Faculty of Physics and Astronomy of the Friedrich Schiller University Jena

Annual Report 2015

The Graduates of the cohort 2014/15

Editors: Prof. Dr. Gerhard Paulus
Prof. Dr. Thomas Pertsch
Prof. Dr. Karl-Heinz Lotze
Dr. Angela Unkroth

Directory

1. The International Year of Light

In 2013, on December 20th, the United Nation's General Assembly proclaimed 2015 as the *International Year of Light*. The goal has been „to raise awareness of how optical technologies promote sustainable development and provide solutions to worldwide challenges in energy, education, agriculture, communications and health". Obviously, the initiative and its motivation fit squarely to Jena, the *City of Light*, and to our department, the Physikalisch-Astronomische Fakultät. Consequently, we did our best to take advantage of the opportunities and synergies offered by the event, in particular with respect to outreach.

In fact, outreach has become an important topic at our department in face of low numbers of incoming students. The reasons probably are complex; two, however, stick out: First, we experience the consequences of the dramatic slump in birth rate in Eastern Germany after German reunification 25 years ago. Second, mathematics and physics were severely cut in the high school curricula in Thuringia such that high school graduates often feel insufficiently prepared for studying math-heavy subjects like physics. We have responded to the challenge by a series of measures ranging from outreach to pre-courses. For the former, for outreach, the *International Year of Light* has offered an ideal framework in 2015. In the following an incomplete summary of events beyond our regular activities like children's university, lectures for school classes, Rent-a-Prof, Physics for Girls, etc. will be given.

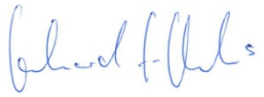
Outreach cannot start too early. In this spirit, we started the *International Year of Light* with a show for pre- and elementary school children by Ralph Caspers in the new Sparkassen arena. When I say „we" then I adorn the department also with borrowed plumes: Without the enormous personnel, financial and organizational commitment of the Fraunhofer Institute for Applied Optics and Precision Engineering and the Leibniz Institute of Photonic Technologies the event would not have been possible. It is one of many examples of the department's smooth and fruitful collaboration with extramural research institutes.

For the same audience, colleagues of the Institute of Applied Physics contributed to a hands-on exhibition in the Goethe-Galerie in April. Later that month, they took part in the *SciFest* in Joensuu/Finland which is targeted at inspiring Finish and Russian pupils for the natural sciences. Of course, the goal was also to promote Jena and our university. Here in Jena, in September, we had the *2. Photonics Academy* for undergraduates from all over Germany. We had also something for grown-ups: The *Kneipenquiz* was a series of fun events at local pubs with questions on light and photonics.

The most elaborate event were the *Highlights of Physics*, an annual format in changing university cities which is funded by the Federal Ministry of Research and Education, the German Physical Society, and the local university. We were fortunate to succeed with our application precisely for the *International Year of Light*. The *Highlights of Physics* had their own tent camp on the Eichplatz from September 22. to 26. and offered a large variety of hands-on experiments, lectures for high-school students, fun science competitions, handicraft lessons for K-12 students, and entertaining science shows. The evenings saw first the *Highlights Show* hosted by Rangar Yogeshwar and subsequently lectures by prominent physicists like Harald Lesch and Stefan Hell. As compared to earlier editions of the *Highlights of Physics*, our's had several novelties: Thanks to the Carl Zeiss Foundation, we were able to support school excursions to Jena. Our Physics Education group backed that up with educational material. The response to the *Highlights of Physics* in Jena was overwhelming and exceeding all previous editions by almost a factor of two. Contributing to this success were also two extra tents on the Eichplatz. The Zeiss company offered microscopy workshops, which were always fully booked, and the Collaborative Research Center TR7 had a special exhibition on gravitational wave astronomy.

In hindsight, we realize that the gravitational waves were discovered just around the time when we presented them to the public here in Jena. They are a very good keyword anyways because 2015 has also been the *Centennial of General Relativity*. Our Institute of Theoretical Physics and the Physics Education Group used the opportunity for a number of teacher training courses, among them one under the umbrella of the German Physical Society and an international course funded by the Wilhelm and Else Heraeus Foundation.

For a lasting effect of our efforts in the *International Year of Light* and the *Centennial of General Relativity*, it will be important to find approaches for a permanent implementation of some key components of the events that we have had in Jena in 2015. The department, in fact the entire university, should be enabled to establish continuing and close ties to the high schools in the catchment area of Jena and beyond. The *Highlights of Physics* have demonstrated how this can work. Accordingly, the establishment of a biannual Science Festival and, very important, the resources to fund school excursions in order to reach out far beyond the city limits could be a decisive step to further the publicity of our department and its attractive teaching and research programs.



Prof. Dr. Gerhard G. Paulus
Dean

2. The Development of the Faculty of Physics and Astronomy in 2015

In 2015, the developments initiated in the years before were successfully continued. This applies to important content-related and organizational issues of teaching as well as the procedures for appointing chairs and professors. Great efforts were put forth to land large promoted projects on the national and international levels.

The *Abbe Centre of Photonics* (ACP) founded in December 2010 will play an important part in the further successful development of close collaboration between academic and non-academic research institutions and the optical industry, in the advancement of junior scientists and in improving permeability between the University and the industry.

The center and its members commit themselves to Jena's tradition of excellence in research and teaching in the field of optics and photonics and thus form the core of the key research area "Light" regarding the University's institutional strategy "Light – Life – Liberty". ACP's main mission is to promote and to coordinate interdisciplinary research jointly performed by scientists from different subject areas and to contribute sustainably both in fundamental and applied optical sciences. While encompassing a broad variety of research fields, ACP concentrates on expertise development in its three strategic domains **ultra optics, strong field physics and biophotonics**. Besides ACP's research efforts, the education of young research scientists, represented by its integrated **Abbe School of Photonics (ASP)**, exhibits its fourth profile cornerstone and cross-connects all research areas.

The Jena Helmholtz Institute founded on 1 July 2009 was successfully evaluated and integrated into the regular funding scheme of the Helmholtz Association in 2014. Within the short period since its foundation, the institute managed to attain good research results in the fields of petawatt lasers, fibre lasers, X-ray optics, laser particle acceleration and strong-field QED and to set up new working groups. This also backs up innovative research fields of our Faculty as well as our collaboration both within the Faculty and especially with GSI Darmstadt, DESY Hamburg and the Helmholtz Centre at Dresden–Rossendorf.

The targeted promotion of junior scientists in the research field of intensive photon and particle radiation takes place at the Research School of Advanced Photon Science founded at the Jena Helmholtz Institute early in 2013 (see chapter 7.11).

The SFB/TR 18 "Relativistic Laser Plasma Physics", successfully evaluated in Jena in 2012, is still active. The funds granted amount to €6.6 million for the period from 2013 to 2016, about 30% of which go to Jena. Participants include the Institute of Optics and Quantum Electronics (IOQ) and the TPI. Prof. Paulus is the deputy speaker.

The Postgraduate College GRK 1523 "Quantum and Gravitational Fields", which forges a link between the Institute of Theoretical Physics and the Institute of Mathematics of the Faculty of Mathematics and Computer Sciences, was confirmed in 2013 and thus enjoys its second period of grant lasting till March 2018.

In 2015, Prof. Ulf Peschel of the Institute of Solid State Theory and Optics held his inaugural lecture in the assembly hall of our University.

In 2015, again, we followed the decision of the Faculty Council that about 40% of the funds due to the institutes be allocated on an achievement basis. In keeping with the CHE criteria, about 0.3% of the third-party funds granted, a fixed sum for each doctorate conferred and approximately 6% of the allocated budget are directly passed on to the institutes according to their impact factors achieved.

It is a matter of importance for our Faculty to develop meaningful assessment factors also for teaching. The awarding of teaching prizes every semester has proved an effective means of recognizing good results in teaching. This year's prize-winners were Prof. Dr. Martin Ammon and Dr. Ronny Nawrodt. In addition, the Dean's teaching prize this year was awarded to the master students Sebastian

Ulbricht and Michel Pannier in appreciation of their extraordinary commitment as tutors of a refresher course in mathematics for the study beginners.

In 2015, again, the Faculty had the possibility to pay bonuses to 8 meritorious colleagues in recognition of their continuously outstanding performance.

The state of research at the Faculty in 2015 is shown by the following indicators: In 2015, third-party funds (not counting those granted by the State of Thuringia) amounted to approximately €18 million. The front runner in successful applications for third-party grants is the IAP (ca. 56%); other main contributors to the good third-party funds account are IOQ, the Otto Schott Institute of Materials Research (OSIM) and the IFK. The number of publications in 2015 totalled 438; the accumulated impact was 1622.403 and the average number of publications per scientist was 1.66. The top position in the number of publications and the accumulated impact factor is held by the IAP (106 / impact factor 419), followed by the IOQ (94 / impact 325). About 43 % of the publications were made together with scientists from foreign institutions. In 2015, 37 doctoral proceedings at the Faculty of Physics and Astronomy were successfully completed.

Since the allocation of funds by the University is not only a function of the number of students enrolled but mainly, and to a growing extent, of the third-party funds granted, and since the result in CHE rankings will have a strong influence on the standing of the Faculty, we will continue to pay close attention to these criteria.

The staff of the Faculty – professors and others – serve on many national and international specialist panels and as peer reviewers for all relevant professional journals, the DFG, the Federal Ministry of Education and Research and the European Commission.

Public awareness of the Faculty has been enhanced by high honours conferred upon our professors and other staff. Prof. Lotze was awarded with the Hanno and Ruth Roelin-Preis für Wissenschaftspublizistik of the Max Planck Institute in Heidelberg.

Notwithstanding these successes in research, it will be of vital importance in the next few years for us to develop a distinctive profile at Jena within the German research landscape, which is about to get more sharply structured in the context of the German universities' Excellence Initiative. Greater efforts will be needed to integrate such fields as photonics, nanotechnology, solid-state physics, materials and life sciences in a wide-scope research alliance in order to maintain access to DFG-funded collaborative research.

After the drastically drop down in 2014 the number of first-year students in the Bachelor courses slightly increased again in 2015. May be that this is a first result of our efforts in winning over young people to study. As a first measure, enrolment of students for bachelor programmes in physics at the start of the summer semester was re-introduced in 2014. Other canvassing measures are the improvement of our website, presence at Facebook and a great number of outreach activities such as "Rent a Prof", the school holiday workshop "Physics for school girls", the setting up of a school student lab and a first "Day of Physics".

Fortunately, the number of graduates in physics (3 diplomas and 45 M.Sc.) and photonics (35 M.Sc.) is increasing about 50% in relation to 2014, whereas the number of graduates in materials sciences (3 diplomas and 25 M.Sc.) remains nearly constant. The number of graduates in physics as a teaching profession (9) has decreased by 60% compared to 2014.

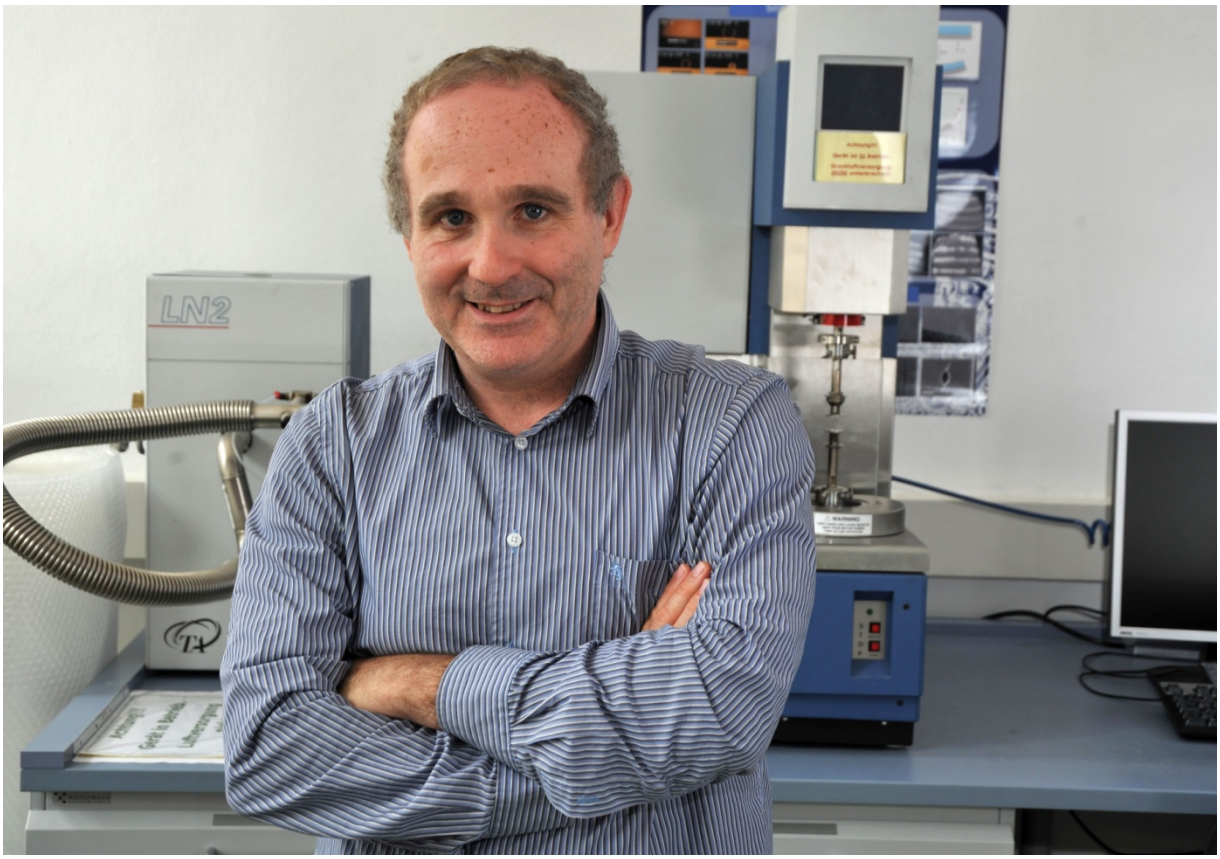
We are grateful to the local industry which continued to support our education tasks in many ways. Besides the measures already mentioned, e.g. those within the scope of the ASP, we were again able to award the Dr.-Ing. Siegfried Werth Prize for the best doctoral thesis in the field of optical measurement; in 2015, it went to Dr. Michael Zürch of the Institute of Optics and Quantum Electronics. Since as early as 1991, the company of Rohde & Schwarz (Munich) has annually donated a prize each for the best diploma or master thesis and the best doctoral thesis at the Faculty. The Carl Zeiss Foundation generously grants scholarships to several doctors and doctoral candidates. Last but not least,

the Carl Zeiss AG finances a professorship for the theory of optical systems and a junior professorship for attosecond laser physics.

In retrospect, 2015 was another particularly active year of the Faculty of Physics and Astronomy, in which national and international awareness of its teaching and research accomplishments heightened. Moreover, we have mapped out the path to continued success in 2016, aiming for qualitative growth despite the inevitable austerity measures.

3. Recently appointed professor

Prof. Dr. Enrico Gnecco
Professor of Physics/Mechanics of Functional Materials
Otto Schott Institute of Materials Research
Appointed in August 2015 http://www.mfm.uni-jena.de/en/Home.html



The main research subject of Enrico Gnecco is the study of friction, wear and adhesion processes on the nanometer scale (so-called nanotribology). He is currently working on different aspects of this subject such as sliding friction in liquid environments, scanning probe-based manipulation of metal clusters and nanocrystals, nano-mechanisms of abrasive wear in polymers, and influence of ultrasonic vibrations on sliding friction. His research tools are both experimental (atomic force microscopy) and theoretical (modeling of sliding systems based on the Prandtl and Eyring theories). The applications of his work are multifaceted, from the reduction of wear and energy consumption in nano- and micro-electromechanical systems to the development of substrate patterns for controlling stem cell migration.
Enrico Gnecco received his PhD from the University of Genova, Italy, in 2001. He worked as postdoctoral researcher at the University of Basel, where he joined the Swiss National Center of Competence of Research in Nanoscale Science. Here, he investigated several phenomena related to atomic-scale friction and self-assembling of organic molecules on insulating surfaces under ultra-high vacuum conditions. In 2010 he moved to Madrid as independent group leader at IMDEA Nanoscience, where he achieved several original results, also in the context of nanotribology. Since August 2015 he is Professor of Mechanics of Functional Materials at Friedrich Schiller University Jena. He published more than 80 research articles in prestigious journals (e.g. Science, Nature Materials and Nano Letters) and authored a Cambridge textbook on the theory and experimental investigation of sliding friction.

4. General Information

4. 1. Contact and Structure of the Faculty

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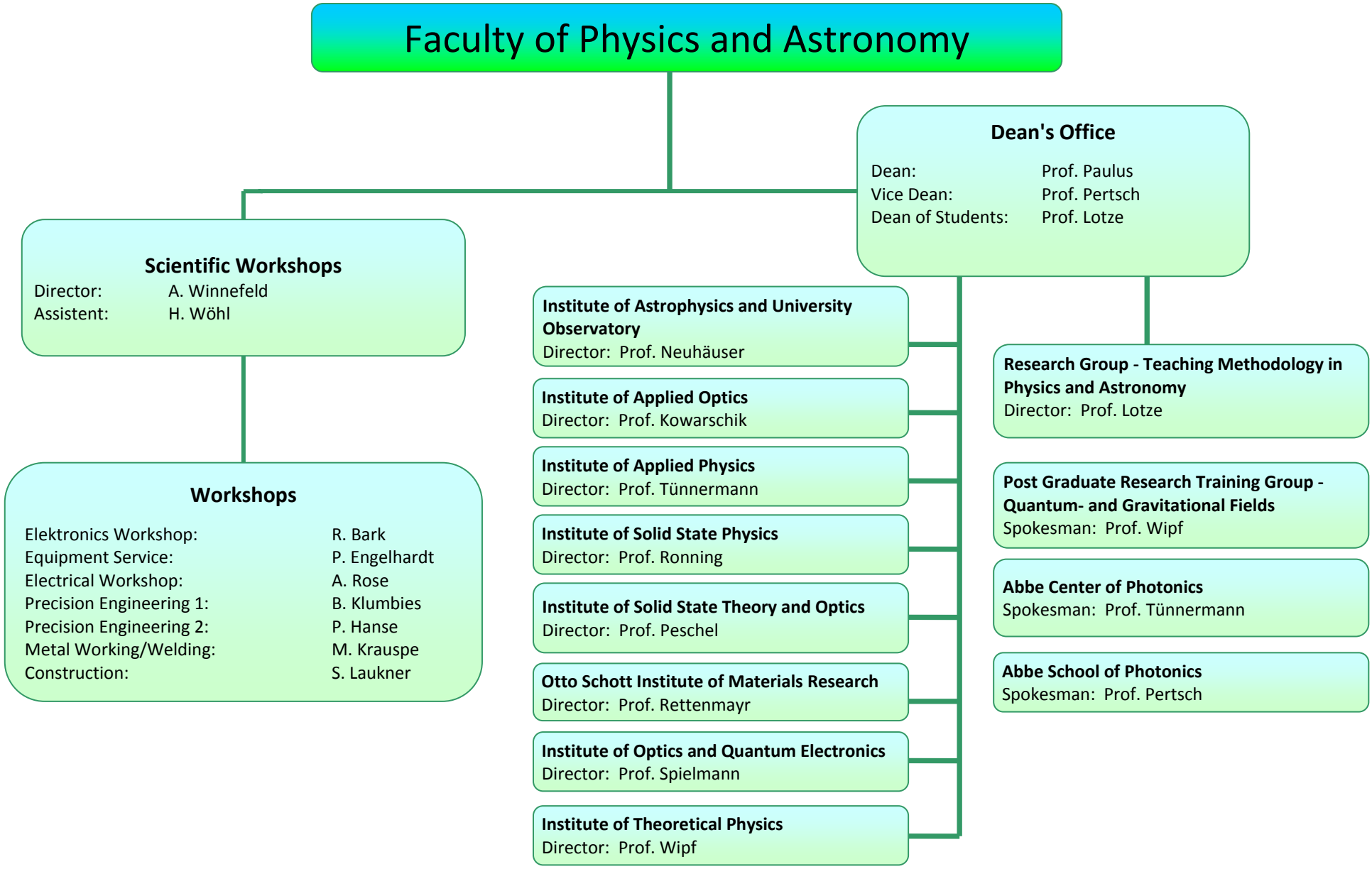
Dean's Office

