices can I verify the theory - but for that I need the theory.
In order for fundamental progress to be translated into quantum applications with added value for society, close cooperation between different disciplines - e.g. computer science, materials science, engineering - is required in addition to the bridge between theory and experiment. I think that Jena offers particularly fertile ground due to the historically proven synergy between basic research and application. I hope to make a contribution in this field of tension between basic research and application."
...

15.11.2023

Pioneering cooperation at Beutenberg: Novel microscopy in extreme ultraviolet reveals the nanoworld of microorganisms

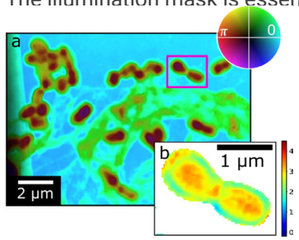
First "Collaboration Award" of Beutenberg e.V. receive researchers of the IAP

In order to develop more targeted cures for diseases, precise knowledge of the different stages in the development of pathogens and their interaction with infected cells is required. Extreme ultraviolet (EUV) light with a very short wavelength is particularly suitable for this, as it allows microscopy with a very high resolution (sub-20 nm).
Now, the interdisciplinary team led by Dr. Jan Rothhardt[1] has been able to examine complex microbiological samples, specifically seedlings of the fungus Aspergillus nidulans and Escherichia coli bacteria, using a novel high-resolution lensless microscope that works with extreme ultraviolet (EUV) light. This made it possible, for example, to identify the tip body of A. nidulans and the chemical composition of the cell wall of E. coli bacteria at different stages of cell division [1].
"Due to the high elemental contrast of the EUV radiation and an exceptionally high spatial resolution, subcellular structures of the two model organisms can be identified and subsequently assigned to known organelles," says Dr. Falk Hillmann[2], impressed. His team selected the biological model samples and developed a suitable preparation method on EUV-transparent silicon nitrite membranes.

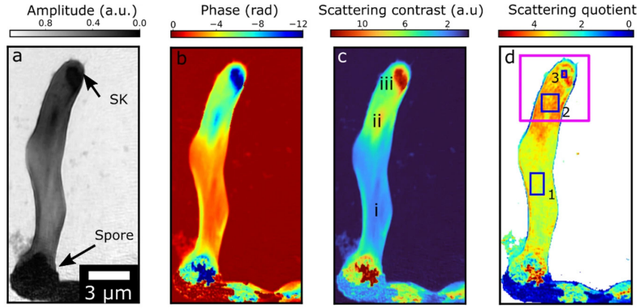
But how exactly does this new type of imaging work and what technical innovations were needed?

A novel EUV microscope adapted to the source was realized in my working group. It is based on the ptychography method, a special form of computer-assisted, lensless imaging [2]. The microscope is the first to use structured EUV illumination, which is crucial for high resolution and excellent image quality [3].
In this context, structured means that the EUV radiation used to illuminate the sample is shaped by a special illumination mask.

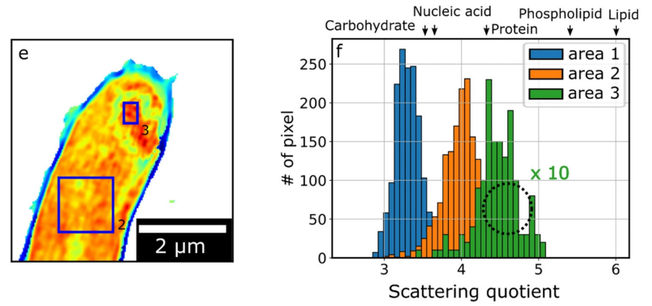
This mask is designed to transfer certain structures in the nanometer range to the EUV radiation. These can be patterns, lines or other shapes, which are then projected onto the biological sample. The structured EUV exposure plays a decisive role in the microscope's high resolution and excellent image quality," explains Dr. Rothhardt.
The illumination mask is essential for the resolution and image quality of the mi-



High-resolution EUV ptychography reconstruction of E. coli bacteria, Picture C. Liu et al.