Dean:	Prof. Dr. Gerhard G. Paulus Institute of Optics and Quantum Electronics Chair for Nonlinear Optics Tel. 03641/ 947000 or 947200
Vice Dean:	Prof. Dr. Thomas Pertsch Institute of Applied Physics Professor for Applied Physics/Nanooptics Tel. 03641/ 9 47000 or 9 478560
Dean of Students:	Prof. Dr. Karl-Heinz Lotze Research Group -Teaching Methodology in Physics and Astronomy Docentship for Teaching Methodology in Physics and Astronomy Tel. 03641/ 9 47010 or 9 47490


Faculty of Physics and Astronomy
Dean's Office
Dean: Prof. Paulus
Vice Dean: Prof. Pertsch
Dean of Students: Prof. Lotze
Scientific Workshops
Director: A. Winnefeld
Assistent: H. Wöhl
Workshops
Elektronics Workshop: R. Bark
Equipment Service: P. Engelhardt
Electrical Workshop: A. Rose
Precision Engineering 1: B. Klumbies
Precision Engineering 2: P. Hanse
Metal Working/Welding: M. Krauspe
Construction: S. Laukner
Institute of Astrophysics and University Observatory
Director: Prof. Neuhäuser
Institute of Applied Optics
Director: Prof. Kowarschik
Institute of Applied Physics
Director: Prof. Tünnermann
Institute of Solid State Physics
Director: Prof. Ronning
Institute of Solid State Theory and Optics
Director: Prof. Peschel
Otto Schott Institute of Materials Research
Director: Prof. Rettenmayr
Institute of Optics and Quantum Electronics
Director: Prof. Spielmann
Institute of Theoretical Physics
Director: Prof. Wipf
Research Group - Teaching Methodology in Physics and Astronomy
Director: Prof. Lotze
Post Graduate Research Training Group - Quantum- and Gravitational Fields
Spokesman: Prof. Wipf
Abbe Center of Photonics
Spokesman: Prof. Tünnermann
Abbe School of Photonics
Spokesman: Prof. Pertsch

Institutes

Astrophysical Institute and University Observatory

Director: Prof. Dr. Ralph Neuhäuser

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Otto Schott Institute of Materials Research
(interdepartmental Institute, section Löbdergraben 32)

Director: Prof. Dr. Markus Rettenmayr

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Institute of Theoretical Physics

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Research Training Group GRK 1523/1 „Quantum and Gravitational Fields"

Spokesman: Prof. Dr. Andreas Wipf

Mailing address:
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07743 Jena

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http://www.qgf@uni-jena.de

Non-university institutes with shared appointed professors at our faculty

Leibniz Institute of Photonic Technology

Director: Prof. Dr. Jürgen Popp

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07745 Jena
Tel.: (03641) 206 020
Fax: (03641) 206 099
e-mail: juergen.popp@ipht-jena.de
http://www.ipht-jena.de

Thüringer Landessternwarte Tautenburg (Observatory)

Director: Prof. Dr. Artie Hatzes

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Tel.: (036427) 863-0
Fax: (036427) 863-29
e-mail: artie@tls-tautenburg.de
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Helmholtz Institute Jena

Director: Prof. Dr. Thomas Stöhlker

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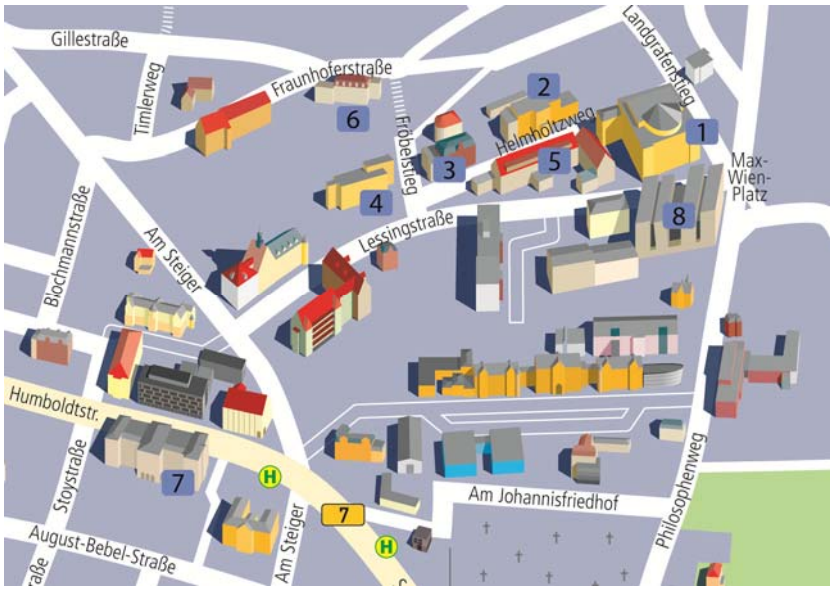
General view of the physical institutes and laboratories near Max-Wien-Platz



1 Max-Wien-Platz 1
- Dean's office
- Office for Student Affairs
- Institute of Optics and Quantum Electronics

2 Helmholtzweg 5
- Institute of Solid State Physics

3 Helmholtzweg 3
- Institute of Solid State Physics
- Max Planck Research Group Laboratory Astrophysics

4 Fröbelstieg 1 (Abbeanum)
- Institute of Applied Optics
- Institute of Solid State Theory and Optics (Chair Condensed Matter Theory)
- Institute of Theoretical Physics

5 Helmholtzweg 4
- Institute of Theoretical Physics
- Computer pool of the faculty
- Institute of Solid State Theory and Optics (Chair Solid State Optics)
- Abbe School of Photonics

6 Fröbelstieg 3
- Institute of Optics and Quantum Electronics / POLARIS - Labs
- Helmholtz Institute Jena

7 August-Bebel-Str. 4
- Research Group - Teaching Methodology of Physics and Astronomy

8 Philosophenweg 7
- Institute of Solid State Physics

4. 2. Staff

Faculty of Physics and Astronomy (altogether)*

* The data for public funded staff are given by the reporting date November 30th, 2015 whereas the data for third-party funded staff are given in full-time equivalents per annum

Public budget funded:	**24**	**university professors**
	6	**university professors at external institutes**
	2	**assistant professor**
	4	**docents/adjunct professors**
	51.65	**research associates**
	109.7	**technical staff members**
Third-party funded:	**2**	**university professors**
	2	**assistant professors**
	188.957	**research associates (including fellowship holders)**
	10.03	**technical staff members**

Astrophysical Institute and University Observatory

public budget funded:	2	university professors	Prof. Dr. Ralph Neuhäuser Prof. Dr. Alexander Krivov
	5	research associates (two of them with open-end contract)	
	3.25	technical staff members	
third-party funded:	2.25	research associates	
	0.3125	technical staff members	

Institute of Applied Optics

public budget funded:	1	university professor	Prof. Dr. Richard Kowarschik
	3	research associates (one of them with open-end contract)	
	4.5	technical staff members (thereof 0.75 in Advanced practical training)	
third-party funded:	1.27	research associates	

Institute of Applied Physics

Public budget funded:	3	university professors	Prof. Thomas Pertsch Prof. Andreas Tünnermann Prof. Frank Wyrowski
	1	assistent professor	Jun.-Prof. Jens Limpert
	3	research associates (two of them with open-end contract)	
	10.875	technical staff members	
Third-party funded:	1	university professor	Prof. Stefan Nolte
	1	endowed professorship	Prof. Herbert Gross
	1	assistant professor	Jun.-Prof. Alexander Szameit

	95.4	research associates incl. fellowship holders	
	2.7	technical staff members	

Institute of Solid State Physics

public budget funded:	3	university professors	Prof. Dr. Carsten Ronning Prof. Dr. Torsten Fritz Prof. Dr. Paul Seidel
	2	adjunct professors	Prof. Dr. Frank Schmidl Prof. Dr. Elke Wendler
	6.567	research associates (two of them with open-end contract)	
	1.5	research associates only for teaching	
	13	technical staff members	
	2	technical staff members university funded (He liquifier)	
third-party funded:	13.25	research associates incl. 2.83 fellowship holders	
	0.6	technical staff members	

Institute of Solid State Theory and Optics

public budget funded:	2	university professors	Prof. Dr. Silvana Botti Prof. Dr. Ulf Peschel
	4	research associates (1.25 of them with open-end contract)	
	2.75	technical staff members (incl. computer pool)	
third-party funded:	5	research associates and Ph.D. students	

Otto Schott Institute of Materials Research, section Löbdergraben 32

public budget funded:	5	university professors	Prof. Dr. Markus Rettenmayr Prof. Dr. Klaus D. Jandt Prof. Dr. Frank A. Müller Prof. Dr. Enrico Gnecco Prof. Dr. Marek Sierka
	9.5	research associates (3.5 of them with open-end contract)	
	20.575	technical staff members (incl. scientific workshop of the institute)	
third-party funded:	23.332	research associates incl. 3 fellowship holders	
	0.667	technical staff members	

Institute of Optics and Quantum Electronics

public budget funded:	3	university professors	Prof. Dr. Gerhard Paulus Prof. Dr. Christian Spielmann Prof. Dr. Malte Kaluza
	9.334	research associates (two of them with open-end contract)	
	9.225	technical staff members	
	4.75	technical staff members for teaching	

third-party funded:	2	university professors at HI Jena	Prof. Dr. Thomas Stöhlker Prof. Dr. Matt Zepf
	1	Carl Zeiss assistent professor	Jun.-Prof. Dr. Adrian Pfeiffer
	31.65	research associates incl. 11.63 fellowship holders	
	3.25	technical staff members	

Institute of Theoretical Physics

public budget funded:	4	university professors	Prof. Dr. Marcus Ansorg Prof. Dr. Bernd Brügmann Prof. Dr. Holger Gies Prof. Dr. Andreas Wipf
	1	assistent professor	Prof. Dr. Martin Ammon
	1	docent	apl. Prof. Dr. Reinhard Meinel
	6.25	research associates (0.66 of them with open-end contract)	
	2.3	technical staff members	
third-party funded:	1	university professors at HI Jena	Prof. Dr. Stephan Fritzsche
	14.48	research associates (thereof 6.99 GRK 1523)	
	0.5	technical staff (GRK 1523)	

Research Group - Teaching Methodology in Physics and Astronomy

public budget funded:	1	docent	apl. Prof. Dr. Karl-Heinz Lotze
	1.5	research associates (one of them with open-end contract)	
	0.75	technical staff members	
third-party funded:	0.825	fellowship holders and research associates	

Scientific Workshops, Teaching Areas and Dean's Office

public budget funded:	1	research associate (functional position with open-end contract)
	33.725	technical staff members
third-party funded:	1.5	research associates (ProQualität Lehre)
	2	technical staff members

Abbe Center and Abbe School of Photonics

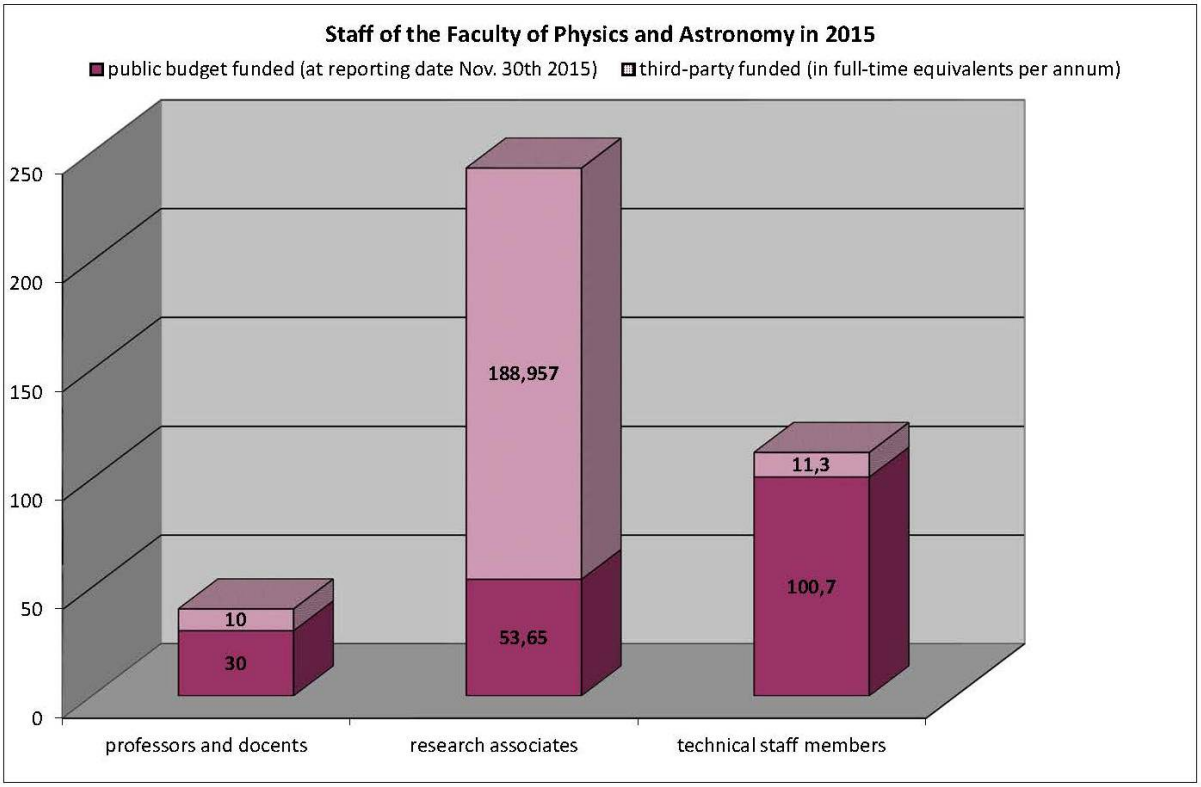
public budget funded:	1	research associate with open-end contract
	2	technical staff members

Leibniz Institute of Photonic Technology

joint appointments:	2	university professors (with reduced teaching responsibilities)	Prof. Dr. Hartmut Bartelt Prof. Dr. Markus Schmidt

Thüringer Landessternwarte Tautenburg (Karl-Schwarzschild-Observatorium)

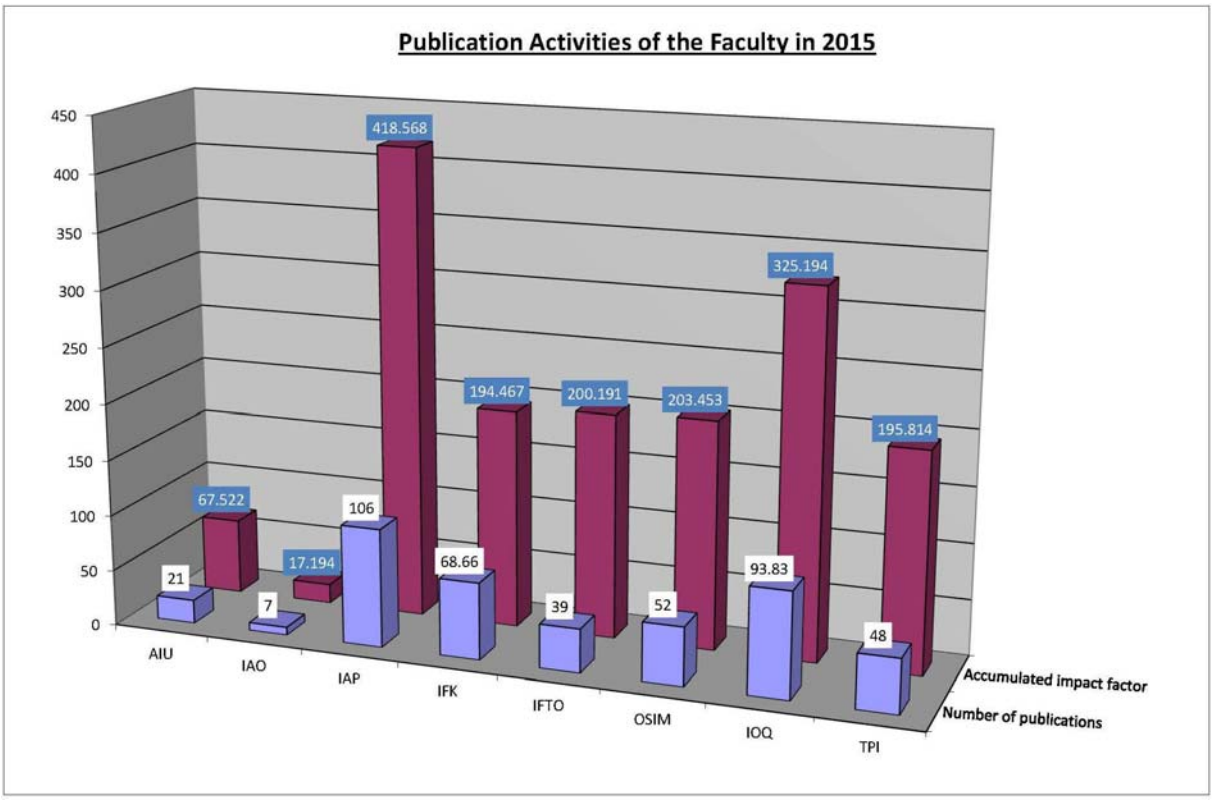
joint appointment:	1	university professors (with reduced teaching responsibilities)	Prof. Dr. Artie Hatzes

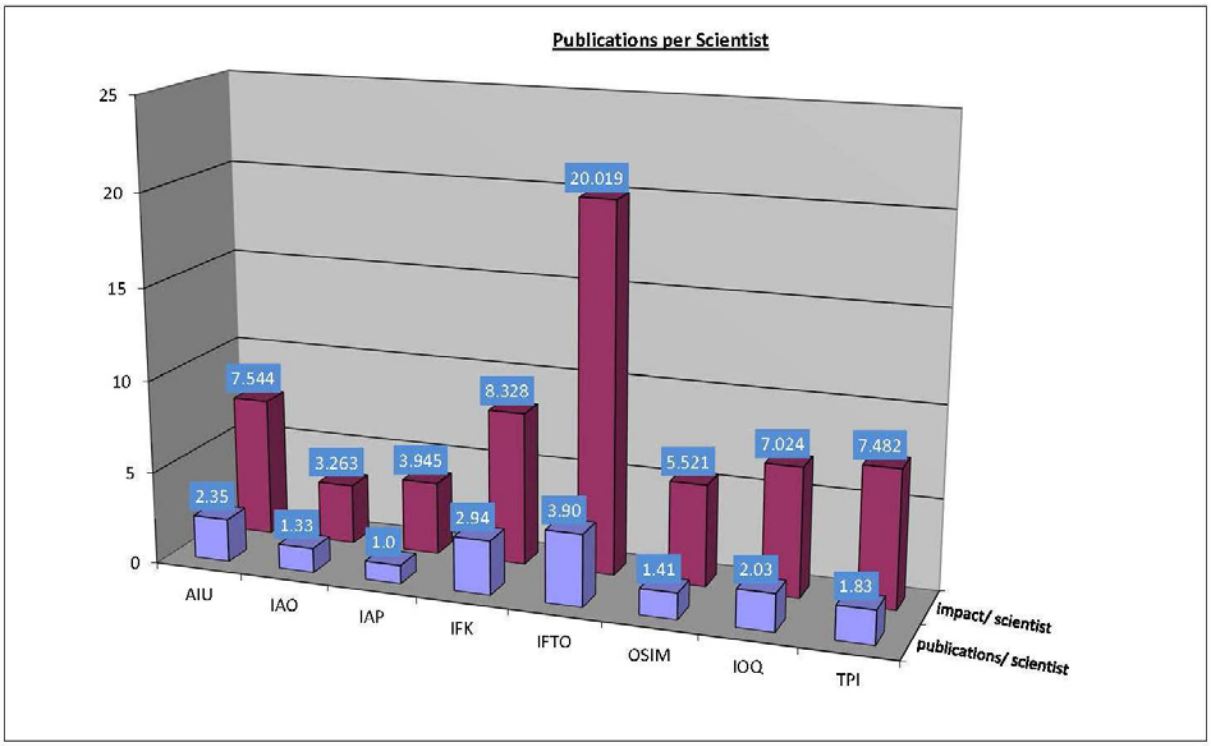


4. 3. Publications and Patents

Some publications were written by scientists from different institutes of the faculty. For this reason a fractional number of publications can arise.

Institute	Number of Publications	Accumulated Impact Factor	Publications per Scientist	Impact per Scientist
Institute of Astrophysics & University Observatory (AIU)	21	67.52	2.35	7.544
Institute of Applied Optics (IAO)	7	17.194	1.33	3.263
Institute of Applied Physics (IAP)	106	418.568	1.00	3.945
Institute of Solid State Physics (IFK)	68.66	194.467	2.94	8.328
Institute of Solid State Theory and Optics (IFTO)	39	200.191	3.90	20.019
Otto Schott Institute of Materials Research (OSIM)	52	203.453	1.41	5.521
Institute of Optics & Quantum Electronics (IOQ)	93.83	325.194	2.03	7.024
Institute of Theoretical Physics (TPI)	48	195.814	1.83	7.482
Faculty as a whole	**435.49**	**1,622.403**	**2.10**	**7.891**



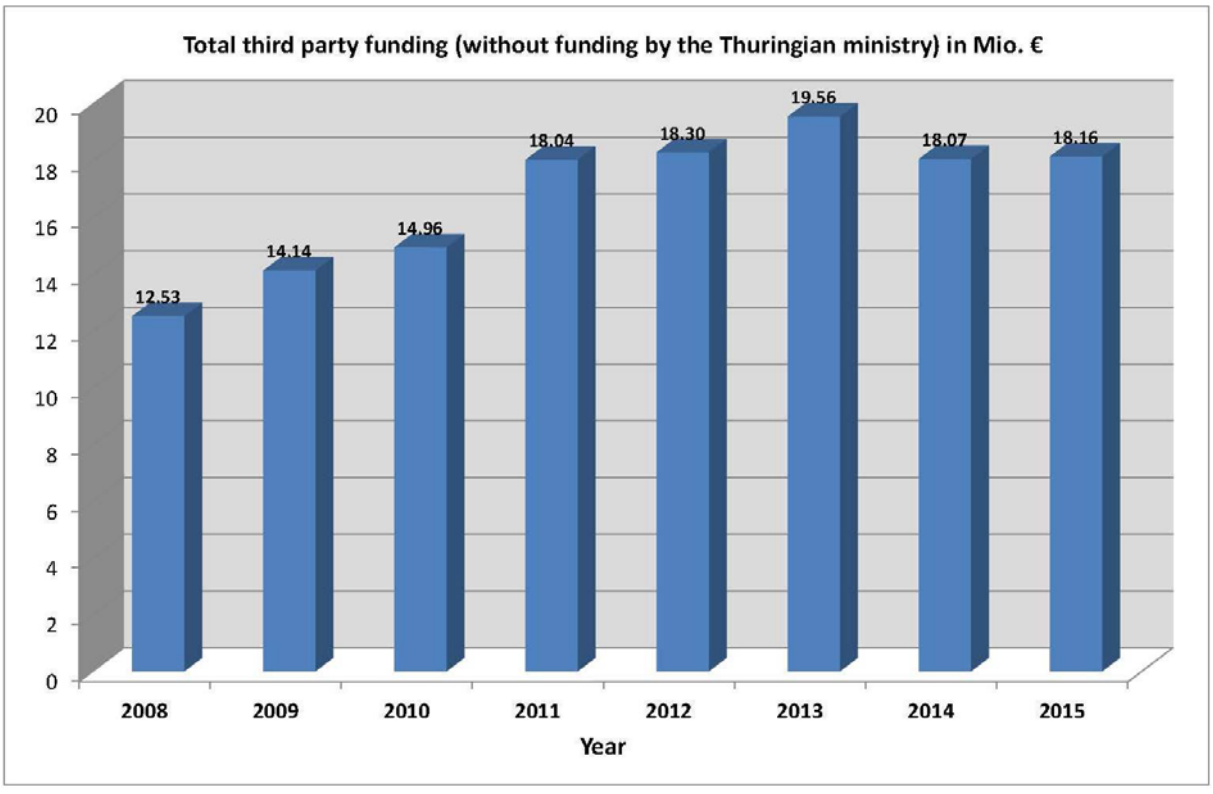


Furthermore, in 2015 there were 3 patent applications and 7 patent assignations. Most of the patents (8) were filed by the Institute of Applied Physics.

4. 4. *Third-party funding*

The following table shows the financial means collected by third-party funding in 2015. The real value of third-party funded means according to the data of the intitutes is higher, because not all of the means were covered by accounts of the university (i.e. nonmonetary benefits, counting and measurement time in largescale Data Centers or large research establishments, personal grants for travelling and others).

Institute	DFG	EU	others	Thuringian Ministry (TMBJS)	Sum of the institution
Deans Office			162.685 €		162.685 €
Abbe Center/Abbe School of Photonics		8.000 €	402.311 €		410.311 €
AIU	144.750 €		13.118 €		157.868 €
IAO	207 €		45.125 €		45.332 €
IAP	778.371 €	474.750 €	8.889.371 €	30.600 €	10.173.092 €
IFK	512.894 €	34.499 €	511.064 €		1.058.457 €
IFTO	151.386 €	13.155 €	19.000 €		183.541 €
OSIM	673.713 €	43.211 €	1.468.840 €		2.185.764 €
IOQ	802.491 €	24.402 €	2.257.361 €		3.084.254 €
TPI	643.528 €		89.744 €		733.272 €
PAD			3.173 €		3.173 €
Faculty as a whole	**3.707.340 €**	**590.017 €**	**13.861.792 €**	**30.600 €**	**18.189.749 €**



5. Teaching

5. 1. Teaching report of the Faculty of Physics and Astronomy

The range of courses offered by the Faculty clearly reflects its main research areas and lines of tradition, i.e. optics, solid-state physics, astronomy and - last but not least - theoretical physics. Accordingly, a higher-than-average breadth of high-quality optics and astronomy courses are offered. Theoretical physics is focused on gravitation and quantum theory and participates in both theoretical and experimental projects related to basics-oriented research and teaching. In spite of this specialized profile, the Faculty guarantees every student a sound fundamental training throughout the breadth of physics.

The study of physics in Jena is well reputed for both the quality of its courses and for its study conditions; secondary school graduates and first-year students frequently refer to the relevant rankings. In the years after 2011, the number of first-year students in the bachelor of physics programme did not attain the high level of the years 2010 and 2011. The decline is mainly due to two three reasons:

1. The abolition of tuition fees in most German federal states has induced more students, especially from the former western states, to study just there. Thuringia has lost its (almost) unique selling proposition of „no tuition fees“.

2. The increasingly deteriorating preparation of secondary school students for studying science subjects has led to school leavers feeling insufficiently qualified and lacking confidence in their capabilities for a study of physics. This is due not only to the reduction in science lessons but also to the uncomprehending, mechanical solving of problems with programmed pocket calculators in mathematics.

3. Taking into account that circa 50 percent of the students who enrol at our faculty come from the nearby regions of Thuringia, Saxony and Saxony Anhalt, the trend of the last years clearly reflects the demographic development 18 or 19 years ago. As a consequence of that development the number of secondary-school leavers continuously decreased during the last years.

Finally, the expectations regarding first-year student figures should not be measured with the yardstick of the years 2010 and 2011, as then, the reduction of secondary school years from nine to eight in some German states led to two age groups leaving school simultaneously; moreover, military service was suspended.

According to a conservative estimate it seems that, fortunately, this trend is stopped and the number of enrolments is increasing again since the winter term 2015/16.

Student figures in the “Materials sciences” bachelor programme, mainly carried out by the Otto Schott Institute of Materials Research jointly with the Ilmenau University of Technology, have evened out at 25 on average.

Besides the Bachelor programme in physics there is, traditionally, a programme for physics as a teaching profession. Here, astronomy can be selected as a minor or supplementary subject. The programme for training physics teachers enjoys persistent popularity, as evidenced by about 25 enrolments over the years. Among them are, unfortunately, almost no middle-school-teacher students. Experience shows that not all students who enrolled actually turn up for the studies, so that one can assume a first-year student number between 25 and 30 for 40 enrolments. In designing the teacher training programme, the beginning modularization and the Jena model of teacher training led to substantial changes, which we have taken into account by revising and modifying the training in physics as well as in teaching methodology. According to the Jena model, the teacher training programme includes a practical semester as an essential constituent, which is of vital importance for gaining experience and a realistic idea of everyday school life. Together with other influences, however, it does not motivate students for their further physics courses. Not seldom, it creates doubts among stu-

dents about the right amount of scientific know-ledge to be imparted in a teacher training programme. It becomes increasingly apparent how problematic it is to let students in the teacher training programme freely decide upon the combination of subjects. Whoever studies physics for the teaching profession is urgently advised to combine with mathematics.

Together with the Faculty of Mathematics and Computer Sciences, we have managed training in mathematics to be better tailored to the requirements of the study of physics. Now, topics important for the basic physics courses (e.g., differential equations, theory of functions) are treated early in the mathematics courses. In addition to the mathematics courses run by the Faculty of Mathematics and Computer Sciences, first-year students of physics also attend a preparatory course in mathematics and a course on mathematical methods in physics, both held by the Faculty of Physics and Astronomy. For a number of years, such courses have been attended successfully and with keen commitment by students in their senior years; they are a striking example of how students of different semesters work together and learn from each other. The same can fortunately be said also of the tutorials in many subjects, which are led by senior students and are very popular as well as effective, so that they, meanwhile, have been turned into a permanent form of learning.

In preparing the documents for the accreditation of the physics and materials science programmes, which was granted in 2009 for five years, we attached special importance to keeping the programmes attractive with updated, modern contents, while maintaining the high level of training. This is evident, e.g., by the greater weight lent to the Faculty's research focuses in the Master programme, both in the compulsory and optional courses, and by better coordination of the courses of a module with regard to contents and time. In the teacher training programmes we particularly saw to it that the modules were better adapted to the requirements of the teaching profession, such as by bringing the start of the methodology training forward to the third semester and adding another methodology semester in preparation to the state examination. Thus, the share of methodology training relative to the science studies is now in agreement with the guidelines recommended by the German Physical Society. Finally, we upgraded the practical seminar „School experiments in physics" by increasing the number of credit points awarded to this course. Nevertheless, in late 2014 we started, together with representatives of the teacher students, a discussion in working groups, aimed at a further improvement of their studies. In particular there is a need for more time to be devoted to optics and thermodynamics as part of experimental-physics courses. A fresh impetus was given to that discussion in 2015. One idea under discussion is to present only Theoretical Mechanics on the high level of a theoretical physics course and to avoid the differentiation between experimental and theoretical physics as far as the other disciplines of physics are concerned. Another topic are the specific needs and interests of middle-school-teacher students as compared to those of high-school-teacher students. First decisions in this direction will be made in 2016.

Now as before we believe that the Bachelor is not a degree that really qualifies for a profession in physics or materials science. Rather, we regard it as a first stage on the way to a Master of Science, which all students should aim at, disregarding rare exceptions. The Faculty first matriculated students in a Master programme for the winter 2010/11 semester. The development of the number of students transferred to the Master programme in the years after can be seen in the diagrams attached. None of the Bachelor graduates finished their studies with the degree of a Bachelor of Science in Physics, although part of our Bachelor graduates started their Master studies at other universities. This was compensated by about as many Bachelor graduates who came to Jena. Mainly in 2015 all arrangements were made to offer the master courses in English, starting in the winter term 2016/17. The specialization subjects of astronomy/astrophysics and gravitational and quantum theory have proved particularly attractive, followed by (nano-)optics. For the subject of Materials Science, too, a Master programme jointly run by the Universities of Jena and Ilmenau was first started in the winter 2010/11 semester. It is to be expected that the Otto Schott Institute of Materials Research founded in October 2013 will add further impetus to this programme.

The experience gathered so far with modularization and the introduction of the Bachelor programmes clearly shows that, compared to the classical diplom programme, the amount of bureaucratic paperwork needed to control the modular system has increased dramatically and would not have been manageable without the provision of added administration capacities. The electronic management system "Friedolin" did not improve the situation considerably. Regrettably, this has boosted the tendency among many students to judge their study by formal rather than content-related aspects, which is not least due to the increased examination burden. For example, it is very difficult to bring students to attend courses that would enhance their general education, unless they can earn credits by attending. Further, we have to see that students changing to another university face difficulties in getting their achievements at University A acknowledged by University B, because it turns out that study programs are not really comparable on a national level, with regard to contents as well as credits earned. On the other hand, study semesters abroad have got under way, with North European countries (Norway and Sweden) and Spain being particularly popular over the years. Recognition of achievements across borders, although possible almost without exception, is by no means easier than within Germany. In addition to the continuation of one's study of physics, encounter with the language, culture and the political conditions in the host country is a substantial motivation.

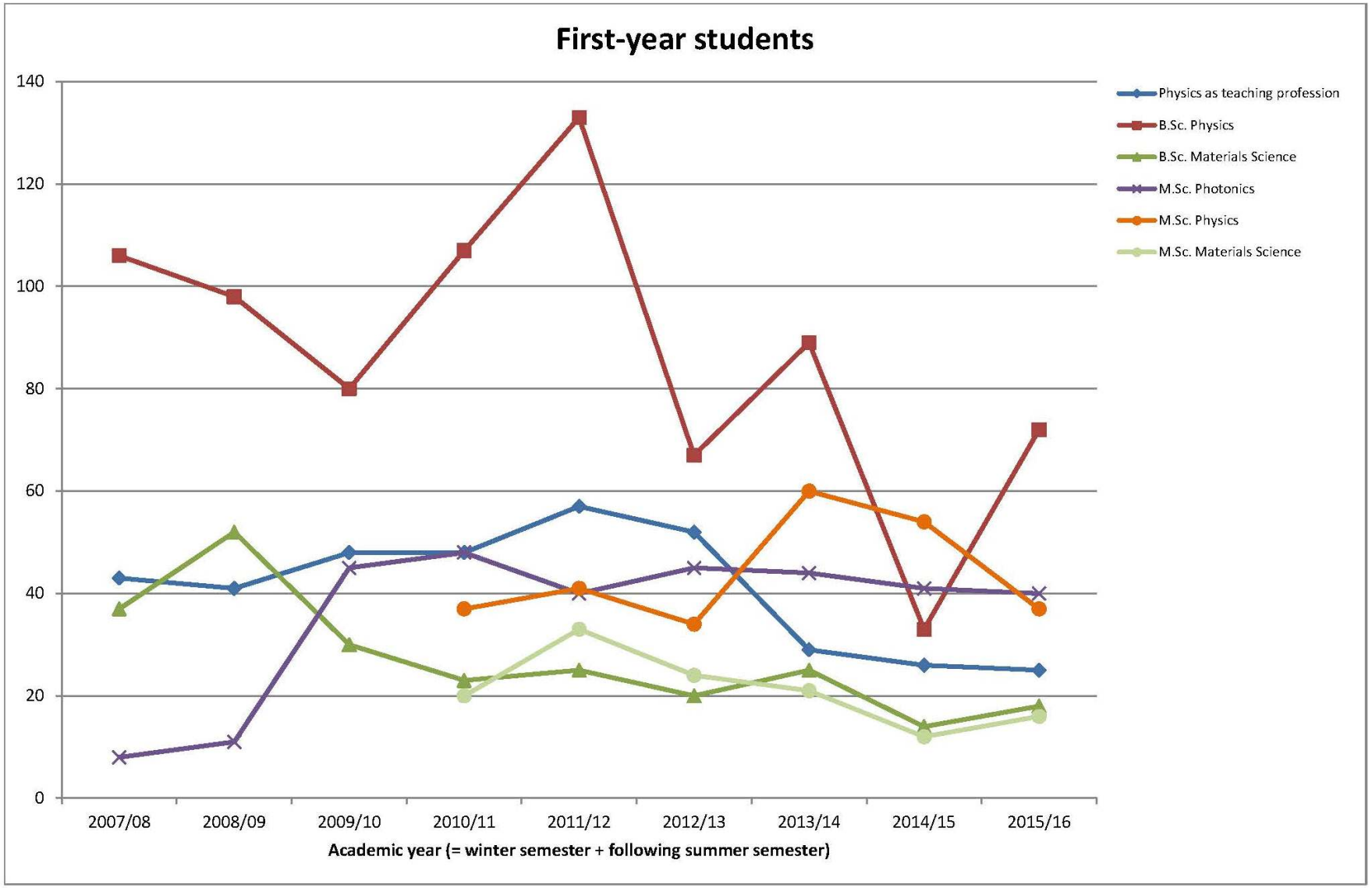
Revising the curricula and the study and exam regulations is an ongoing task. For example, on the students' request, the share of oral examinations relative to the proctored written ones was increased. Also, the Bachelor of Science and Master of Science in Physics programmes were revised to offer more elective courses and reduce redundancy in the compulsory part. At the same time, starting in 2015, working groups in each of the four main directions of research (optics, solid-state physics, astronomy, theoretical physics), consisting of professors and students as well, tightened up the extensive offers of elective courses and developed recommendations how to get through the respective programmes in the most effective way.

One of the important activities of the Faculty in the realm of teaching since the end of 2013 was the preparation for student enrolment for the summer 2014 semester. Over a number of years, it will be examined whether an appreciable number of students will register for the summer semester. The relatively high number of enrolments (between 20 an 30) is unrealistic as among these students are many so-called "parking students". The real number of students is between 5 and 10, i.e. about 5 after one or two semesters. They will be offered a full-scale, independent Bachelor of Science in Physics programme (transfer to the Master programme is possible even in the current summer semester). This programme provides for the students to get their own, independent course in experimental physics. Their integration in the basic practical course is no problem as far as contents are concerned. The students attend theoretical physics lectures together with those studying for the teaching profession, whose theoretical lectures are shifted by one semester relative to the regular Bachelor program. In case that the theoretical-physics programme for teacher students will be substantially revised according to their specific needs (see above), the faculty will have to face the problem that this programme is no longer compatible with the demands of bachelor studies. With the colleagues of the Faculty of Mathematics and Computer Sciences we agreed, at least for 2014, on how the said students can be offered adequate training in mathematics. However, it turned out that the assistance by professors of Theoretical Physics is essential. A completely independent second Bachelor programme, starting in summer term, could be more easily justified if the faculty introduced new fields of study like medical and/or computational and/or nanophysics. This is now under consideration.