High-resolution EUV image of A. nidulans. a and b show the reconstructed amplitude and unwrapped phase respectively. At the bottom, the spore is visible, which shows low transmission. While at the center the tubulus is visible and at the top, the high phase shift at the top indicates the Spitzenköper (SK). In c the scattering contrast is shown, where three regions are indicated by i, ii, and iii. d shows the scattering quotient. e shows the magnified region indicated in d by the pink box. f Histogram of the scattering quotient in the blue boxes in d and e by the blue boxes labeled 1, 2, 3. The number of pixels for area 3 is multiplied by a factor of 10 to facilitate comparison.



croscopic image. Prof. Thomas Pertsch[3], who has driven its development, emphasizes: "The production of this EUV mask requires the highest precision. A process has been developed with which absorbing binary EUV masks can be produced on the basis of thin metal foils. The nanostructuring was applied to the masks using a focused ion beam. By combining these nanostructured masks, the unique EUV light source and the novel EUV microscope, we were able to achieve a record resolution of 16 nm and demonstrate this in a resolution test [3]. Since the EUV microscope provides quantitative amplitude and phase information in each image pixel, it is even possible to identify the chemical composition on the nanoscale."
The compact EUV light source required for this was developed under the leadership of Prof. Jens Limpert's[4] working group. Laser-driven coherent EUV light sources on a laboratory scale have undergone rapid development in recent years. Record performances have already been demonstrated at the Institute of Applied Physics, which are comparable to synchrotron beam sources in some areas of EUV [4]. However, the laser-driven EUV light sources from Jena can be operated more cost-effectively and are compact and portable. Both are key application advantages over large-scale synchrotron research facilities.

Expanding possibility of applications & accessibility

"The new extreme ultraviolet (EUV) method enables high-resolution imaging of biological samples in an entirely new way," says Prof. Limpert, emphasizing the importance of this scientific milestone: "The interdisciplinary collaboration has enabled us to create a compact EUV microscope on a laboratory scale and demonstrate it on microorganisms. This not only expands the possible applications, but also makes the technology more accessible."
This special interdisciplinary collaboration across the top research institutes at Beutenberg was honored on 15.11.2023 with the Science Prize of the Beutenberg Campus Jena e.V., which was awarded for the first time in the category "Excellent interdisciplinary cooperation". "This award highlights exactly what the campus lives for and makes it special: cutting-edge research with outstanding application relevance beyond disciplinary boundaries, in other words "... where life science meets physics!", says Dr. Christiane Meyer, Scientific Officer of the Beutenberg-Campus e.V., delightedly.

Sources:

[1] C. Liu, W. Eschen, L. Loetgering, D. S. Molina, R. Klas, A. Iliou, M. Steinert, S. Herkersdorf, A. Kirsche, T. Pertsch, F. Hillmann, J. Limpert, J. Rothhardt, "Visualizing the ultra-structure of microorganisms using table-top extreme ultraviolet imaging," PhotoniX 2023 4:1 4(1), 1–15 (2022).

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[3] W. Eschen, L. Loetgering, V. Schuster, R. Klas, A. Kirsche, L. Berthold, M. Steinert, T. Pertsch, H. Gross, M. Krause, J. Limpert, J. Rothhardt, "Material-specific high-resolution table-top extreme ultraviolet microscopy," Light: Science & Applications 2022 11:1 11(1), 1–10 (2022).

[4] R. Klas, A. Kirsche, M. Gebhardt, J. Buldt, H. Stark, S. Hädrich, J. Rothhardt, J. Limpert, "Ultra-shortpulse high-average-power megahertz-repetition-rate coherent extreme-ultraviolet light source," PhotoniX 2(1), 1–8 (2021).

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1 Dr. Jan Rothhardt, Soft X-ray Spectroscopy and Microscopy, Institut für Angewandte Physik (IAP) & Helmholtz Institut Jena
2 Dr. Falk Hillmann, Evolution Mikrobieller Interaktionen, Leibniz-Hans-Knöll-Institut, Jena
3 Prof. Thomas Pertsch, Nano & Quantum Optics, IAP, Friedrich Schiller University Jena
4 Prof. Jens Limpert, Fiber & Waveguide Lasers, IAP & Fraunhofer IOF

German article:

PUBLICATIONS

Aim of applied research is the implementation of the results and thus to make contributions to overcome certain problems of the future. For this reason, the research actually not only ends in itself, but their results must be discussed and adjusted with further findings. In the end again, new ideas and scientific approaches can be developed.

Journals

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Conferences

Invited

C.P. Jisha, Light confinement using geometric phase, International Workshop on Atomic Physics - Focus days on "Research highlights in the eyes of the editors", Dresden, Germany.

J. Rothhardt, Quantitative and material-specific nanoscale imaging with table-top high harmonic sources, European Optical Society Annual Meeting (EOSAM) , Dijon, France.

J. Rothhardt, W. Eschen, C. Liu, D. Penagos, R. Klas, J. Limpert, High performance high harmonic sources, imaging and metrology in the EUV, EUV Source Workshop, Aachen, Germany.

M. Chambonneau, Q. Li, M. Blothe, V. Yu. Fedorov, S. Tzortzakis, S. Nolte, Silicon–metal and silicon–silicon ultrafast laser welding with domesticated filaments, SPIE Photonics West, Laser-based Micro-and Nanoprocessing XVII, San Francisco, USA.