First-year students in the period 2007 – 2016

Study courses Physics, Physics as teaching profession, Materials Science and Master Photonics

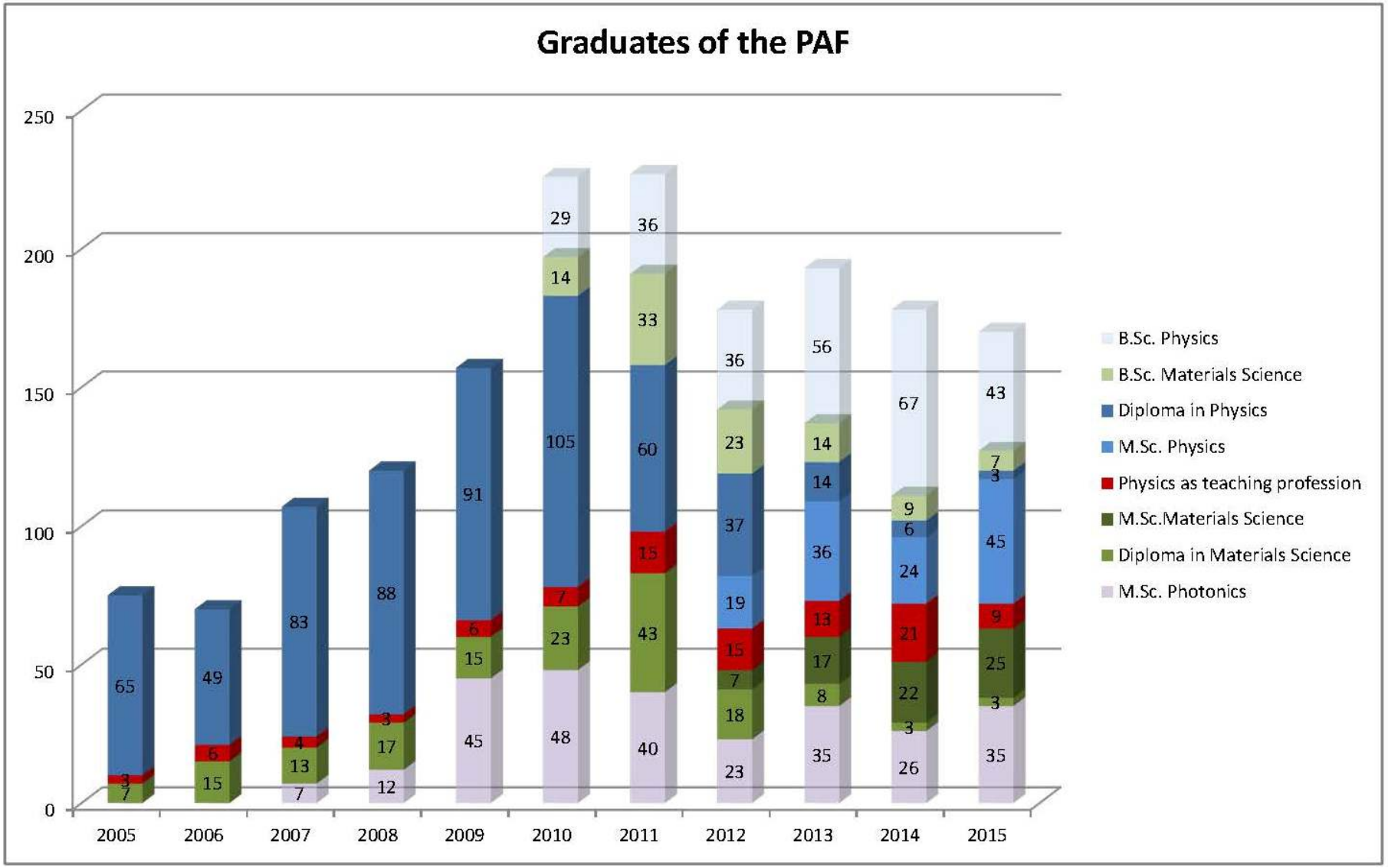
Period	Physics			Materials Science		M.Sc. Photonics
	B. Sc.	M.Sc. (ab WS 10/11)	as teaching profession	B. Sc.	M.Sc. (ab WS 10/11)	
WS 2007/08 + SS 2008	79 + 27 = 106		43	37		7 + 1
WS 2008/09 + SS 2009	84 + 14 = 98		41	52		11
WS 2009/10 + SS 2010	80		48	30		45
WS 2010/11 + SS 2011	107	31+ 6	48	23	20	48
WS 2011/12 + SS 2012	133	31+11	57	25	33	40
WS 2012/13 + SS 2013	66	27 + 14	39	23	22 + 2	44 + 4
WS 2013/14 + SS 2014	60 + 29	49 + 13	29	25	17 + 4	44
WS 2014/15 + SS 2015	33	55	26	15	12	40
WS 2015/16 + SS 2016	50 +22	26 + 11	25	18	12 + 4	40


First-year students
140
120
100
80
60
40
20
0
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14
2014/15
2015/16
Academic year (= winter semester + following summer semester)
Physics as teaching profession
B.Sc. Physics
B.Sc. Materials Science
M.Sc. Photonics
M.Sc. Physics
M.Sc. Materials Science

The following table shows the devolepment of the number of graduations in physics and physics as teaching profession.

Number of graduations in physics, Period 2005 – 2015

Year	Prediploma (Vordiplome) in Physics since 2010 B.Sc. in Physics	Diploms in Physics Since 2012 M.Sc. in Physik	Intermediate examinations for physics as teaching profession Since 2011 1. State examination
2005	92	65 (9 A) + 1 Bakkalaureat	7
2006	78 (1 xdefinitely failed)	49 (6 x with distinction)	2
2007	69 (37 of it in the modularized study course)	83 (6 x with distinction)	13
2008	77 (73 of it in the modularized study course)	76 (7 x with distinction)	20 (18 of it in the modularized study course)
2009	21 (all modularized)	99 (11 x with distinction)	5
2010	4 (3 of it in the modularized study course) 29 B.Sc. (1 x with distinction)	80 (19 x with distinction) 34 (14 x with distinction) of it modularized	2
2011	36 B.Sc.	60 (14 x with distinction) 45 (14 x with distinction) of it modularized	15
2012	36 B.Sc.	37 34 (10 x with distinction) of it modularized, 19 M.Sc.	15 8 of it according to Jena model
2013	56 B.Sc.	14 10 of it modularized, 36 M.Sc.	13 according to Jena model
2014	67 B.Sc.	6 modularized 24 M.Sc.	21 according to Jena model
2015	43 B.Sc.	3 modularized 45 M.Sc.	9 according to Jena model


Graduates of the PAF
250
200
150
100
50
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
65
3
7
49
6
15
83
4
13
7
88
3
17
12
91
6
15
45
105
7
23
48
60
15
43
40
33
14
29
36
23
37
19
15
7
18
23
36
14
14
36
13
17
8
35
56
67
9
6
24
21
22
3
26
43
7
3
45
9
25
3
35
B.Sc. Physics
B.Sc. Materials Science
Diploma in Physics
M.Sc. Physics
Physics as teaching profession
M.Sc.Materials Science
Diploma in Materials Science
M.Sc. Photonics

Graduations in Materials Science

(D =with distinction)

Year	B.Sc.	Diplom ab 2012 M.Sc.	Average Grade
2010	20 (1 D)	18 (6 D)	1.7
2011	33	43 (5 D)	1.7
2012	23	18 (1 D) 7 M.Sc.	1.68
2013	14	8 17 M.Sc.	1.8
2014	9	22	2.1 (B.Sc.) 1.8 (M.Sc.)
2015	7	3 25 M.Sc.	2.04 (B.Sc.) 1.68 (M.Sc.)

Since 1995, the Faculty offers a four-semester post-graduate training **correspondence course in laser technology**, with the Otto Schott Institute of Materials Research as the leading partner. The table below gives the development of student figures.

Correspondence course in laser technology, 2004 – 2014

Year	Enrolments	Graduates
2004	16	13
2005	9	14
2006	8	7
2007	16	8
2008	11	6
2009	10	8
2010	6	4
2011	12	4
2012	7	4
2013	10	8
2014	No enrolment possible	7
2015	20	8

5. 2. Abbe School of Photonics

The Abbe School of Photonics (ASP) forms the central education constituent of the Abbe Center of Photonics by crosslinking its three key research areas – ultra optics, strong field physics and biophotonics (see figure on page 126). In a nutshell, ASP offers a full-scale higher education program on the Master and doctoral level with special focus on optics and photonics. Thus, ASP serves as a career springboard by promoting academic careers, as well as providing opportunities to gain job experience in the photonics industry. Its interdisciplinary education programs are embedded in ACP's

cross-fertilizing research environment. Although deeply rooted in the Faculty of Physics and Astronomy, ASP clearly has a cross-institutional and interfaculty character by involving teaching staff and students also from the Faculties of Chemistry and Earth Sciences, Biology and Pharmacy, and Medicine, respectively.

ASP' curriculum is divided into internationalized Master's degree programs as well as a structured PhD/doctoral program. The former's core area is the international **Master's degree program M.Sc. Photonics**, which is funded in a public-private partnership by the federal government, the Thuringian government and the German optics industry. From this funding, e.g. 2-years Master scholarships are regularly given to the most excellent foreign applicants. The studies are completed by intercultural trainings, language and block courses. Likewise, the **Master's degree program in Physics**, with a strong specialization in photonics, continues to be the backbone of Jena's optics and photonics curriculum and is meant to be subject to a coherent internationalization process during the next years. Starting in autumn 2016, and under the lead of the University's Center of Medical Optics and Photonics (CeMOP), a new **Master's degree program in Medical Photonics** will be launched in cooperation with ASP. The **structured doctoral program** offers its doctoral candidates outstanding research possibilities in a multidisciplinary surrounding and also exhibits an umbrella organization for all active doctoral students and postdocs in the optics and photonics research environment of the University. All Master's degree and doctoral programs are complemented and fueled by a renowned guest professor program with international top-ranking scientists.

5.2.1. Master's degree program

The ASP Master's degree program Photonics offers an internationally recognized graduate degree providing multidisciplinary coverage in the fields of optics and photonics. Students enrolled in this two-year graduate photonics program are trained for technical or scientific positions in both industry and academia.

Within the M.Sc. Photonics course, until 2014 ASP was engaged in the Erasmus Mundus program "Optics in Science and Technology - OpSciTech", supported by the European Union. As a result, still in 2015 the M.Sc. Photonics is reputed and well connected to some of the leading centers in European and U.S. photonics education. Many of these partnerships have led to long-term exchange agreements, enabling ASP students to be highly mobile. Since 2015, ASP can build on the education support of the Thuringian ProExcellence program "ACP^{2020} – Agenda for Excellent Photonics". This support enables to continue the awarding of 2-years Master scholarships to the most excellent applicants until at least 2019. This mechanism is vital to make international students aware of the education opportunities in ASP and in Jena, and to generate a large pool of matching applicants.

M.Sc. Photonics graduates at the Alumni Day in 2015.

During the course of the year 2015, 33 M.Sc. Photonics students finished their studies successfully. In October, another new 41 students from all over the world were enrolled at ASP. Among them, nine students were awarded a full 2-year scholarship and another eight students a 1-year scholarship with the prospect to cover their living expenses during the second year of study by themselves. Moreover, and in order to reward excellent course achievements with financial reliefs, the Federal Government issued scholarships for excellent German students ("Deutschlandstipendien"), whereby high-performing students are supported with EUR 300 per month. In 2015 again, with the help of industrial partners, two of these prestigious scholarships have been awarded to two M.Sc. Photonics students of the 2nd semester: Younesi Mohammadreza and Jialin Jin.

27 of the new students took the opportunity to come to Jena one month earlier than at the beginning of the semester and to attend a pre-sessional intensive German language course. This course was offered by the Language Center of the University. It is our firm belief that the course is an excellent opportunity to learn German before the actual classes are starting and to get to know Jena in a relaxed setting without the busy schedule of the normal semester. Right after that, in October and for the first time, the ASP Welcome Days and the Study Introduction Days of the Faculty were jointly organized by ASP and the Faculty's student council.

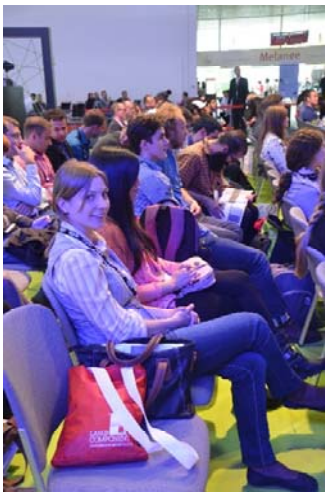
M.Sc. Photonics students during the Welcome Days.

Welcome Lecture by the dean for all students of the Faculty of Physics and Astronomy.

On October 22nd, a personal warm welcome was extended by the University's leadership on behalf of all new students of the Faculty to the freshly enrolled M.Sc. student Mohmmed Al Houri at a festive matriculation ceremony in the Volkshaus. Furthermore, he was honored to plant the traditional tree together with the President of the Friedrich Schiller University.


Left-hand side: festive matriculation ceremony of Friedrich Schiller University, right-hand side: Traditional tree-planting in the Griesbach-Garden.

A special and by now quite traditional feature of ASP's Master's degree program is exhibited by the close integration of industrial partners concerning the technical training. Many students complete their practical trainings and Master's degree theses in regional and national optics companies. Furthermore, study trips to industry partners and research institutions provide the opportunity to gain insight into research and career possibilities. A dedicated application training has been established for the increasing amount of graduates. By visits of fairs, like the visit of the Laser World of Photonics Conference in Munich, and the organized participation in job exchange fairs of the Friedrich Schiller University and the University of Applied Sciences in Jena, Master's degree as well as doctoral students got the chance to apply for job vacancies, traineeships or research topics in well-respected companies of the optics industry and in non-university research institutions.

ASP excursion to the Laser World of Photonics in June 2015.

In 2015, for the second time, the job fair of the Faculty of Physics and Astronomy ("Jobbörse der PAF") and ASP's Photonics Career Day where merged and held jointly together. Students had the possibility to get in touch with future employees and could book a private speed dating session with the company´s representatives. The synergetic merging of two formerly separated recruitment events was regarded a full success by everybody involved, and thus will be continued.

In June 2015, around 25 M.Sc. Photonics graduates joined ASP's first Alumni day. The reunion served as a forum for reflection on the study program and career opportunities. Furthermore, it provided an excellent opportunity for graduates to reunite with former classmates. This gathering was used as well as the opportunity to give an official farewell to Ricarda Knetsch, who passed the position of the coordinator of the Master's degree program to Dr. Margrit Glaser.

Impression from the 2015 edition of the job fair jointly organized by the Faculty of Physics and Astronomy and the Abbe School of Photonics.



ASP Alumni-day and farewell to former M.Sc. Photonics coordinator Ricarda Knetsch.

5.2.2. ASP doctoral program

In 2015, ASP's doctoral program has again received a constantly growing input of graduates of the M.Sc. Photonics. Currently, 54 out of 150 doctoral students are of foreign origin. Based on the thoroughly positive experiences of the Master's degree programs, ASP has continued its consequent internationalization process also with regard to its doctoral program. During the last years, this strategic aim was supported by successfully acquired third-party funding and scholarships from the German Academic Exchange Service (DAAD) and from Thuringian's ProExcellence programs. Moreover, currently more than ten ASP doctoral students are working on their research topics under the support of scholarships from the Carl Zeiss Foundation. The international DFG research training group GRK 2101 "Guided light, tightly packed", coordinated by ASP, is another well-matching element of the strong bonds with three Canadian higher education units.

Since its foundation, at least 87 ASP doctoral students have completed their doctorate on a subject in optics and photonics. Only in 2015, 16 doctoral theses within ASP's auspices were finished (see chapter). This year's dissertation prize of the Friedrich Schiller University in the physics category was awarded to former ASP doctoral student Dr. Stefanie Kroker. During the award ceremony, she gave a public talk on the results of her distinguished thesis at the award ceremony, representing all doctoral graduates of the University in 2015.


The dissertation prize in physics 2015 was awarded to Dr. Stefanie Kroker by Prof. Wolfgang Meyer (Chairman of the Society of Friends and Supporters of the University of Jena) and the President of the University, Prof. Walter Rosenthal.

The start of the first cohort of doctoral students of the International Research Training Group GRK 2101 “Guided light, tightly packed” was surely one of the highlights of the year. Along with ASP’s internationalization strategy and the guidelines of the German Research Foundation, an international recruitment process was launched to attract the most outstanding applicants. In sum, the GRK 2101 received more than 100 applications from 23 nations. Out of them, 21 students were short-listed and took part in a recruitment meeting in Jena under the supervision of the GRK’s selection committee. By the end of 2015, seven doctoral positions and one postdoc position were already filled. The young researchers started their projects in autumn 2015 and also visited their Canadian co-supervisors in Toronto, Montréal and Québec City to initiate the transatlantic research scheme.

The freshman of the GRK 2101 during their visit in Canada at INRS in Québec City.

A central component of the doctoral program is the interdisciplinary, cross-faculty ASP seminar. This seminar takes place on Friday afternoon every two weeks at the Carl Zeiss seminar room of the Fraunhofer Institute of Applied Optics and Precision Engineering (IOF). It provides an excellent platform on which the students may present their research results at a broader audience. At the same time, the seminar offers a vivid forum for discussion between academics and graduate students, both within the University and in exchange for the non-university institutions. It is again worth to point out here that all staff and student members of the Faculty of Physics and Astronomy are cordially invited to join the ASP seminar and discuss pertinent trends of doctoral research. In 2015, the following presentations were given within the ASP seminar:

- Sina Saravi, IAP, Lithium niobate photonic crystal waveguides for classical and quantum optical nonlinear interactions: New phase-matching and dispersion-engineering possibilities
- Felix Herrmann, IPHT, Variation of the electro-optical properties of small-molecule thin films for OPV application by tuning their supra- molecular structure
- David Kaiser, IPC, Towards biomedical sensing with chemically functionalized graphene FETs
- Moritz Klein, IPHT, Spectroscopic Elucidation of Reaction Mechanisms and Kinetics of CORM Breakdowns
- Stefan Schwinde, IOF, Protected and enhanced silver for mirrors - damage mechanisms and how to prevent them
- Stefan Demmler, IAP, High repetition rate OPCPA system for strong-field applications
- Judith Krawinkel, IAO, Gold nanoparticle-mediated laser-based manipulation of cells
- Zhanna Samsonova, IOQ, Extreme nonlinear optics with nanostructured targets
- Aleksandar Lukic, IPHT, Fiber Probes for Nonlinear Imaging Applications
- Ruri Wahyuono, IPHT, Synthesis and Investigation of Optical and Defect Properties of ZnO Nanoflower for Dye-Sensitized Solar Cell

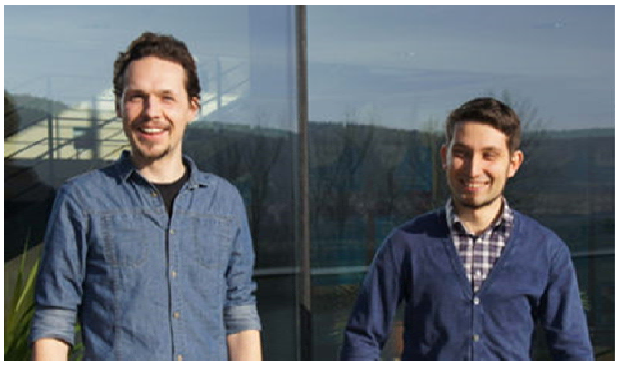
- Silvio Fuchs, IOQ, Nanometer optical coherence tomography using broadband extreme ultra violet light
- Julia Zeuner, IAP, Topological phenomena in photonic graphene
- Erich Eckner, IOQ, Enhanced ROM Harmonics
- Bayarjargal Narantsatsralt, IAP, Scanning near-field optical microscope probe based on plasmonic superfocusing
- Nadja Felde, IOF, Defining roughness structures as a key to multifunctionality
- Christian Reichardt, IPHT, Spectroscopy on DNA-Intercalating Photodrugs
- Christian Franke, IOF, Optical Properties of Aluminum Oxide/ Aluminum Fluoride Mixture Coatings Prepared by Evaporation
- Clara Stiebing, IPHT, Fatty Acid Distribution inside Macrophages on Single Cell Level Using Raman Micro-Spectroscopy
- Philipp Naujok, IOF, Development of Multilayer Coatings for Beyond EUV Lithography

For evaluation and constant improvement of the seminar's quality, regular feedback from the auditorium is utilized. The best seminar contributions of the year were awarded a prize. In 2015, all together four "**Best Talk Awards**" were awarded. In the first term, Matthew Schwab has been awarded the Prize for the Best Talk on "Optical Probing of Laser Wakefield Acceleration Experiments", while Aurélie Jost won the second prize for her talk "Advances in Structured Illumination Microscopy (SIM): Blind Reconstruction and Simultaneous Multi-Focus Acquisition". In the second term, Stefan Schwinde for his talk "Protected and enhanced silver for mirrors – damage mechanisms and how to prevent them", and Stefan Demmler for his talk "High repetition rate OPCPA system for strong-field applications" have been awarded the prizes for their talks.

Two of the winners of the 2015 edition of ASP seminar's „Best Talk Awards". Left-hand side: Aurélie Jost (IPC) and Stefan Demmler (IAP, center) flanked by the ASP seminar's responsible Prof. Christian Spielmann.

Again, in 2015 the doctoral program was enriched by optional qualification courses which were open to all ASP doctoral students. Particularly, the weekly course "Zemax for doctoral students" taught by Prof. Herbert Gross was highly appreciated by all participants. In addition and at the beginning of the year, the doctoral students re-elected their doctoral student representatives which were endowed to represent the students' needs and voices: Jan Sperrhake (IAP, speaker) and Mario Chemnitz (IPHT, deputy speaker). The representatives hosted several events to provide information and receive feedback from their doctoral fellows. As an initial activity, the members introduced themselves by hosting a New Year's Reception in January 2015 where they informed about their plans and initiatives and received helpful suggestions. Throughout the year, at the "International Lunch" non-German ASP

students came together and discussed the everyday life issues such as insurance or residence permit. The representatives also supported the organizing team for the doctoral student's conference DoKDoK, which was led by Marie Walde (IPC) and Sapna Shukla (IPHT). This 4th edition of DoKDoK conference was held in October at the Landhotel "Alte Fliegerschule" in the medieval town of Eisenach. Continuing the growing positive response over the years, the conference was attended by about 55 young researchers, six invited speakers and six industry representatives. The participants hailed from over 20 different institutes in six countries across Europe, testifying the increasing reach of the DoKDoK conference series in the international research community.




Left-hand side: ASP's doctoral students' representatives 2015/2016: Jan Sperrhake (left) and Mario Chemnitz. Right-hand side: Group picture DoKDoK2015 at the castle Wartburg in Eisenach.

Also in 2015, the Friedrich Schiller University has considerably strengthened its marketing efforts to attract new students via "Studiencheck". For this purpose, a series of topical video clips intended to present different career prospects by ASP doctoral students, faculty members, and alumni were produced by the University's central marketing department and ASP. Likewise, four out of six protagonists were current or former ASP members. These video clips are available on the University's Website of "Studiencheck".

Last but not least, to promote the ASP's education programs and to recruit new students, Dr. Dorit Schmidt attended the PhD Workshop in China and performed more than 70 interviews with applicants from Beijing and Shanghai. She was also invited as speaker in a panel discussion to present the marketing strategy of the ASP at the DAAD marketing congress.

5. 3. Compulsory Courses

The responsibility for the compulsory courses was divided between the institutes according to their competences.

Klassische Experimentalphysik I+II
Institute of Optics and Quantum Electronics, Institute of Solid State Physics, Institute of Applied Optics (seminares)

Auffrischungskurs Mathematik für Studienanfänger, Vorkurs Mathematik und Mathematische Methoden der Physik I
Research Group - Teaching Methodology in Physics and Astronomy

Elektronik, Messtechnik, Kern- und Elementarteilchenphysik (auch für Lehramt)
Institute of Solid State Physics

Physikalisches Grundpraktikum
Institute of Optics and Quantum Electronics with assistants from all experimental institutes

Theoretische Mechanik, Elektrodynamik, Quantenmechanik I+II, Thermodynamik / Statistische Physik (auch für Lehramt)
Institute of Theoretical Physics, Research Group - Teaching Methodology in Physics and Astronomy

Optik und Wellen
Institute of Applied Optics

Fundamentals of Modern Optics (degree program M.Sc. Photonics)
Institute of Applied Physics

Optical Metrology and Sensing (degree programme M.Sc. Photonics)
Institute of Applied Optics

Laser Physics, Intorduction to optical modeling (degree program M.Sc. Photonics)
Institute of Applied Physics

Computational Physics I und II
Institute of Applied Physics, Institute of Theoretical Physics

Atom- und Molekülphysik (auch für Lehramt)
Institute of Applied Physics, Institute of Optics and Quantum Electronics

Festkörperphysik (auch für Lehramt und Werkstoffwissenschaft)
Institute of Solid State Physics, Institute of Condensed Matter Theory and Solid State Optics

Structure of Matter (degree program M.Sc. Photonics)
Institute of Solid State Theory and Optics

Physikalisches Fortgeschrittenen-Praktikum, Proseminar und Zusatzversuche
Institute of Solid State Physics with assistants from the Institute of Optics and Quantum Electronics, Institute of Applied Optics, Institute of Applied Physics and the Astrophysical Institute

Technische Mechanik, Grundlagen der Fertigungstechnik, Grundlagen der Werkstoffwissenschaft, Metalle, Polymere , Materialprüfung, Stochastik und Versuchsplanung, Modellieren und Simulation, Werkstofftechnologie, Materialkundliches Praktikum, Kommunikation und Präsentation, Materialcharakterisierung
Otto Schott Institute of Materials Research

Physik als Nebenfach

V Physik für Mediziner, Zahnmediziner und Biochemiker
Institute of Solid State Physics

V/Ü Physik für Biologen, Ernährungswissenschaftler, Pharmazeuten, Chemiker, Biogeowissenschaftler
Institute of Solid State Physics

V/Ü Experimentalphysik für Werkstoffwissenschaftler, Geologen, Mineralogen
Institute of Optics and Quantum Electronics

P Physikalisches Grundpraktikum für Mediziner, Zahnmediziner
Institute of Solid State Physics with assistants from all experimental institutes

P Physikalisches Grundpraktikum für Nebenfächler (Biologie, Chemie, Ernährungswissenschaft)
Institute of Solid State Physics with assistants from all experimental institutes

P Physikalisches Grundpraktikum für Pharmazie
Dean's office with assistants from all experimental institutes

Didaktik der Physik, Didaktik der Astronomie, Physikalische Schulexperimente, Begleitseminar zum Praxissemester, Vorbereitungsmodul für die Staatsprüfung Fachdidaktik der Physik
Research Group - Teaching Methodology in Physics and Astronomy

Vorbereitungsmodul für die Staatsprüfung Theoretische Physik
Institute of Theoretical Physics

Vorbereitungsmodul für die Staatsprüfung Experimentalphysik (Lehramt)
Institute of Optics and Quantum Electronics, Institute of Solid State Physics

Laborpraktikum für Masterstudiengang Photonics
Institute of Applied Optics, Institute of Applied Physics, Institute of Optics and Quantum Electronics

Oberseminar Optik
Institute of Applied Physics, Institute of Optics and Quantum Electronics

Oberseminar Festkörperphysik
Institute of Solid State Physics

Oberseminar Gravitations- und Quantentheorie
Institute of Theoretical Physics

5. 4. Optional and special courses

L=Lecture [Vorlesung], E=Exercise [Übung], P=Practical course [Praktikum], S=Seminar, T=Tutorial [Tutorium], AS=Advanced seminar [Oberseminar]

Astrophysical Institute and University Observatory

L/E/P	Astronomische Beobachtungstechnik
L/E	Einführung in die Astronomie
L/E	Celestial mechanics (in English language)
L/E	Physics of planetary systems (in English language)
L/E	Physik der Sterne
L/E	Radioastronomie
L/E/S	Terra-Astronomie
P	Astrophysikalisches Praktikum
AS	Beobachtende Astrophysik: Variabilität von Sternen
AS	Beobachtende Astrophysik: Sonnenaktivität
AS	Theoretische Astrophysik
S	Aktivität von Sternen
S	Beobachtende Astrophysik
S	Labor-Astrophysik
S	Neutronensterne
S	Staub, Kleinkörper und Planeten
S	Terra-Astronomie
T	Computational astrophysics (in English language)
T	Statistics in astrophysics (in English language)
T	X-ray astronomy (in English language)

Institute of Applied Optics

L	Precourse Optics
L	Holographie – Grundlagen und Anwendungen

Institute of Applied Physics

L/E	Advanced lens design
L/E	Astrophotonics
L/E	Computational Photonics
L/E	Design and correction of optical systems
L/E	Diffractive Optics
L/E	Fundamentals of microscopic imaging
L/E	Fundamentals of Quantum Optics

V/S Grundlagen der Laserphysik
L/E Imaging and aberration theory
L/E Introduction to nanooptics
L/P Lens design
L/E Micro/nanotechnology
L/E Optical Modelling and Design
L/E Thin Film Optics
L/E Ultrafast Optics

Institute of Solid State Physics

L Nuclear solid state physics
L Nanomaterials and nanotechnology
L Nuclear and particle physics
L Ion beam modification of materials
L Optical properties of solids and thin films
L Optoelectronics
L Supraleitende Materialien
L Vakuum- und Dünnschichtphysik
L Gravitational Wave Detection
L Einführung in die Elektronik
L Tieftemperaturphysik
L Laboratory Astrophysics (together with Dr. Mutschke, AIU)

Institute of Solid State Theory and Optics

L/S Theory of Nonlinear Optics
L/S Electronic structure theory

Otto Schott Institute of Materials Research

V/S Biomaterialien und Medizintechnik
V Legierungen - Anwendungen und Eigenschaften
V Präzisionsbearbeitung und Oberflächenmesstechnik
V Innovative Beschichtungsverfahren
V Innovative Verfahren in der Fertigungstechnik
V Lasertechnik für Materialwissenschaftler
V Lasertechnik - Grundlagen und Anwendungen I + II
V/S Polymerphysik
V Abfallverwertung - werkstoffkundliche Aspekte des Recycling
V/S Materialwissenschaft für Physiker
V/S Keramische Werkstoffe in der Medizin
V Biomimetische Materialsynthese
V Phasenumwandlungen
V/S Nanostrukturierte Oberflächen und Nanomaterialien
V Archäometallurgie
V/Ü Advanced Computational Materials Science
V Theoretisch-chemische Grundlagen der Materialwissenschaft
V/Ü Algorithmen des Wissenschaftlichen Rechnens

Institute of Optics and Quantum Electronics

L/S Biomedical Imaging I,II
L/S Plasma physics

L/E Grundlagen der Photonik
L Nonlinear Optics
L High-intensity /Relativistic optics
L/S XUV and X-ray optics
L Physical Foundations of Renewable Energies
S Zeitaufgelöste Röntgenspektroskopie
S Lektürekurs: Journal Club
L/E Interaction of high-energy radiation with matter
L/E Strong Field Laser Physics
L/E Moderne Methoden der Spektroskopie
L/E Attosecond laser physics
L/E Physics of ulftrafast optical discharge and filamentation
S of the Research School for Advanced Photon Science of the Helmholtz Institute Jena
L/S Fundamentals of X-ray Physics
L Introduction to accelerator physics/Beschleunigerphysik
T Mathematische Methoden der Physik II
L/E Lasergetriebene Strahlungsquellen/Laser driven radiation sources
L The Physics of Extreme Electromagnetic Fields: Experiment and Theory
L/E Modern Methods in Nuclear Physics: Theory and Application
L/E Particles in strong electromagnetic fields

Institute of Theoretical Physics

V/S Allgemeine Relativitätstheorie
V/S Quantenfeldtheorie I+II
V/S Einführung in die Teilchenphysik/Standardmodell
V/S Relativistische Physik
V/S Relativistische Astrophysik
V/S Theoretische Atomphysik
L/E Atoms in External Fields
V/S Quantenphysik mit dem Rechner
V/S Symmetrien in der Physik
V/S Quantenfeldtheorien auf dem Gitter
L/E Physics of the quantum vacuum
L/E Gauge theories
V/S Mathematische Methoden der Physik für Fortgeschrittene
AS Theory: Symmetry Breaking

Research Group -Teaching Methodoly in Physics and Astronomy

V Mathematische Methoden der Physik II
V Gastvorlesung Kosmologie (Lehramt) an der Martin-Luther-Universität Halle -Wittenberg
V Relativitätstheorie und Relativistische Astrophysik (Lehramt)
S Doktorandenseminar Fachdidaktik der Physik (Ergänzungsfach für Promovierende in der Fachwissenschaft)

5. 5. Seminars of the institutes and divisions

Institute of Astrophysics and University Observatory

Astrophysical colloquium (in cooperation with TLS Tautenburg)
Institute seminar "Astrophysics"

Institute of Applied Optics

Institute colloquium Applied Optics
Seminar Applied Optics for students and postgraduates
Working Group Seminar Optical Measurement Techniques

Institute of Applied Physics

Advanced fabrication technologies (Dr. Zeitner)
Applied computational optics (Prof. Wyrowski)
Applied physics (Prof. Tünnermann, Prof. Nolte, Prof. Pertsch, Jun.-Prof. Limpert)
ASP-seminar Applied photonics (Prof. Tünnermann together with IFTO and FhG-IOF)
Design of optical systems (Prof. Gross)
Diamond optics (Jun.-Prof. Szameit)
Fiber lasers (Jun.-Prof. Limpert)
Microstructure technologies - Microoptics (Dr. Kley, Dr. Schrempel)
Nano optics (Prof. Pertsch)
Ultrafast optics (Prof. Nolte)

Institute of Solid State Physics

Seminar of the Institute of Solid State Physics
Group Seminars: Applied Solid State Physics / Surface Science
Ion beam physics
Nanostructures
Photovoltaics
Low Temperature Physics and Superconductivity
Laboratory Astrophysics (together with Dr. Mutschke, AIU)

Institute of Solid State Theory and Optics

Group Seminar Solid State Theory
Group Seminar Photonics

Otto Schott Institute of Materials Research

OSIM seminar: Materialwissenschaftliches Kolloquium des OSIM

Group seminars: Materials Science Research
Metallic Materials
Colloids, Surfaces and Interfaces
Computational Materials Science
Mechanics of Functional Materials

Institute of Optics and Quantum Electronics

Seminar of the Institute
Mitarbeiterseminar des IOQ

Group seminars: Quantum electronics
Nonlinear Optics
Relativistic Laser Physics
X-ray Optics
Attosecond Laser Physics

Seminar of the Helmholtz Institute Jena

Institute of Theoretical Physics

Institutsseminar Theoretische Physik
Bereichsseminar Quantentheorie
Bereichsseminar Relativitätstheorie
GRK 1523/1: Kollegiatenseminar Quantum and Gravitational Fields
Group seminar Quantum Dynamics in Strong Fields

5. 6. Postgraduate Training

Institute of Astrophysics and University Observatory together with the Research Group -Teaching Methodoly in Physics and Astronomy

Organised part-time postgraduate training in astronomy to achieve the teaching qualification in a further subject at secondary schools according to the Thuringian Regulations (Astronomy as third school subject)

Research Group -Teaching Methodoly in Physics and Astronomy

Nation wide further teacher training in Astronomy in Jena from July 13rd to July 15th, 2015 (160 participants, including referents) including a Colloquium for Doctoral Students on Teaching Methodology in Astronomy

- Hamel, J. (Hrsg.): „Astronomie – Jena 2014“, Astronomie+Raumfahrt im Unterricht, 52(2015)(3/4)

The organizing team of the nation wide further teaching training

24 public lectures (most of them for further education of teachers) par example at the universities of Hildesheim, Kiel, Nürnberg, Potsdam and Dresden as well as in Bad Honnef:

- Gravitationswellen
- Kosmologie
- Gravitationslinsen
- Galilei, Kepler und der Übergang vom geozentrischen zum heliozentrischen Weltbild
- Spezielle Relativitätstheorie

Presentation of the "Physical Laboratory for School Students" at the further teacher training course in Ostthüringen (East Thuringia)

Colloquia in teaching methodology of the central German universities Halle-Leipzig -Jena

Hereaus Sommer School from 4 Perspectives, third meeting:
Jena, August 31st - September 5th, 2015, Theme „Gravitational Wave Astronomy “
Vorbereitungsmodul „Relativistische Astrophysik (Lehramt)“ (see above) in sommer term 2015, student's reports, 16 participants (students and practising teachers)

Participants of the third meeting of the German-Italian Heraeus Summer School

Presentation of the project "Optics with LEGO®" at the DPG school of lab instructors in Bad Honnef (in March) and at the DPG workshop "Innovative Lehrmittel für das Erlernen physikalischer Konzepte" in the Magnushaus Berlin (in June)

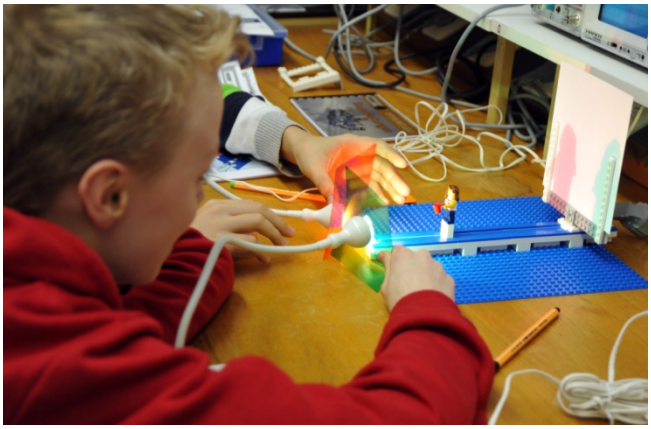


Foto: Annegret Günther (FSU)

DPG training course for physics teachers "Einstein relativ einfach - 100 Jahre Allgemeine Relativitätstheorie" , July 20th - July 24th 2015, Bad Honnef (together with Prof. Dr. Ute Kraus, Hildesheim, and Prof. Dr. Bernd Brügmann, Jena)

Organisation of the "studium generale" at the Friedrich Schiller University in winter term 2015/16
6 lectures to the topic "Allgemeine Relativitätstheorie und unsere Wahrnehmung der Welt in den letzten 100 Jahren"

Institute of Applied Optics
Prof. Kowarschik - Chairman of the JENA-Carl Zeiss Optics Colloquium

Otto-Schott-Institut für Materialforschung
Correspondence course „Lasertechnik“ (including other institutes of optics for labwork)

Institute of Theoretical Physics

Spring School for Bachelor students: Perlen der theoretischen Physik
Jena, 30. March - 1. April 2015
Organizers: Professors of the Institute of Theoretical Physics, Jena

Topical Workshop at Mainz Institute for Theoretical Physics: “Quantum Vacuum and Gravitation”
Mainz, 22. - 26. Juni 2015
Organizers: M. Asorey (Zaragoza), E. Mottola (Los Alamos), I. Shapiro (Juiz de Fora), A. Wipf (Jena)

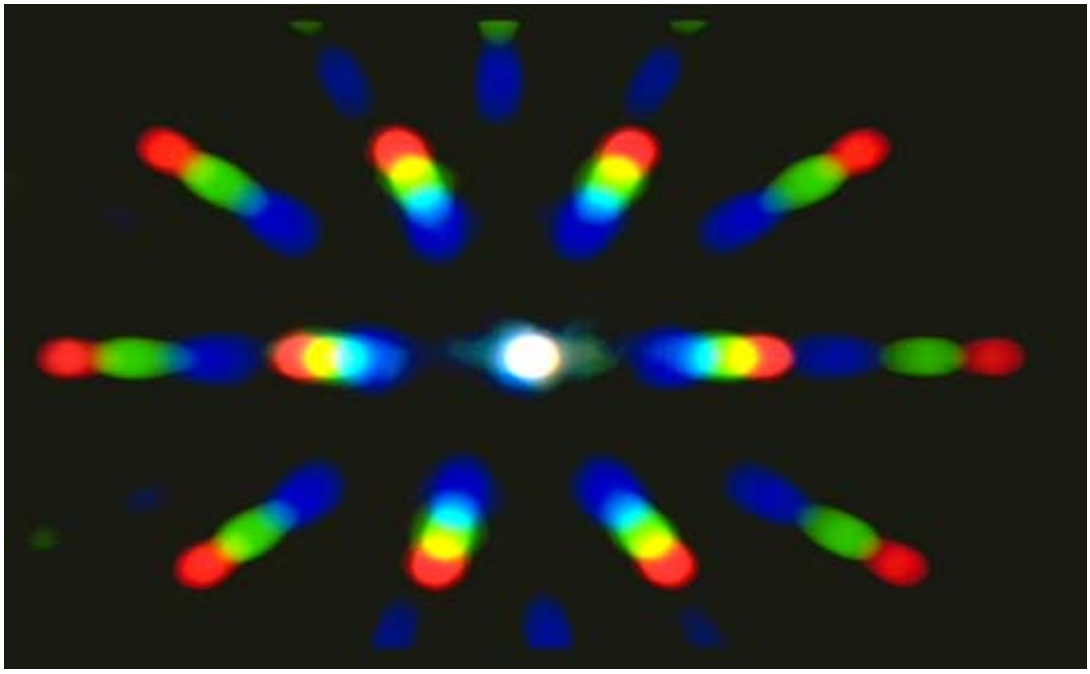
Workshop "Strongly-Interaction-Days Jena-Graz-Wien"
28. – 29. September 2015 in Jena
Meeting of the Research Training Groups „Quantum- and Gravitational Fields“ from Jena, „Hadrons in Vacuum, Nuclei and Stars“ from Graz and „Particles and Interactions“ from Wien
Organizers: Professors of Quantum Field Theory and Particle Physics from Graz, Jena and Wien

Workshop on “Strongly-Interacting Field Theories”
Jena, 05. – 07. November 2015
Organizers: M. Ammon, H. Gies, A. Wipf, L. Zambelli, O. Zanusso

21. Saalburg summer school for PhD-Students of Theoretical Physics in Wolfersdorf
"Foundations and new Methods in Theor. Physics", Wolfersdorf, 31. August – 11. September 2015
Speakers: R.M. Wald (Chicago), S. Hollands (Leipzig), A.N. Schellekens (Amsterdam), J. Zinn-Justin (Saclay), J.W. van Holten (Amsterdam)
Organizers: A. Hebecker (Heidelberg), O. Lechtenfeld (Hannover), I. Sachs (Munich), S. Theisen (Potsdam), A. Wipf (Jena)

Participants of the Saalburg Summer School 2015

5. 7. Public Saturday Morning Lectures



24.01.2015 Prof. Dr. Herbert Gross
Institute of Applied Physics
Ernst Abbe und die moderne Optik

14.02.2015 Prof. Dr. i. R. Gernot Neugebauer
Institute of Theoretical Physics
Einstein und die Vermessung der Welt
Zum 100. Geburtstag der Allgemeinen Relativitätstheorie