S. Nolte, Processing of transparent materials using ultrashort laser pulses, DGG-USTV Joint Annual Meeting, Orléans, France.

S. Nolte, N. Alasgarzade, A. Alberucci, M. Blothe, C. P. Jisha, G. Matthäus, M. Chambonneau, Ultrashort pulse laser processing of silicon, SPIE Photonics West, Frontiers in Ultrafast Optics: Biomedical, Scientific, and Industrial Applications XXIII, San Francisco, USA.

S. Nolte, N. Alasgarzade, A. Alberucci, M. Blothe, C.P. Jisha, M. Chambonneau, Ultrafast laser modifications of semiconductors, Progress in Ultrafast Laser Modification of Materials (PULMM), Nikko, Japan.

T. Pertsch, The route towards strongly dispersive metamaterial volumes, Optical Innovation Summit on Meta-Optics, Jena, Germany.

T. Pertsch, Resonant metasurfaces for strongly enhanced nonlinear interactions and light generation,14th International Conference on Information Optics and Photonics (CIOP2023), Xi'an, China.

T. Pertsch, Adaptive and nonlinear diffractive metasurfaces, PIERS 2023 - Progress In Electromagnetics Research Symposium, Prague, Czech Republic.

T. Pertsch, Light emission controlled by resonant localization of light at nanostructured metasurfaces, Molecular Plasmonics, Jena, Germany.

M.A. Weissflog, Photon-Pair Generation in Resonant Dielectric Nanostructures, META 2023, Paris, France.

V.R. Besaga, Quantum polarimetry: resource of photon entanglement, The 2nd Spring Biophotonics Conference, Espinho, Portugal.

C.P. Jisha, Light confinement using geometric phase, International Workshop on Atomic Physics - Focus days on "Research highlights in the eyes of the editors", Dresden, Germany.

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V.R. Besaga, Quantum polarimetry: resource of photon entanglement, The 2nd Spring Biophotonics Conference, Espinho, Portugal.

A. Tünnermann, Prospects in power scaling if fiber lasers and amplifiers, Conference on Lasers and Electro-Optics/Europe (CLEO/Europe 2023) and European Quantum Electronics Conference (EQEC 2023), Munich, Germany.

Talks & Posters

A. Alberucci, C.P. Jisha, M. Monika, U. Peschel, S. Nolte, Experimental demonstration of gauge confinement in point-wise shifted periodic potentials, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), Munich, Germany.

A. Kirsche, M. Gebhardt, R. Klas, M. Benner, W. Eschen, H. Stark, J. Buldt, J. Rothhardt, J. Limpert, Continuously tunable high harmonic source for 92 eV/13.5 nm, Ultrafast Optics, Bariloche, Argentina.

A. Klenke, A. Steinkopff, M. Bahri, C. Aleshire, C. Jauregui, J. Nold, N. Haarlammert, T. Schreiber, J. Limpert, Rod-type Multicore Fiber with 49 Cores for Coherent Beam Combination of Femtosecond Pulses, Advanced Solid State Lasers Conference (ASSL), Tacoma, USA.

A. Klenke, A. Steinkopff, C. Aleshire, M. Bahri, C. Jauregui, J. Nold, N. Haarlammert, T. Schreiber, A. Tünnermann, Jens Limpert, High power ultrafast laser systems based on rod-type multicore fibers, Ultrafast Optics, Bariloche, Argentina.

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C. Jauregui, A. Klenke, A. Steinkopff, C. Aleshire, M. Bahri, J. Nold, S. Kuhn, N. Haarlammert, T. Schreiber, J. Limpert, Optimized Multicore Fiber Designs For Coherent Combination, Conference on Lasers and Electro-Optics Europe (CLEO Europe), Munich, Germany.

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M. Karst, C. Grebing, M. Müller, H. Stark, J. Buldt, J. Limpert, High nonlinearities in gas-filled multipass cells, European Optical Society Annual Meeting (EOSAM) , Dijon, France.

M. Karst, P. Pfaller, R. Klas, M. Abdelaal, Z. Wang, J. Rothhardt, J. Limpert, Multipass cell post-compression at 515 nm as an efficient driver for a table-top 13.5 nm source, European Optical Society Annual Meeting (EOSAM), Dijon, France.

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M. Lenski, M. Gebhardt, T. Heuermann, Z. Wang, C. Gaida, C. Jauregui, J. Limpert, Highly efficient, in-band pumped thulium-doped fibers for high-power ultrafast 2 µm wavelength laser systems, SPIE Photonics West, Components and Packaging for Laser Systems IX, San Francisco, USA.

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R. Klas, M. Gebhardt, M. Karst, J. Rothhardt, J. Limpert, New aspects of HHG efficiency considerations – towards the Watt level, Ultrafast Optics, Bariloche, Argentina.

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Z. Wang, T. Heuermann, M. Gebhardt, M. Lenski, P. Gierschke, R. Klas, C. Jauregui, J. Limpert, Tm:fiber CPA driven nonlinear pulse compression delivering mJ-level, sub-two cycle pulses at 2 µm with >100 W average power, Conference on Lasers and Electro-Optics Europe (CLEO Europe), Munich, Germany.

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T. Pertsch, Volume metamaterials – Their fabrication and application, 4th International Conference on Optics, Photonics and Lasers – OPL-2023, Hiroshima, Japan.

M.A. Weissflog, A. Fedotova, Y. Tang, B. Laudert, F. Abtahi, S. Shradha, S. Shinde, S. Saravi, I. Staude, T. Pertsch, F. Setzpfandt, Y. Lu, F. Eilenberger, Spontaneous Parametric Down-Conversion in Transition Metal Dichalcogenides, CLEO®/Europe-EQEC 2023, Munich, Germany.

M.A. Weissflog, A. Fedotova, Y. Tang, B. Laudert, F. Abtahi, S. Shradha, S. Shinde, S. Saravi, I. Staude, T. Pertsch, F. Setzpfandt, Y. Lu, F. Eilenberger, Photon pairs in 3R-stacked MoS_2, Frontiers in Optics + Laser Science, Tacoma, USA.

S. Saravi, Understanding Diffractive Deep Neural Networks, workshop on “Inference in Microscopy”, Jena, Germany.

F. Setzpfandt, Scanning quantum microscopy, IX International School and Conference on Photonics - Photonica 2023, Belgrade, Serbia.

F. Setzpfandt, Photon-pair generation in thin-film materials, META 2023, 13th International Conference on Metamaterials, Photonic Crystals and Plasmonics, Paris, France.

S. Shinde, A. Fedotova, M. A. Weissflog, S. Saravi, F. Setzpfandt, Towards Polarization Controlled SPDC from a Nanostructured LN Metasurface, TMOS Conference 2023: Meta Together, Brisbane, Australia.

M. Younesi, D. Yang, HY. Liu, S. Saravi, F. Setzpfandt, Y.H. Chen, T. Pertsch, Er-doping of thin-film lithium niobate on insulator using ion exchange process, CLEO, San Jose, California, USA.

T.D. Pham, Y.X. Lin, C.C. Chiu, H.P. Chung, A. Niko, P.J. Tsai, M. Younesi, R. Geiss, F. Setzpfandt, T. Pertsch, Y.H. Chen, Integrated Photonic Quantum Sources and Circuits in Lithium Niobate Platform,28th Microoptics Conference (MOC), Miyazaki, Japan.

J. Kumar, A. Kristic, S. Saravi, F. Stezpfandt, Squeezed light generation in High Gain SPDC, DoKDoK 2023, Lusienthal, Germany.

D. Repp, F Vitale, C. Ronning, T. Pertsch, Coupling of semiconductor nanowire lasers to dielectric cylinders, Meta 2023, Paris, France.

B. Narantsatsralt, Scanning probe microscopy to explore the unseen and unimagined world at the nanoscale, EMIMEO Summer School 2023, Bilbao, Spain.

M.A. Weissflog, J. Ma, J. Zhang, S. Saravi, T. Pertsch, D.N. Neshev, F. Setzpfandt, A.A. Sukhorukov, Tuneable Spatially Entangled Photon-Pair Emission from a Nonlinear Metasurface, 2023 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), Munich, Germany.

M.A. Weissflog, A. Fedotova, Y. Tang, B. Laudert, F. Abtahi, S. Shradha, S. Shinde, S. Saravi, I. Staude, T. Pertsch, F. Setzpfandt, Y. Lu, F. Eilenberger, Entangled Photon-Pair Generation in 3R-MoS_2, DoKDoK 2023, Luisenthal, Germany.

J. Ma, S. Lung, J. Zhang, M.A. Weissflog, F. Setzpfandt, A.A. Sukhorukov, Spectral engineering of photon pairs from a nonlocal metasurface, Australian and New Zealand Conference on Optics and Photonics and the Australian Institute for Physics Summer meeting, Canberra, Australia.

V.R. Besaga, L. Zhang, A. Vega, P.S. Chauhan, T. Pertsch, A. Sukhorukov, F. Setzpfandt, Experimental Classification of Samples with Few Coincidence Measurements Using Polarization-Entangled Photon Pairs, Conference on Lasers and Electro-Optics/Europe (CLEO/Europe 2023) and European Quantum Electronics Conference (EQEC 2023), Munich, Germany.