24.10.2015 Prof. Dr. Jürgen Reichenbach
Medizinische Physik, Institut für Diagnostische und Interventionelle Radiologie, Universitätsklinikum Jena
Mit Magnetfeldern ins Körperinnere blicken. Wie Kernspins als Spione eingesetzt werden

14.11.2015 Prof. Dr. Rainer Heintzmann
Institut für Physikalische Chemie und Leibniz Institut für Photonische Technologien
Ausgetrickst – mit Chemie zur hochauflösenden Lichtmikroskopie

28.11.2015 Prof. Dr. Stephan Fritzsche
Helmholtz-Institut Jena und Theoretisch-Physikalisches Institut
"Gedankenexperimente": Empirische Erkenntnis dank paradoxer Vorstellungen

12.12.2015 Prof. Dr. Markus Rettenmayr
Otto-Schott-Institut für Materialforschung
Metalle - Macht, Mythos, Innovation

5. 8. Physical Colloquia

Organizers: Prof. Dr. M. Ansorg (up to March 2015), Prof. Dr. T. Fritz (up to September 2015), Jun.-Prof. Dr. A. Szameit (since April 2015), Prof. Dr. S. Botti (since October 2015)

12.01.2015	**PD Dr. Hanspeter Beck** Universität Bern AEC for Fundamental Physics	Die Physik des Higgs Bosons
19.01.2015	**Prof. Dr. Horst Schmidt-Böcking** Goethe Universität Frankfurt /Main Institut für Kernphysik	Otto Stern: einer der großen Pioniere der Atom- und Kernphysik
26.01.2015	**Dr. Daniil Kartashov** Inst. für Optik und Quantenelektronik, FSU Jena	Ultrafast nonlinear optics in mid-IR spectral range
09.02.2015	**Prof. Dr. Klaus G. Strassmeier** Leibniz-Inst. für Astrophysik, Potsdam	Magnetfelder bei Sternen: Von cool bis hot
13.04.2015	**Prof. Dr. Ulf Peschel** Institut für Festkörpertheorie und –optik	**Inaugural Lecture** Bewegtes Licht – über die erstaunlichen Ausbreitungseigenschaften von Photonen
27.04.2015	**Prof. Dr. Dirk Vanderbeke** Institut für Anglistik/Amerikanistik	Physik der Fantastik – Fantastische Physik
11.05.2015	**Dr. Ulrich Schneider** Ludwig-Maximilians-Univ. München	Probing Bloch band geometry and topology with ultracold atoms
01.06.2015	**Prof. Dr. Andreas Schadschneider** Universität zu Köln	Keine Panik! Die Physik der Fußgängerdynamik und Evakuierungsprozesse
15.06.2015	**Prof. Dr. Bernhard Holzapfel** Karlsruher Institut für Technologie	Power and Magnet Applications of High Temperature Superconductors
29.06.2015	**Dr. Michael Borys** Physikalisch-Technische Bundesanstalt	Die Neudefinition des Kilogramm: Aktueller Stand und mögliche Auswirkungen auf die Darstellung und Weitergabe der Einheit
26.10.2015	**Prof. Dr. Hubert Gönner** Universität Göttingen	100 Jahre Forschung zur allgemeinen Relativitätstheorie
02.11.2015	**Prof. Dr. Horst Stöcker** Universität Frankfurt/Main	Cosmic Matter in the Laboratory
05.11.2015	**Prof. Dr. Anne L'Huillier** University of Lund (Sweden)	**Awarding of the honorary doctorate** Attosecond Laser Physics
09.11.2015	**Dipl.-Ing. Udo Gleim** TU Darmstadt	Von seinen eigentlichen künstlerischen Leistungen wissen wir wenig. - Der Architekt Ernst Neufert und das Abbeanum in Jena

The colloquium was connected with the inauguration of the bench seat and the display case rebuilt according to the original design of Ernst Neufert. On the bench are sitting Andreas Winnefeld (technical manager of the PAF), Bernhard Klumbies (leader of the department of pecision engineering 1) and the Neufert expert Udo Gleim.

23.11.2015	**Prof. Dr. Roland Scheer** Martin-Luther-Universität Halle - Wittenberg	Carrier liftime and diffusion constant: How to determine solar cell material properties by time-resolved photoluminescence

5. 9. Physics day

Because of the great response to the first Physics Day in 2014 and the need of winning students we organized a second Physics Day.

The frame topic of the 2. Physics Day was Astrophysics and it was held on Friday, 20th March 2015. On the same day a partial solar eclipse happened between 9:34 and 11:45. The maximum coverage of the sun was 73.8 % at 10:42. We set up some telescopes on the roof terrace of the faculty's main building for the observation of the solar eclipse. Scientists of the research group of teaching methodology and teacher students guided the solar eclipse by public lectures didactically. Many people (school students, parents, teachers, alumni and the interested public) came to see this rare event.

On the roof terrace of the faculty's main building. (Foto: Andreas Unkroth)

An attratractive programme was intended to give an insight into physics and its exploration. For a whole day, information stalls and hands-on expreiments were set up in the building at Max-Wien-Platz. Individual consulting on studying physics was also offered.

After the end of the solar eclipse Dipl.-Phys. Thomas Kaiser gave a lecture "What does physicist really do?"

The highlight of the 2. Physics Day was a public lecture on the **Rosetta mission** held by its "father", Dr. Gerhard Schwehm from the European Space Agency (ESA) in Darmstadt. Dr. Schwehm was the scientific leader of the Rosetta mission from 1985 up to his retirement in 2014.

Between the lectures, the visitors were offered guided tours of selected labs of the Faculty, such as the new laboratories for electron spectroscopy at the Centre of Applied Research, which attracted much interest.

To prevent visitors getting hungry at lunchtime, our workshops furnished roast sausages, funded by the Alumni Association.

Dr. Gerhard Schwehm, the "father" of the Rosetta mission

6. Student research projects; Bachelor, Diploma and Master thesis, exam thesis in educational physics, dissertations

Institute of Astrophysics and University Observatory

Bachelor Thesis

Marie Braasch
Spektralklassifikation potentieller OB-Sterne

Denny Häßner
Sonnenfleckenstatistik

Cora Preiß
Aurora-Katalog für Grand Minima Oort, Wolf und Spörer

Master theses

Sven Buder
The search for Supernovae Progenitors – Spectroscopic and Binary Analysis of Possible OB-Stars

Dario Fritzewski
Variabilität der Sterne in IC 348

Fabian Geiler
Struktur von Zwei-Komponenten-Trümmerscheiben

Susanne Richter
Rekonstruktion der Sonnenaktivität im Maunder-Minimum

Sabrina Schönfeld
Runaway Sterne bei PSR B1951+32

Jan Sende
Atmospheric reaction to gamma ray events

Daniel Wagner
Suche, Beobachtung und Untersuchung von transienten Röntgenquellen

Kim Werner
Einschränkung der Zustandsgleichung unter parallaktischer Entfernungsbestimmung des Neutronensterns RX J1856-3754 mithilfe der WFPC2- und ACS-Kamera des HST

PhD theses

Claudia Marka
The close environment of AFGL 490 in radio-interferometric observations

János Schmidt
Beobachtung von quasi-periodischen Oszillationen bei jungen Neutronensternen

Martin Seeliger
Die Suche nach Transitzeitvariationen mittels bodengebundener Beobachtungen

Habilitation Tretise

Dr. Torsten Löhne
The Properties of Dust and Planetesimals in Debris Systems

Institute of Applied Optics

Bachelor Thesis

Isabel Barth
Optimierung einer holographischen optischen Pinzette zur Messung von Kräften zwischen Bakterien

Conrad Rößler
Untersuchungen zur zerstörungsfreien 3D-Formvermessung mittels eingeprägter Wärmemuster

Christian Hünecke
Aufbau eines 3D-Messverfahrens mit Laserspecklemustern

Master Thesis

Andreas Stark
Verbesserung digital-holographischer Verfahren durch den Moiré-Effekt

Eugene Wong
Experimental Implementation of a Ray-Calibrated Stereophotogrammetric System

Lichun Meng
Error characterization for 3D sensors

Doctoral Thesis

Peter Lutzke (ASP)
Untersuchungen zur optischen 3D-Vermessung von transluzenten Objekten mittels aktiver Triangulation

Institute of Applied Physics

Bachelor Theses

Toni Bauer
Mikro- und Nanostrukturierung von Diamant mit dem Helium-Ionen-Mikroskop

Clemens Kloß
Electrical characterization and study of THz-Emission from monocrystalline silicon

Kim Alina Lammers
Untersuchungen zur Ladungsträgerdynamik in Doppelpulsversuchen mit ultrakurzen Laserpulsen

Wilko Middents
Spektrale Stabilisierung von Laserdioden mittels ultrakurzpuls-geschriebener Volumen-Bragg-Gitter in Kieselglas

Friedrich Möller
Development of an FTIR spectrometer for the characterization of photonic nanostructures

Konrad Naumann
Untersuchung von induzierten Spannungen an direkt gefügten Kristallen

Tom Pertermann
Mikrostrukturierung von Glas mit ultrakurzen Laserpulsen

Sönke Ziemer
Comparison of propagation models of ultrashort pulses

Master Theses

Ernest Ahiavi
Nucleation Studies and Nanolaminates for x_Ray mirrors

Nils Becker
Adaptive pulse measurement using a pulse shaper

Méabh Garrick
Spectrally Resolved Laser-induced Damage Testing

Li Guangrui
Gold nanostructures fabricated by nanoshere lithography

Fabian Heisler
Characterization and application of the resonant properties of out-diffused silver nanoislands

Robert Klas
Measurement of the Magneto-Optical Kerr-Effect with High Repetition Rate High Harmonic Sources

Chang Liu
Design of a near-infrared broadband microscopic objective

Diinesh Lokanathan
Investigations of induced aberrations in optical systems

Gregor Matz
Correction of microscopic endoscope objectives

Sergii Morozov
Relaxation dynamics of quantum systems in the vicinity of plasmonic structures

Marcin Olecki
Dynamic low-order correction by active optical compensators

Rafael Quintero-Bermudez
Parametric frequency conversion in nanostructured waveguides

Marc Reig Escalé
Mapping the guided light distribution in nanowires

Olga Rodenko
Autofluorescence modeling in microscopy

Immam Setiawan Wahyutama
Table-Top Coherent Imaging - Towards Nanometer Resolution

Evgeny Shestaev
Femtosecond oscillators for non-steady-state enhancement cavities

Svetlana Shestaeva
Atomic layer deposition of dielectric materials for optical coatings

Getnet Kassa Tadesse
Spectral Beam Combining by Femtosecond Laser Written 2D Volume Bragg Gratings in Fused Silica

Maxim Tschernajew
High Harmonic Sources

Zongzhao Wang
Analytical Handling of Optical Wavefront

Kai Wang
Aharonov-Anandan Geometric Phase in Glauber-Bloch Photonic Lattices

Xiaohan Wang
Field enhancement using plasmonic nanoparticles and their use in integrated optical spectroscopy

Michal Wojdyr
Investigations of novel schemes of spatial and temporal combining of ultrashort pulses

Norman Worku
Simulation of pulse propagation through optical systems

Yueqian Zhang
Design of camera lens for vision sensor

Exam Theses in Educational Physics

Samuel Haase
Realisierung von Mikrokanälen in Fasern mittels ultrakurzer Laserpulse

Doctoral Theses

Anika Brahm (ASP)
Terahertz-Computer-Tomographie mit Zeitbereichsspektroskopie-Systemen

Stefan Demmler
High Average-Power Few-Cycle OPCPA System for Strong-Field Applications

Wiebke Eckstein (ASP)
Computergenerierte Hologramme auf Basis binärer Subwellenlängenstrukturen

Nils Heidler (Promotion an TU Ilmenau)
Untersuchungen zylindrischer Gasführungselemente für Hochvakuumanwendugen

Tobias Herffurth (ASP)
Light scattering and roughness analysis of optical surfaces and thin films

Christoph Jocher (ASP)
Generation, Amplification and Characterization of Cylindrical Vector Beams in Optical Fibers

Robert Kammel (ASP)
Tailored Femtosecond Laser Structuring for Intraocular Surgery

Angela Klein (ASP)
Scanning Near-Field Optical Microscopy: From Single-Tip to Dual-Tip Operation

Nicolas Lange (ASP)
Lithografisch hergestellte, polymerbasierte elektrostatische Aktuatoren ohne Pull-In-Effekt

Reinhold Lehneis
Pulse shortening of passively Q-switched microchip lasers

Hans-Jürgen Otto (ASP)
Modeninstabilitäten in Hochleistungsfaserlasern

Stephan Ratzsch
Untersuchung der plasmaunterstützen Atomlagenabscheidung für das Auftragen von optischen Schichten

Stefan Steiner
Richtungsselektive optische Filterelemente auf Basis von Gitterstrukturen

Lorenz Stürzebecher (ASP)
Beugungslithographie zur Fertigung optischer Nanostrukturen

Fabian Stutzki
Yb- and Tm-based ultrashort-pulse fiber-laser systems

Marcus Trost (ASP)
Light scattering and roughness properties of optical components

Christian Voigtländer (ASP)
Bandbreitenkontrolle von Femtosekundenpuls-induzierten Faser-Bragg-Gittern

Habilitation Tretise

Jun.-Prof. Dr. Alexander Szameit
Dirac Dynamics in Photonic Waveguide Arrays

Institute of Solid State Physics

Bachelor Thesis

Paul Schenk
Röntgendiffraktometrie an CIGS-Dünnschichtsolarzellen

Adrian Weisskopf
Scanning tunneling microscopy and spectroscopy of PbPc on graphite(0001)Diploma, Master and state examination theses

Johannes Dickmann
Mechanische Verluste von SiO_2-Schichten

Johann Schwengber
Untersuchungen zum Einfluss von Au-Nanopartikeln auf die kritische Stromdichte von YBCO-Schichten

Lena Kath
RBS-Untersuchungen an kristallinem LiNbO3 in Zufallsrichtungen und entlang verschiedener HauptachsenTitel

Diploma, Master and state examination theses

Sven Bauer
Nanostrukturierung von Lithiumniobat mittels selbstorganisierter Nanostrukturmasken und Ionenstrahlen

Markus Schwiderke
Anregungs- und temperaturabhängige Lasingeigenschaften von Halbleiternanodrähten

Michelle Geelen
Ion beam doping and defect engineering of ZnO nanowires for photodetection and sensing applications

Max Riedieger
Emissionscharakteristik von ZnO Nanodrahtlasern

Tim Barth
Wachstum und Charakterisierung von Vanadiumdioxid-Mikrodrähten

Ellen Butz
Herstellung und Charakterisierung von Kaliumfluorid-behandelten Cu(in,GA)Se_2-Solarzellen

Felix Otto
Untersuchung der Kalium-Dotierung von Tetraphenyldibenzoperiflanthen (DBP) mittels Photoelektronenspektroskopie

Erik Haubold
Strukturanalyse kupferarmer Cu(In,Ga)Se Phasen mittels Röntgenabsorptionsspektroskopie

Adebowale Anthony
Structural and optical characterisation of Cu(In,Ga)Se2 solar cells

Jonas Gronemann
Charakterisierung von Au-modifizierten Korngrenzen-Kontakten

Marcus Junghanns
PEDOT:PSS Emitter auf mc-Si Absorbern für Hybrid-Dünnschicht-Solarzellen

Rene Glaser
Untersuchungen zur Photoelastizität von Silizium

Philip Pastrik
Optische Untersuchungen an Materialien für zukünftige Gravitationswellen-detektoren

Martin Feltz
Voruntersuchungen zur Realisierung eines Parker-Mazin-Designes auf Ba-122

Lukas Maczewsky
Mechanische Spektroskopie optischer Materialien für Gravitationswellen-detektoren

Valentin Biehl
Aufbau und Charakterisierung eines Messsystems zur Detektion kleiner mechanischer Schwingungen

Gregor Becker
Defektuntersuchungen an ionenimplantiertem Lithiumniobat

Dissertations

Christoph Heisler
Herstellung und Dotierung von polykristallinen CdTe-Dünnschichten für Solarzellen

Andreas Johannes
High-fluence ion beam irradiation of semiconductor nanowires

Steffen Wolf
Metallische Nanopartikel in Lithiumniobat für plasmonische Anwendungen

Sebastian Döring
Dünnschicht-Josephson-Kontakte zur Charakterisierung eisenbasierter Supraleiter

Christian Katzer
Gold Nanopartikel und deren Auswirkungen auf die physikalischen Eigenschaften dünner Schichten

Institute of Solid State Theory and Optics

Master thesis / Diploma thesis

Junchao Tang
Optische Frequenzverdopplung und Zwei-Photonen-Fluoreszenz durch Nanopartikel mit Hilfe ultrakurzer Laserpulse

Thomas Mittelstaedt
Untersuchungen zur Photosynthese von Clorella vulgaris bei zeitlich modulierter Beleuchtung mit LEDs

Dissertations

Benjamin Höffling
The Interfaces between Silicon and Transparent Conducting Oxides

Andreas Schrön
Ab-initio Studies of the Magnetic Properties of the3d Transition-Metal Oxides and their Surfaces"

Lars Matthes
Structural, electronic and optical properties of group-IV honeycomb crystals from first principles

Sebastian Küfner
Electronic and topological properties of low-dimensional alpha-Sn and HgTe structure

Samuel Wiesendanger (ASP)
Photonmanagement in Dünnfilmsolarzellen

Robert Filter (ASP)
Nanoantennas: New Prospects in Light-Matter-Interactions

Otto Schott Institute of Materials Research

Bachelor theses

Josef Slowik
Dynamische Lösungen der propagierenden Welle mit der Phasenfeldkristallmethode

Wolfram Hartramph
Bioaktivierung chemisch inerter Oberflächen

Stefan Hoffmann
Machbarkeitsstudie zur Ausrichtung lamellarer mikrophasenseparierter Nanostrukturen aus Diblockcopolymeren durch Wärmebehandlung mit lokalem Temperaturgradienten

Jialu Chen
Physical Nanostructuring of Gold Surfaces Using Gold Nanoparticles for Biomedical Application

Master theses

Conrad Guhl
Gefügebildung and der Grenzfläche von plattierten Kontaktwerkstoff-Schichtverbunden

Robert Hanke
Einfluss von Verformung auf das Oxidationsverhalten von Edelstahl

Marc Schneider
Tribologische Eigenschaften laserstrukturierter ZTA/ATZ-Keramiken

Clemens Kunz
Herstellung von Dünnschichten mittels Pulsed Laser Deposition im Materialsystem TiO2-ZnO

Steffen Weyrauch
Abformung laserinduzierter, periodischer Oberflächenstrukturen mittels präkeramischer Polymere

Markus Schilling
Herstellung von ZnO/TiO2-Nanopartikeln mittels Laservaporisation

Max Hennig
Grenzflächenhaftung zwischen Polyglactinfasern und bruschitbildendem Calciumphosphat- Zement

Armen Klisch
Materialcharakterisierung von Stahlwerkstoffen durch Bestimmung verschiedener Ultraschallkenn-größen wie Schallgeschwindigkeit, Dämpfung und spektraler Zusammensetzung

Bojia He
How Carbon Nanotubes are Dispersed and Oriented by a High Molecular Mass Amphiphilic Diblock Copolymer

Wolfgang Brehm
Oberflächennanonstrukturen mittels doppelkristalliner Diblockcopolymere durch kontrollierte Kristallisation

Hendryk Marx
Blends aus kristallinen Diblockcopolymeren und ihren kristallinen Homopolymeren

Sören Laschke
Thermisch leitfähige RTM-Werkzeugdeckschichten zur effizienten mikrowelleninduzierten Aushärtung von Faserverbundwerkstoffen: Simulation und Experiment

Diploma theses

Stefan Siewert
Beherrschung des Benetzens von Loten auf Zr-Basis auf Keramiken

Doctoral theses

Hannes Engelhardt
Experimente und Methoden zur Bestimmung thermodynamischer und kinetischer Daten

Institute of Optics and Quantum Electronics

Bachelor thesis

Dennis Adamek
Ultrafast control over optical nonlinearities in molecular gases

Stefan Aull
Optimierung einer Harmonischen-Lichtquelle für die Kohärenztomographie im extremen ultravioletten Spektralbereich

Hannes Damm
Abschätzung der Wirtschaftlichkeit von Kleinwindkraftanlagen im Stadtgebiet

Lê Hoáng
Velocity Map Imaging of Strong-Field Ionisation at 3.6 µm Laser

Sebastian Linß
Aufbau und Charakterisierung einer RF-Plasma-Ionenquelle

Julius Reinhard
Untersuchung einer Hohen Harmonischen Quelle mit mehreren Gasdüsen im extremen ultravioletten Spektralbereich

Gregor Sauer
Charakterisierung der linearen und nichtlinearen optischen Eigenschaften einer antiresonanten Hohlkernfaser

Ramona S. Scheibinger
Parametrische Studien zur Ionenbeschleunigung mit Hochleistungslaserpulsen

Felix Wiesner
Auswirkung von raumzeitlichen Kopplungen in Laserfeldern auf die Erzeugung von relativistischen Oberflächenharmonischen

Lukas Wolf
Experimenteller Ansatz zum eindeutigen Nachweis korrelierter Ionisationsdynamik

Master thesis

Julius Biedermann
Laser-Driven XUV Coherence Tomography

Benjamin Grabiger
Untersuchungen zu lichtstarken Röntgenoptiken für hohe Energien

Jan Reislöhner
Laser-basierte Protonenbeschleunigung mit ultradünnen Folien und ultrahohem Kontrast

Jürgen Reiter
Aktive Amplitudenmodulation von kurzen und schnellen Impulsfolgen eines diodengepumpten Lasersystems

Daniel Ullmann
Optical Diagnostics for LWFA Experiments

Doctoral thesis

Kai Sven Schulze (ASP)
Methoden und Möglichkeiten der hochpräzisen Röntgenpolarimetrie

Institute of Theoretical Physics

Bachelor thesis

Eric Abraham
Mutually unbiased bases and quantum state tomography with a minimal set of measurements operators

Paul-Hermann Balduf
Numerische Untersuchung von gluonischen Zwei- und Dreipunktfunktionen im Rahmen der Gitter-QCD

Lennart Dabelow
Global Analytic Approximation to the Wilson-Fisher Fixed Point Potential

Hans Joos
Emulation fermionischer Systeme in waveguide-arrays

Milena Leutnant
Lösung der Geodätengleichung in der Raumzeit ebenfrontiger Gravitationswellen mit parallelen Strahlen

Robert Ostermann
Wechselwirkung eines wasserstoff-ähnlichen Systems mit Twisted Light

Jan-Hendrik Plank
Unterschiede im asymptotischen Tail-Verhalten relativistischer Wellen

Katharina Wölfl
Implementierung, Simulation und Analyse verschiedener Protokolle zur Quantenteleportation

Master thesis

Jörg Dommaschk
Lösung axialsymmetrischer Wellengleichungen in der Kerr-Metrik durch eine Laplacetransformations-Methode

Tom Dörffel,
High-order Finite Differencing Schemes for the Divergence Cleaning Approach of Relativistic Magnetohydrodynamics

Matthias Pilz,
A new ADER-DG Scheme based on a Local Continuous Runge-Kutta Method

Andreas Schoepe
Kugelsymmetrischer Gravitationskollaps in der Einstein-Maxwell-Theorie

Marco Vockert
Nichtlineare Wechselwirkungen ebener Gravitationswellen

Matthias Warschinke
Impact of higher dimensional operators on lower Higgs mass bounds in a Higgs-Yukawa system

Doctoral thesis

Marianne Heilmann
A Renormalization Group Study of Supersymmetric Field Theories

Andreas Weyhausen
Numerical Methods for Collapsing Gravitational Waves

Appointments of scientists of the Institute

Andre Sternbeck
Secundo loco for W2 professor, University of Giessen

Research Group - Teaching Methodology in Physics and Astronomy

State examination thesis

Valentin Biehl
Aufbau und Charakterisierung eines Messsystems zur Detektion kleiner mechanischer Schwingungen

Jonas Johne
Physik bei den Simpsons

Lukas Maczewsky
Mechanische Spektroskopie optischer Materialien für Gravitationswellendetektoren

Doctoral thesis

Stefan Völker
Schülerprojekte mit astronomischen Originaldaten für den Einsatz im Astronomieunterricht der Oberstufe

Abbe School of Photonics

Doctoral thesis (in other faculties only)

Mirko Tiegel
Mechanische und spektroskopische Eigenschaften von seltenerd-dotierten Alumninosilicatgläsern

7. Research Activities

7.1. Institute of Astrophysics and University Observatory

a) Fields of research and results

Observational Astrophysics:

Terra-Astronomy: In the new field of Terra-Astronomy, we study variability of stars (solar and stellar flares and (super-)novae) and their influences on Earth. We investigate such phenomena with astrophysical observations, and also using terrestrial archives, both radionuclide archives and historic reports about observations. We have continued our detailed study of the C-14 variation around AD 775, compared it to the 2nd largest variation (in AD 1795) and compiled a full list of historically observed aurorae around that time (several publications by Neuhäuser & Neuhäuser). We also presented two new Arabic observations of SN 1006, which may indicate an early explosion in mid April 1006 (Rada & Neuhäuser).

Neutron Stars: We could find and secure a first case where both a runaway star and a neutron star can be traced back to the same position, the geometric center of a supernova remnant, both objects were ejected in the supernova explosion some 35,000 years ago. This is the first proof that runaway stars can be born in supernovae in binaries (Dinçel et al.). We also could show that the faint object detected close to the nearby bright star Fomalhaut, previously interpreted as planet, could well be a nearby neutron star – given its colors and proper motion (Neuhäuser et al.).

The individual instruments, which are operated at the university observatory in Großschwabhausen, were used in 2015 in total in 124 nights for astronomical research, as well as for teaching activities, in practical courses of the lecture “Astronomical Observational Techniques” and in the “Astronomical lab”.

Observatory Großschwabhausen: With the Schmidt-Teleskop-Kamera (STK) and the Cassegrain-Teleskop-Kamera (CTK-II), several transits of exoplanets could be observed to search for transit timing variations. In the course of the YETI-project, several young open clusters were monitored, to detected exoplanets, variable stars, and flare events. In addition, photometric monitoring campaigns of the young variable stars DH Tau and GM Cep, as well as of the quasar OJ287 were carried out with the STK and CTK-II. The Echelle spectrograph FLECHAS was used in 2015 during 76 nights for (1) the spectral classification of young and massive stars, (2) to determine the radial velocity of stars, (3) to derive the orbital elements of binary systems, (4) to study the Lithium abundance of runaway-star candidates. Furthermore, the Refraktor-Teleskop-Kamera (RTK) was utilized in 2015 to observe several hundred visual binaries to determine their current relative astrometry. The observational results obtained at the university observatory were published in several articles in refereed astronomical journals (MNRAS, AN).

In 2015 several guided tours were offered at the university observatory for groups of visitors (among them e.g. several tours offered in the course of the 1200 year anniversary celebration of the municipality of Großschwabhausen, and one tour offered for the FSU presidential office including the president and vice-president of the FSU), as well as for students of the university, in the course of the lecture “Stellar Physics”.

Theoretical Astrophysics:

Analyzing a sample of spatially resolved debris discs, we have identified a previously unknown trend between the dust grain sizes in the discs and the luminosity of their host stars and proposed possible explanations of the trend (Pawellek & Krivov). For the debris disc around the nearby M-dwarf AU Microscopii, we set up detailed theoretical models through multi-parameter fitting and in-depth collisional modelling with our ACE code (Schüppler et al.). Further, we used a subsample of the Her-

schel-resolved young, bright debris discs to shed more light on the possible stirring mechanisms operating in them (Moór et al., MNRAS 447). Another research project focused on the analysis of ALMA and Herschel observations of the neighbouring binary alpha Cen A-B. With this analysis, we were able to constrain the temperature profiles in the atmospheres of both stars (Liseau et al, A&A 573).

(This research has been carried out by A. Krivov, T. Löhne, Ch. Schüppler, and N. Pawellek; in cooperation with the Herschel/DUNES- and GASPS-teams and several groups in Germany, Europe, USA, and Japan, with funding granted by the DFG).

Following a proposal submission in January and a review panel colloquium in March in Jena, the German Research Foundation (DFG) has approved a new Research Unit FOR 2285 "Debris disks in Planetary Systems" (speaker: Prof. Alexander Krivov). The Research Unit is a collaborative effort of several institutes of the University of Jena, Technical University of Braunschweig, University of Kiel, and the Hamburg Observatory. The goal is to employ state-of-the-art theoretical and laboratory methods to deeply analyze a wealth of observational data available and to prepare future observations of debris discs. The Research Unit has been set for three years and is funded with 2.2 million Euros. It comprises a total of 10 projects, five of which are hosted by the AIU (project leaders: Krivov, Löhne, Mutschke).

Laboratory Astrophysics I – Astromineralogy:

In the Laboratory group of the AIU, the DFG-funded project on measuring dust opacities at long wavelengths and low temperatures was continued (P. Mohr, H. Mutschke, G. Born, DFG-Schwerpunktprogramm 1573 – "Physics of the Interstellar Medium"). The apparatus for the quenching of glass melts as been reconstructed and allows now for working under protective atmosphere. The glasses produced in this way are currently analyzed with respect to the influence of the diminished iron oxidation (Moessbauer spectroscopy, collaboration with U. Reislöhner, IFK). At the 1. Phys. Institut der Universität Köln, the temperature dependent measurements of the millimeter wave absorption have been started (collaboration with F. Lewen, T. Dressler, S. Schlemmer).

At shorter infrared wavelengths, reflection spectroscopy with polarized radiation of a crystallographically oriented diopside crystal (collaboration with O. Wehrhan, IOQ) has been carried out. The measurements at many different polarization angles have been analyzed with respect to the frequencies and orientations of the lattice vibration modes of the crystal (Dispersion analysis, collaboration with T. Mayerhöfer, IPHT Jena). Currently, theoretical approaches for the simulation of absorption cross sections for diopside dust particles are investigated. This work will lead to the submission of a joint project proposal to DFG, in which such data for highly anisotropic materials shall be calculated.

For the new research project within the DFG Research Unit "Debris disks in planetary systems" (installed in summer 2015), DFG has provided a new Time-domain THz spectrometer, which has been delivered at the end of the year. For the selection of this instrument, test measurements have been performed at various companies. The instrument (Fa. TOPTICA) will guarantee fast and flexible measurements of the dust opacity in the sub-millimeter wavelength range during the project duration of up to 6 years. Different groups within the Research Unit will deliver dust samples to be analyzed for absorption/emission coefficients and refractive indices in this wavelength range (collaboration with F. Langenhorst – IGW Jena, C. Jäger – IFK Jena, J. Blum – IGEP Braunschweig).

7.2. Institute of Applied Optics

a) Fields of research and results

The main fields of research at the IAO are

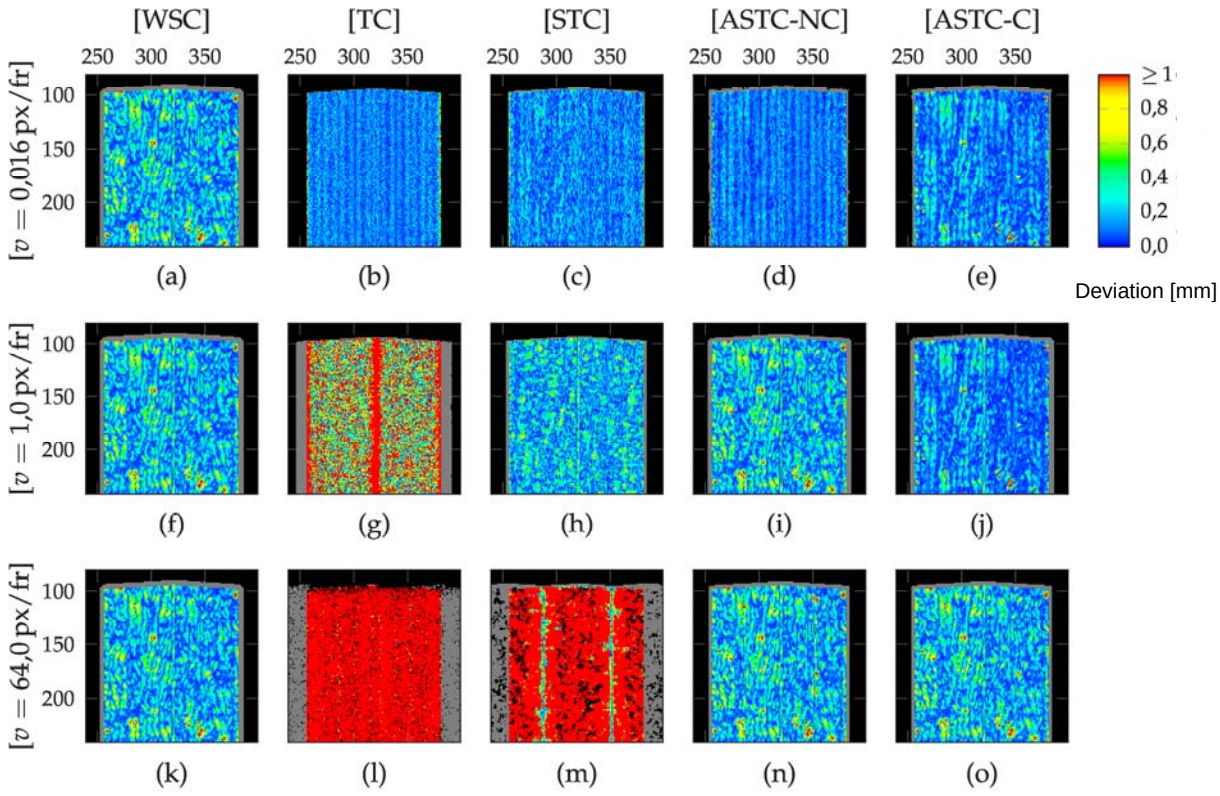
- Optical measurement techniques
- Optical information storage and processing
- Interaction of optical wave fields with materials and surfaces
- Synthesis, analysis and transformation of laser modes and laser beam forming with diffractive optical elements (DOE)
- Cell and tissue manipulation by ultrashort laser pulses

Following a long tradition at the IAO, works in the field of optical metrology at the institute are highly focused on possible applications. Corresponding techniques are the optical acquisition of three-dimensional shapes and changes of shapes (structured illumination, holography and interferometry) as well as wavefront sensing and the analyzing of laser beams.

In the field of 3D-metrology using stereophotogrammetry several new developments and advancements have been done. Based on the high-speed techniques that were developed over the last years, as the ultra-fast switching of speckle patterns with and without acousto-optical deflectors, physical limits of such systems have been determined and existing systems have been enhanced in various fields. These works have been underpinned by numerical simulations.

In this context, different ways of camera calibration have been tested.
Furthermore, work on a speckle based projection system using spectral filters has been done to enable such systems to be used at high background light (e.g. daylight).
Works also have started on a unique deflectometric setup using speckle projection techniques as well.
An already developed speckle illumination with a linear shape has been evolved. So, it was possible to improve the optical and stereophotogrammetric properties of such systems. Additionally, different possibilities to create variable objective speckle patterns have been tested.

Besides fast measurement techniques, there are different possibilities to measure moving objects. Another method uses an adaptive spatiotemporal correlation method that adopts its temporal and spatial support to motion and further applies motion compensation. This makes the measurement system robust on movements of the measured objects. The results of the weighted spatial correlation (WSC) are independent from motion. The deviation maps keep unchanged when the velocity of the measured objects is increased (see the following figure a, f, k). But in return, the spatial correlation achieves quite low precisions (also for static or slow moving objects). The temporal correlation (TC) and the classic spatiotemporal correlation (STC) achieve a much higher precision for static or slow moving objects (b, c). But when the velocity is increased, the precision decreases (g, h, l, m). The spatiotemporal correlation, which has a lower temporal support than the temporal correlation (here: 5 frames vs. 21 frames), is less sensitive to motion. Hence, the precision for medium velocities (v = 1 px/fr) is higher (g, h). The new adaptive spatiotemporal correlation (ASTC) achieves a high precision for static or slow moving objects (d, e), similar to the temporal correlation (b) but much higher than the spatial correlation (a). When the velocity is increased, the adaptive spatiotemporal correlation converges into the classic spatial correlation: In the case of high velocities there is visually no difference between the deviation maps (k, n, o). In the internal competition of both adaptive correlations the one with additional motion compensation (ASTC-C)features a lower sensitivity to motion than the one without motion compensation (ASTC-NC), i.e. the correlation with motion compensation converges slower into the spatial correlation (i, j). In return, the correlation without motion compensation achieves a higher precision at low velocities (d, e). An iterative spatiotemporal correlation could combine the two approaches in order to take advantage from the pros of both.

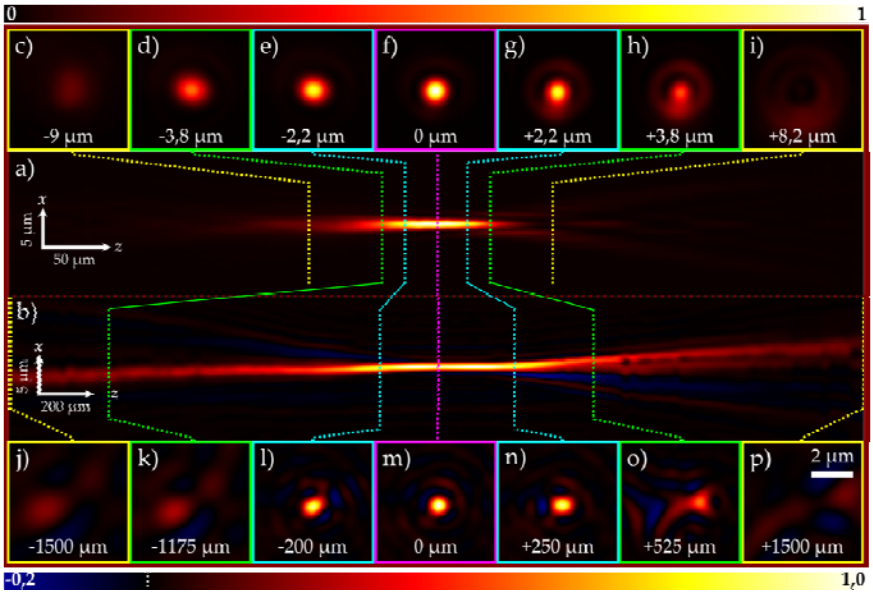


Deviation maps for a simulated scene with a moving wedge (wedge angle: 90 °). Two different version of the new adaptive spatiotemporal correlation (ASTC-NC and ASTC-C) are compared to three classic correlation techniques: a weighted spatial correlation (WSC), a temporal correlation (TC) and a classic spatiotemporal correlation (STC). The adaptive spatiotemporal correlations ASTC-NC and ASTC-C differ from each other in that the latter further applies motion compensation. The results are visualized for three different velocities (v, measured in pixels per frame) of the moving wedge.

The partnership with the Fraunhofer IOF, Jena, several companies and academic institutions in the field of 3D-measurement was intensified within the strategic alliance 3dsensation. Within this alliance our working group is currently active within two projects, the first being the development of a suitable calibration at a multi-aperture system. The second project is part of the project Muse3h, which aims to develop and implement highly dynamic and accurate stereophotogrammetric systems. Within this project, amongst others, we develop and enhanced a line-based laser speckle projection system.

The research in digital holography using high resolution CCD-chips was continued. The Moiré-effect was used to increase the angular size of objects to be recordedin free space propagation and to increase the resolution of objects in image field holography.

In 2015, there were several progresses in the field of coherence imaging microscopy at the IAO. To achieve this, some enhancements and upgrades were made on the interferometric setup. While using a microscope objective with a numerical aperture of 0.40, it was possible to improve the depth of field compared to a conventional microscope by a factor of 125. Besides, the transmitted light illumination and incident light illumination could be tested successfully. Furthermore, coherence imaging microscopy enables the correction of optical aberration during the imaging process. It was possible to correct wavefront errors of about 8 µm (P-V) with the result that an almost diffraction limited image could be gained.