V.R. Besaga, Towards quantum polarimetry with photons entangled in polarization, CZS Center QPhoton Networking Conference in Ulm, Germany.

Colloquia

F. Eilenberger, Warum photonische Quantentechnologien unser Leben verändern (ohne dass wir es merken), Thüringisch-Schweizer Handwerkskammer, Zürich, Switzerland.

F. Eilenberger, Er würfelt nicht! Er würfelt doch! Nein. Doch. Aua!, Samstagsvorlesung der Phys.-Astr.-Fakultät, Jena, Germany.

F. Eilenberger, Photonics for Climate. Nanophotonic Instruments to analyse the atmosphere, MPSP Lecture, Jena, Germany.

F. Eilenberger, Nano4Climate. Empowering ESA's CO2m with Nanophotonics Solutions., Photonics Days, Jena, Germany.

F. Eilenberger, Photonics for Climate- Nanophotonicinstruments to analyse the atmosphere, Fraunhofer Photonics, Jena, Germany.

F. Eilenberger, Er würfelt nicht! Er würfelt doch! Nein. Doch. Aua!, MINT Festival, Jena, Germany.

F. Eilenberger, Quantum Technology as a Driver of Innovation, V2023, Dresden, Germany.

F. Eilenberger, Quantum Computing: An Introduction, QPTech.edu Seminar, Jena, Germany.

F. Eilenberger, Quantum Algorithms: an Introduction, Kooloqium Bauhaus Uni, Weimar, Germany.

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A.Tünnermann, How the laser happened, HZDR Laser Symposium, Dresden, Germany.

A.Tünnermann, Quantentechnologien – wissenschaftliche Spielerei oder volkswirtschaftlich relevant?, Erfurter Technologiedialog, Erfurt, Germany.

A.Tünnermann, Markets of photonics industry - status and perspectives ,W3+, Jena, Germany.

Book

D. Grojo, M. Chambonneau, S. Lei, A. Mouskeftaras, O. Utéza, A. Wang

Internal Structuring of Semiconductors with Ultrafast Lasers: Opening a Route to Three-Dimensional Silicon Photonics

R. Stoian, J. Bonse, **Ultrafast Laser Nanostructuring**, *Springer 2023, ISBN 978-3-031-14751-7*

Granted Patents

A. Tünnermann, J. Limpert, T. Gottschall
Device and Method for Generating Laser Pulses
US 11,579,512B2

A. Tünnermann, J. Limpert, T. Gottschall
Vorrichtung und Verfahren zur Erzeugung von Laserpulsen
EP 3411754B1

A. Tünnermann, C. Stihler, C. Jauregui Misas, J. Limpert
Vermeidung von Modeninstabilität in einer optischen Verstärkerfaser
EP 3656024B1

S. Nolte, M.P. Siems, T.A. Goebel, R. Krämer, D. Richter
Method and device for machining by means of interfering laser radiation
US 11,590,607B2

J. Limpert, J. Rothhardt, W. Eschen
Verfahren und Vorrichtung zur linsenlosen Bildgebung mittels Fourier-Transformations-Holographie
DE 102020101994B4

A. Turchanin, F. Eilenberger, M.A. Schmidt, A. George
Anordnung und Verfahren zur effizienten nichtlinearen Lichtkonversion
DE 102020118780.7

ACTIVITIES

A key feature of the IAP is the active and engaged exchange of its employees within the scientific community. This commitment can be measured in both the participation at conferences and at cooperation in projects with other institutions. Such community projects are the fruits of compulsory networking and strengthen the reputation of the institute within the research society and industrial associations. Appreciation of these efforts are also the call-ups of particular scientists in committees and editorial positions of academically approved journals.

PhD student Ria Krämer at the workshop she planned for A-level graduates on the subject of refraction and diffraction. The feedback from the pupils was very positive; they felt better prepared for the upcoming Abitur.

29.09.2023

Enthusiasm at the MINT FESTIVAL JENA

The IAP inspires pupils of grades 8 & 12

Right on the 1st day of the 3-day MINT Festival we were able to inspire pupils for optical phenomena. Two events were designed to be age-appropriate, focusing on (total) reflection and diffraction.

Dr. César Jáuregui-Misas conjured up astonished looks in the faces of an 8th grade class of the Abbe-Gynasium. He skillfully attracted the attention and the thirst for knowledge by magic tricks, which were then elucidated by the physical phenomena behind them.

In Ria Krämer's workshop, twelfth graders were able to try out the way students work by experimenting on their own. The understanding of the refractive behavior of light and its wave nature was promoted by means of optical gratings. - A good preparation for the Abitur!

Before and after the event, the students were offered a wide range of activities from the world of science at many information and hands-on booths and on a stage, which was enthusiastically accepted.

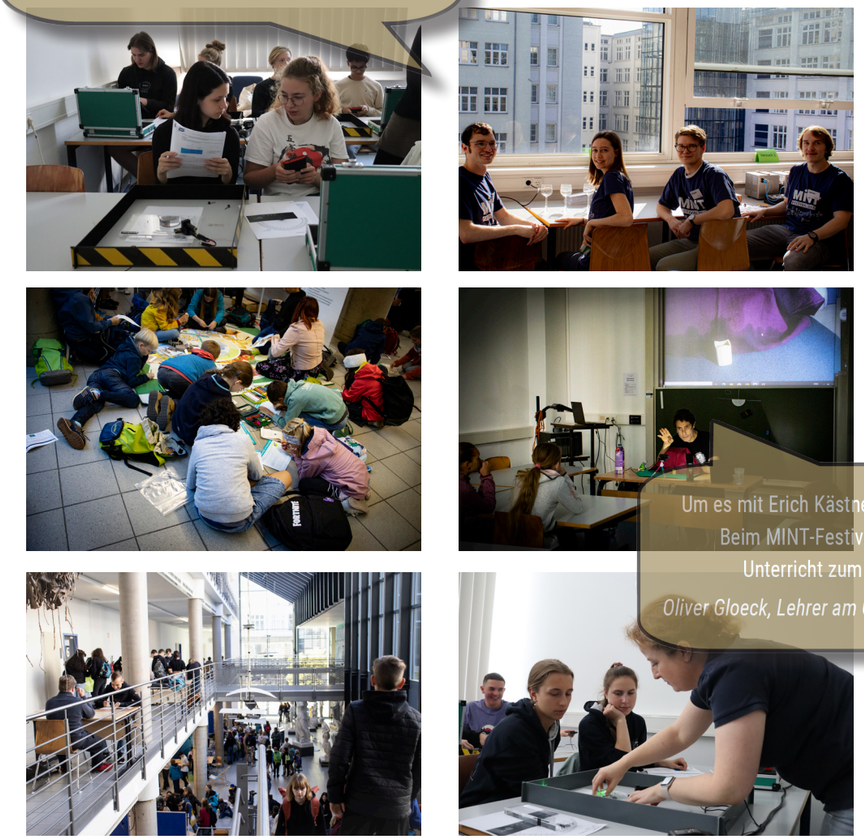
The MINT Festival shows how science and technology can inspire and reach young people, which is a very important impulse, especially in times of reduced teaching hours, lack of teachers and curriculum cuts.

More pictures:

ZUFRIEDENHEIT DER LEHRERINNEN UND LEHRER MIT DEM PROGRAMMANGEBOT

Man konnte ganz viel erleben! Die physikalischen Sachen waren die tollsten!

Iris Lauck, Lehrerin an der Grundschule Louis Fürnberg Weimar



Um es mit Erich Kästners Worten zu sagen: Beim MINT-Festival Jena wird der Unterricht zum Lokaltermin.

Oliver Gloeck, Lehrer am Gymnasium Münchberg

From top left to buttom right: Pupils discuss solution paths at the workshop of Ria Krämer / Physics teaching students help out / Pupils immersed in research tasks / Dr. César Jáuregui-Misas enchants with optical tricks / Foyer of the main building full of research(ers) questions / Dr. Silvana Fischer assists with the workshop.

Awards

Domenica Bermeo-Alvaro
Honours-Programm für forschungsorientierte Studierende, FSU Jena
Vier-Wellen-Mischung in mikrostrukturierten Fasern

Dr. Jan Sperrhake, Prof. Maria Mittag, Michael Steinert, Dr. Jan Petersen & Prof. Thomas Pertsch
Digital Innovation Hub Photonics (DIHP) Award
Fraunhofer Institute for Applied Optics and Precision Engineering
Development of nanostructures on glass chips with multiple chambers of different environmental conditions and microbial cultures migrating in between - a light-controlled microverse

Wilhelm Eschen & Chang Liu
Siegfried Czapski Publication Prize
The Jena Alliance of Graduate Schools, Carl-Zeiss-Stiftung
Visualizing the ultra-structure of microorganisms using table-top extreme ultraviolet imaging

Tobias Heuermann
3rd Place Best Student Presentation Award, SPIE. Photonics West
Scaling of ultrafast thulium-doped fiber laser systems using coherent beam combination of large mode area fiber amplifiers

Richard Kindler
Honours-Programm für forschungsorientierte Studierende, FSU Jena
Erschließung neuer Wellenlängenbereiche für integrierte Optiken mittels Photonic Integrated Circuits (PICs)

Robert Klas
3rd Place Hugo Geiger Award
Fraunhofergesellschaft & Bayrisches Wirtschaftsministerium

Manuel Klockow
Applied Photonics Award, Fraunhofer Gesellschaft
Evaluating Diffractive Neural Network Architectures

Josefine Krause
Fakultätspreis Masterarbeit Rohde & Schwarz
Physikalisch-Astronomische Fakultät (PAF) der FSU Jena
Coupling of Quantum Emitters in 2D Materials into Laser-Written Waveguides

Dr. Martin Landmann
Preis der Dr.-Ing. Siegfried Werth Stiftung für beste Promotion
Schnelle und genaue 3D-Formvermessungmittels Musterprojektion und Stereobildaufnahme im thermischen Infrarot

Prof. Jens Limpert & Prof. Thomas Pertsch & PD DR. Jan Rothhardt
Wissenschaftspreis für „Exzellente interdisziplinäre Kooperation“
Beutenberg-Campus Jena e.V.
Neuartige Mikroskopie im extremen Ultraviolett enthüllt Nanowelt der Mikroorganismen

PD Dr. Jan Rothhardt
Senior Member Optical Society (OSA)

Dr. Sina Saravi
Nexus Fellowship, Carl-Zeiss-Stiftung
Metasurfaces for Diffractive Deep Neural Networks

Dr. Jan Sperrhake
Fakultätspreis Dissertation Rohde & Schwarz
Physikalisch-Astronomische Fakultät (PAF) der FSU
Coupling of Quantum Emitters in 2D Materials into Laser-Written Waveguides

Dr.Jan Sperrhake at the ceremonial awarding of his prize at the faculty.

Dr. Ziyao Tang
Friedrich Hund Dissertationspreis
Wilhelm und Else Heraeus-Stiftung
Improved correction methods for symmetry-free systems

Dr. Tobias Vogl
Nachwuchswissenschaftspreis des Beutenberg-Campus Jena e.V.

Ziyao Wang
1st Place Best Student Presentation Award, SPIE. Photonics West
Nonlinear pulse compression of a high-power ultrafast thulium-doped fiber laser in a gas-filled capillary

Maximilian Weissflog
EPS-QEOD Travel Grant Student Award
European Physical Society (EPS), Quantum Electronics and Optics Division (QEOD)
Tuneable Spatially Entangled Photon-Pair Emission from a Nonlinear Metasurface

Prof. Uwe D. Zeitner
MOC Contribution Award, Japan Society of Applied Physics
For significant contributions to successfully hold the MOC2022 in Jena, Germany

Organizing Activities

Dr. Falk Eilenberger

- Fellow of the Max-Planck-School of Photonics
- Referee for Optica, Annalen der Physik, Opt. Comm.

Prof. Dr. Markus Gräfe

- Journal-Referee for: Nature Photonics, Optics Letters, APL Photonics, Physical Review Letters, Physical Review A, Optics Communication, Advanced Photonics Research, Laser & Photonics Reviews, Journal of Microscopy
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Member of the ACP

Prof. Dr. Jens Limpert

- Member of Deutsche Physikalische Gesellschaft (DPG)
- Member of the Optical Society of America (OSA)
- Referee for several scientific journals

Prof. Dr. Stefan Nolte

- Deputy Director of the Institute for Applied Optics and Precision Engineering IOF
- Fellow of the Max Planck School of Photonics
- Member of the scientific advisory board of the Deutsches Optisches Museum D.O.M.
- Member of the financial board of the Max Planck School of Photonics
- Member of the executive board of the Abbe School of Photonics
- Chair of the Faculty´s Budget Commission and member of the Budget Board of the Senate
- Member of jury “Jugend forscht”
- Member of several scientific committees (e.g. Phot. West, CLEO, ICALEO, LANE, Lasertagung Jena)
- Fellow of the Optical Society of America (OSA)
- Fewllow of the International Society for Optics and Photonics SPIE
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Referee for several scientific journals and funding organizations

Prof. Dr. Thomas Pertsch

- Spokesperson of the steering group of the profile line "Light" of the Friedrich Schiller University Jena
- Spokesperson of the Abbe School of Photonics at the Friedrich Schiller University Jena
- Member of the board of directors of the Abbe Center of Photonics at the Friedrich Schiller University Jena
- Member of the advisory board of London Institute for Advanced Light Technologies (www.london-light.org) of King’s College London, Imperial College London and University College London
- Member of the board of trustees of the Center of Excellence in Photonics (“Leistungszentrum Photonik”) of the Fraunhofer Society
- Member of the board of directors of the Thuringian Innovation Center for Quantum Optics and Sensing
- Associate Investigator of the ARC Centre of Excellence for Transformative Meta-Optical Systems
- Associate Investigator of the Cluster of Excellence Balance of the Microverse
- Fellow of the Max Planck School of Photonics
- Fellow of the OPTICA (formerly Optical Society of America, OSA)
- Member of the Undergrad Committee of the Faculty of Physics and Astronomy at the Friedrich Schiller University Jena
- Study program director for “Master of Science in Photonics“ at the Friedrich Schiller University Jena – also responsible for accreditation
- Advisor of the Student Chapter Jena of the Optical Society of America

PD Dr. Jan Rothhardt

- Member of the extended directory board of the Helmholtz Institute Jena
- Member of the Program committee for EOSAM conference 2021 and Ultrafast Optics 2023 conference
- Member Optical Society of America (OSA)

PD Dr. Frank Setzpfandt

- Journal-Referee for: Laser & Photonics Reviews, Science Advances, Advanced Photonics
- Managing Director of the „Thüringer Innovationszentrums für Quantenoptik und Sensorik”
- Associate Investigator of the ARC Centre of Excellence for Transformative Meta-Optical Systems
- Member of the Undergrad Committee of the Faculty of Physics and Astronomy at the Friedrich Schiller University Jena

Dr. Thomas Siefke

- Journal-Referee for: Applied Research, Optica, EOS
- Program committee member SPIE Modeling Aspects in Optical Metrology
- Organizer NANO-FAME 2023 Micro and Nano fabrication technology meets Nano metrology

Prof. Dr. Fabian Steinlechner

- Referee for Physical Review Letters, Nature Physics, Optica, and other international journals
- Reviewer for DFG & Swiss National Science Foundation

Prof. Dr. Andreas Tünnermann

- Member of the BMBF Research Cluster “infectooptics”
- Spokesman of the BMBF Center for Innovation Competence ZIK “ultra optics”
- Spokesman of the BMBF Program Zwanzig20 “3Dsensation” & BMBF Program “QuNET”
- Spokesman of DFG Research Training Group GRK2101
- Council member of the DFG excellence cluster “Balance of the microverse”
- Director Fraunhofer IOF
- Director Carl Zeiss-Stiftung Center for Quantum Photonics (CZS Center Q Photon)
- Chairman of the Technical Council Fraunhofer- Gesellschaft
- Spokesman of the Fraunhofer Innovation Cluster “Leitprojekt Quilt”
- Co-Spokesman of the Fraunhofer Cluster of Excellence “Advanced photon source”
- Spokesman of the Thuringian Innovation Center of “Quantum optics and sensors”
- Board of Directors Helmholtz Institute, Jena
- Supervisory board member Jenoptik AG
- Board of Trustees MPA, Heidelberg
- Spokesman of the “Max-Planck-School of Photonics”
- Surveyor BMBF, DFG, EU, AIF, MF, VF Projektträger Euronorm (BMWI)
- Alexander von Humboldt Stiftung - Selection Committee Alexander-von-Humboldt Professur
- Jury member STIFT - Thüringer Innovationspreis
- Stakeholder Photonics 21-Platform
- Member of Program Committee "Quantensysteme 514", BMBF
- Member of „Rat für technischen Souveränität RAT4TS“, BMBF
- Member of the Strategic Advisory Board for the Quantum Technologies Flagship (SAB), EU
- Council Member of the TU Bergakademie Freiberg
- Council Member of the Faculty PAF at FSU Jena
- Member of the Excecutive Board of the Abbe Center of Photonics at FSU Jena
- Spokesman of the Fraunhofer Innovation Cluster “Leistungszentrum Photonik” & Fraunhofer Graduate College "Fraunhofer Graduate Research School Photonics"
- Member Wissenschaftliche Gesellschaft Lasertechnik e .V. - Chairman "AG Naturwissenschaften"
- Member of acatech "Deutsche Akademie der Technikwissenschaften"
- Fellow of OPTICA (formerly Optical Society of America, OSA) and SPIE
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Member of the Strategy Advisory Board "industrielle Produktion und Systeme"
- Spokesman Thuringian Quantum Hub
- Representative of „Fraunhofer-Gesellschaft im QVLS | Quantum Valley Lower Saxony“
- Representatives of the Fraunhofer-Gesellschaft in the Munich Quantum Valley
- Member CPM Advisory Board
- ODF'24 Member Advisory Board

Prof. Dr. Tobias Vogl

- Member of Deutsche Physikalische Gesellschaft (DPG)
- Speaker of Research Network QUICK3, DLG and BMWK
- Referee for international journals

Prof. Dr. Uwe D. Zeitner

- Member of the International Advisory Committee for 28th the Microoptics Conference MOC2023, Japan
- Referee of several scientific journals

LOCATION

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