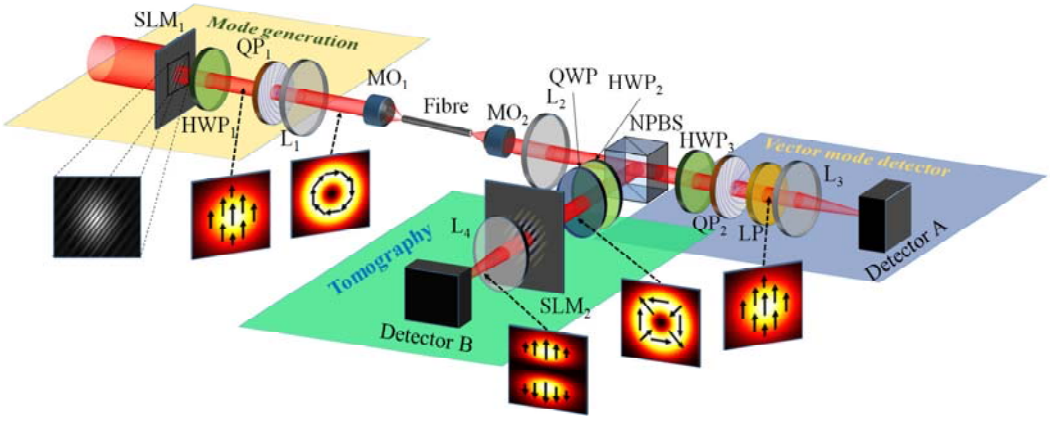


Axial cross section of the point spread function of the conventional microscope (a) and the coherence imaging microscope (b) both using the same microscope objective with a numerical aperture of 0.40 (λ = 633 nm). Figures c)-i) and j)-p), respectively, show the lateral images at the denoted distance to the focal plane.

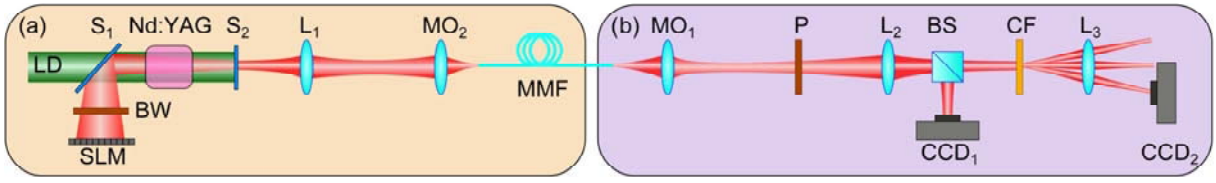
A further area of research of the institute is connected with the synthesis, analysis, and transformation of laser modes respectively laser beams, as well as laser beam shaping, mainly by means of diffractive-optical elements (DOEs). Also in 2015 the focus was on on-line laser beam analysis, which is not only of fundamental physical interest, but represents an essential precondition for the industrial application of certain laser systems. Especially in connection with the investigation of transversal modes in so called optical passive fibers, intended for lossless transportation of brilliant laser radiation from its origin (fiber laser respectively solid state laser) to the point of application, but furthermore in the case of active optical fibers, the concept of modal analysis by correlation filter method delivers valuable information about the laser beam. This concerns (relative) modal strengths, intermodal phase differences as well as mode-resolved polarization states – parameters of the laser beam hard or even impossible to access by “standard” measurement procedures.
Well-defined selective excitation of specific modal superpositions at the input of few-mode-fibers in combination with high precision measurement of the modal distribution of the optical field at the fiber output, allows to determine the so called “Modal Transfer Function” of the waveguide under test. This approach will enable promising applications for the future.

A further new approach of mode treatment is the application to synthesis and recognition of laser beams carrying specific Optical Angular Moments (OAM). OAM represents an additional degree of freedom for information transfer in fiber bound respectively free space communication lines, additionally to the actually used parameters wavelength and polarization state. To synthesize or to recognize such “vector beams” characterized by their spatially varying polarization state, a new class of optical elements called “Q-plates” has to be applied in conjunction with standard DOEs and standard polarization optical elements. In 2015 this approach has been tested in collaboration with leading international groups, resulting in two interesting papers.

Furthermore, two different new approaches to excite higher order modes in few mode fibers, by means either of a “digital laser” (see Figure) or by micro phase plates directly on the fiber facet were realized and successfully tested.



Experimental setup used to generate and detect vector beams after propagating through a fiber by two separate measurement techniques: vector mode detection and tomography. Insets depict a hologram used on SLM 1 and beam profiles at different planes.SLM - spatial light modulator; HWP - half wave plate; QP - q-plate; MO - microscopic objective; L - lens; NPBS - non-polarizing beam splitter; LP - linear polarizer; QWP – quarter wave plate.

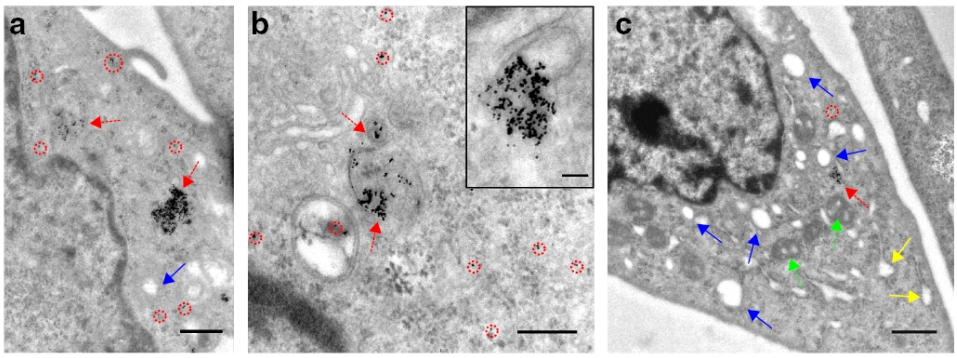


Scheme of the experimental setup for: (a) the creation, and (b) the detection of fiber modes. SLM, spatial light modulator; BW, Brewster window; LD, laser diode; S_1, high reflective mirror; S_2, output coupler; Nd:YAG, gain medium; L_1, lens (f = 200 mm); $MO_{1,2}$, Microscopic objective f = 10 mm; L_2, lens (f = 400 mm); P, polarizer; BS, beam splitter; CF, correlation filter; L_3, Fourier lens (f = 200 mm); $CCD_{1,2}$, charge coupled device.

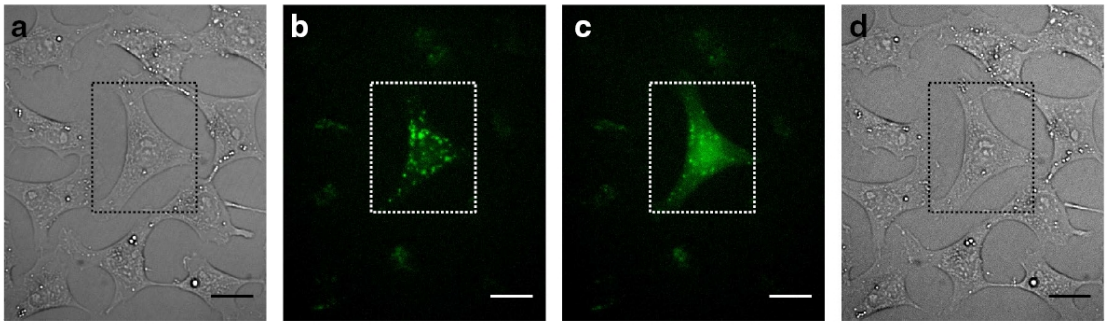
In the area of biomedical optics and biophotonics (RG Heisterkamp) further work has been conducted in 2015, as a remaining laboratory (1 PhD student) was still operated in close collaboration between Hannover and Jena.

The research has been performed in close collaboration with the Barcikowski group at UDE, Essen. In detail the manipulation of biofilms using the interaction of gold nanoparticles and ns-lasers has been studied, in order to disrupt the integrity of the biofilm matrix. The characterization of gold nanoparticles agglomerates was further pursued and resulted in a recently accepted joint publication between Jena, Hannover and Essen:
J. Krawinkel, U. Richter, M.L. Torres-Mapa, M. Westermann, L. Gamrad, C. Rehbock, S. Barcikowski, A. Heisterkamp, Optical and electron microscopy study of laser-based intracellular molecule delivery using peptide-conjugated photodispersible gold nanoparticle agglomerates, J. Nanobiotechnology, 14, 2, 2016.

The figures below provide an insight into the uptake and release mechanisms of the agglomerates after laser irradiation; see the following figure for the scanning electron studies, collaboration with RG Westermann, FSU Jena.



TEM images of laser-irradiated cells containing endosomes with CPP-AuNPs. Cells irradiated with 25 mJ/cm^2 (**a**) and 35 mJ/cm^2 (**b**, **c**). CPP-AuNPs are desagglomerated and endsosomes are partly or completely opened. Most particles are isolated, but still close to each other and the endosome they escaped (*red dashed arrows*). Some particles are distributed already inside the cytoplasm (*red dashed circles*). *Blue arrows* indicate laser-induced vacuoles. Vacuoles are also found in mitochondria (*green dotted arrows*) and blown up lumen of the endoplasmic reticulum (*yellow arrows*). *Scale bars*: **a** 500 nm, **b** 300 nm, *inset* 100 nm, **c** 800 nm



Visualization of calcein uptake and release. Calcein was co-incubated with CPP-AuNPs and cells for 4 h. The cell within the dotted box was irradiated. Brightfield images show no change of cell morphology after irradiation (**d**) compared to before (**a**). **b** Fluorescent image of cell before irradiation exhibits clear fluorescent spots. **c** After irradiation some of these spots are still visible, but calcein was released and spread all over the cytoplasm. *Scale bars*: 20 µm

The figure shows the analysis of the laser triggered release of endosomal calcein using fluorescence microscopy.

b) National Cooperations

In the field of optical measurement techniques we have collaborations with several institutes of our Faculty and German companies. Long-term cooperation and relationships exist with the Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF, Jena, on the subject of optical 3D-shape measurement with structured illumination especially within the strategic alliance 3dsensation..

With the group of Prof. Barcikowski, the works on gold nanoparticles and cell manipulation are continued.

Concerning the spatial characterization of laser beams respectively of modal properties of waveguides, both by means of Diffractive Optical Elements, we cooperate with the Leibnitz Institute of Photonic Technology, Jena, and with a major German laser manufacturer.

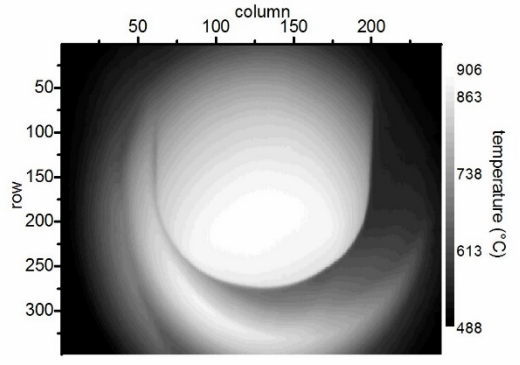
7.3. Institute of Applied Physics

a) Research areas and results

The Institute of Applied Physics practices fundamental and applied research in the fields of micro- and nano-optics, fiber and waveguide optics, ultrafast optics as well as optical engineering. It develops novel optical materials, elements and concepts for information and communication technology, life science and medicine, security and mobility, environment and energy as well as process technology including material processing and optical measurement techniques.

Ultrafast Optics (Prof. Stefan Nolte)

The research group works on various applications of femtosecond laser pulses, such as materials processing and micro / nano structuring of optical materials.



Thermal imaging of a test particle inside of the HITECOM reactor.

- Linear and nonlinear interaction processes between light and matter
- Micro- and nanostructuring with ultrashort laser pulse
- Sub-wavelengths structuring
- Fiber Bragg Gratings (FBG), Volume Bragg Gratings (VBG)
- Linear and nonlinear optics in discrete systems
- Medical laser applications in ophthalmology
- THz technology
- Spectroscopic methods for gas analysis

Nanogratings – artificial local birefringence in glasses

The micromachining of transparent materials with ultrashort laser pulses allows to fabricate photonic devices with feature sizes smaller than the wavelength of light. By focusing ultrashort laser pulses in the bulk of glasses self-assembled structures, so-called nanogratings, can be induced. While the amount and direction of the induced birefringence can be set by the laser parameters and polarization orientation, respectively, laser scanning allows to arbitrarily arrange the structures within the bulk. This facilitates the fabrication of photonic functionalities, ranging from microfluidics, optical data storage to the generation of optical vortex beams for high-resolution microscopy.

In particular, nanograting-based waveplates are used to extend the well-known structured illumination microscopy (SIM; see Fig. 1) [1]. Based on the tailored arrangement of nanogratings (see Fig. 2) optical sectioning can be performed in a single exposure. Consequently, rapidly changing samples such as biological tissue can be imaged in-situ.

Despite the various applications of nanogratings the fundamental formation process is still not fully understood. One challenging aspect is the non-invasive structural investigation of the buried material modification. Typical methods base on time-consuming sample preparation techniques such as polishing and etching which also destroys fine structural details such as nanometric pores.

To overcome these challenges a combination of small-angle X-ray scattering (SAXS) as well as focused ion beam milling and SEM imaging was used [1]. The latter allows for imaging the three-dimensional distribution of the nanoporous structure without harming the structural morphology. Moreover, SAXS reveals average feature sizes, shape and total pore number as function of the laser parameters without any sample preparation. Thus, the growth of pores and their arrangement in periodic grating planes was comprehensively analyzed. This facilitates a better understanding of the complex physical mechanism of the nanograting formation and allows to further optimize the induced birefringence for tailored photonic functionalities [2].

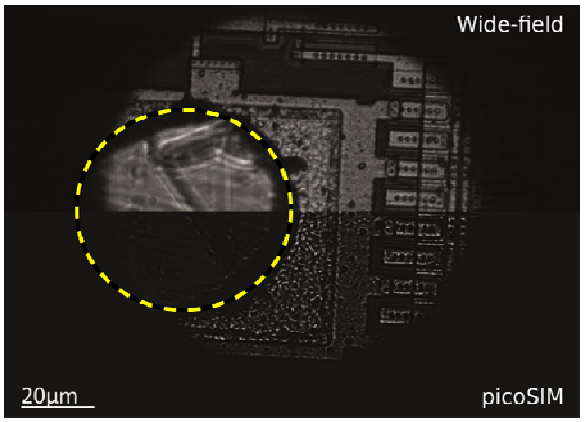


Figure 1: Comparison of a ceramic chip imaged with conventional wide-field (upper) and polarization-coded structured illumination microscopy (lower). The latter significantly reduces the out-of-focus light (marking).

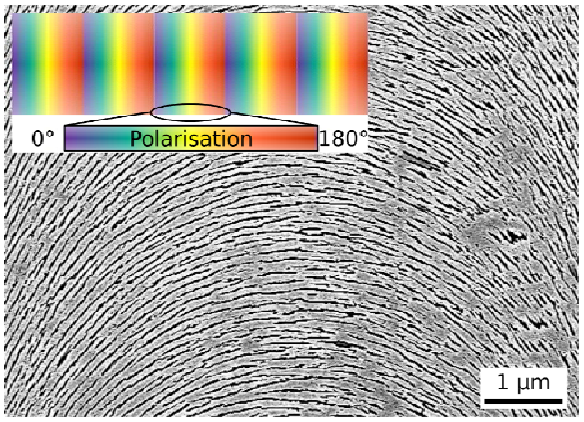


Figure 2: (inset) Desired polarization distribution for polarization encoded optical sectioning microscopy and (lower) SEM micrograph of the inscribed nanograting structure.

[1] F. Zimmermann, et al.: „Ultrashort pulse-induced periodic nanostructures in bulk glass - from fundamentals to applications in high-resolution microscopy“, book title: “Optically Induced Nanostructures: Biomedical and Technical Applications”, Ed.: K. König, Ed.: A. Ostendorf, Berlin: De Gruyter, ISBN: 9783110354324, 93-116 (2015)
[2] F. Zimmermann, et. al., Optics Letters 40, 2049-2052 (2015)

Nano Optics (Prof. Thomas Pertsch)

The research group Nano Optics deals with light propagation and nonlinear light-matter interaction in micro and nano structures, optical metamaterials as well as photonic crystals.

Complexly shaped plasmonic nanoparticles of about 500 nm are examined, using a microscope spectrometer to determine their optical properties which will be exploited for the control of light.

- light-matter interaction in microstructured and nanostructured matter
- optical metamaterials, photonic crystals, plasmonics, near field optics, high-Q nonlinear optical microresonators,
- nonlinear spatio-temporal dynamics, quantum phenomena, opto-optical processes in integrated optics, all-optical signal processing
- multi-tip scanning optical nearfield microscopy (SNOM), photoemission electron microscopy (PEEM)
- multi-functional diffractive optical elements based on photonic nanomaterials
- application of advanced photonic concepts for astronomical instruments
- application of optical nanostructures for efficiency enhancement of photovoltaic elements
- Application of nanostructures to the enhance efficiency of photovoltaic elements

Coupled nonlinear waveguides for the generation of photonic quantum states

Photonic quantum states enable the realization of quantum optical simulators and computers, which can be used for unbreakable cryptography and powerful computer algorithms. Together with collaborators from the Australian National University Canberra we experimentally realized a new paradigm for the flexible generation of such quantum states by using coupled nonlinear waveguides made from lithium niobate as integrated quantum state sources. In such waveguides, photon-pairs are generated by spontaneous parametric down-conversion. The interplay between the nonlinear

generation of photon pairs and the linear light dynamics in the system of coupled waveguides leads to a number of novel ways to create two-photon quantum states.
To demonstrate the power of this concept for the generation of nonclassical photon states [1], classical pump light was coupled to a single waveguide of a periodic arrangement of many coupled waveguides, namely a waveguide array. Photon pairs generated along the pumped waveguide can couple to other waveguides, thus undergoing a quantum walk. Quantum interference of photon pairs generated at different positions in the pumped waveguide leads to cascaded quantum walks, which can be manipulated by changing the parameters of the pump light and waveguide array. Thus, control of the output quantum state can be achieved. We experimentally demonstrated such control by generating nonclassical as well as classical quantum light states by tuning the wavelength of the pump light.
Whereas the photon states generated in the waveguide array are distributed over many output waveguides, for practical applications just two spatial output modes are often sufficient. Using just two coupled waveguides to implement the concept described above, we could experimentally demonstrate a source for two-photon quantum states with all-optically tunable degree of entanglement and spatial composition [2]. Among other examples, this configuration was used to generate optical NOON-states.
The operating principle of the demonstrated quantum state sources is suitable for practical implementation of reconfigurable photon sources in on-chip quantum circuits, thus marking an important step towards the realization of a flexible integrated optical quantum architecture.

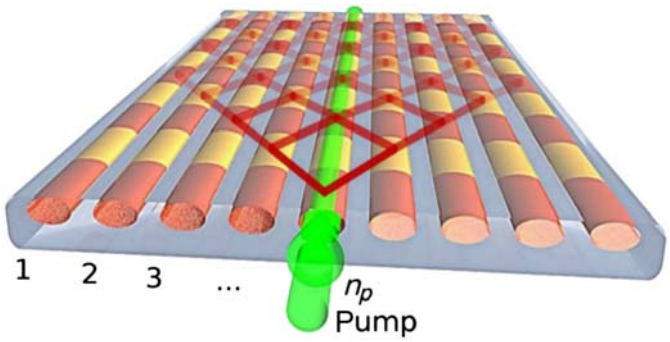


Figure 1: Scheme of the generation of photonic quantum states in nonlinear optical waveguide arrays by cascaded quantum walks. A pump beam (green) is coupled to one waveguide and generates photon pairs (red) by spontaneous parametric down-conversion, which are transformed into the desired output quantum state.

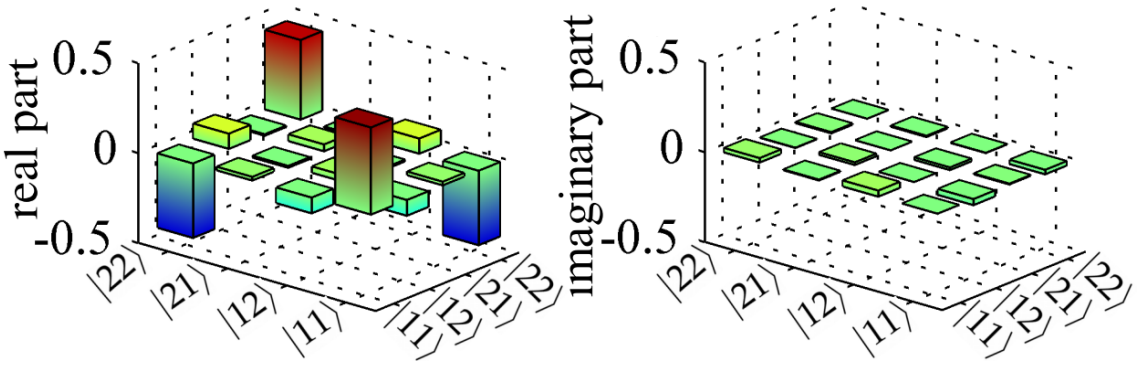
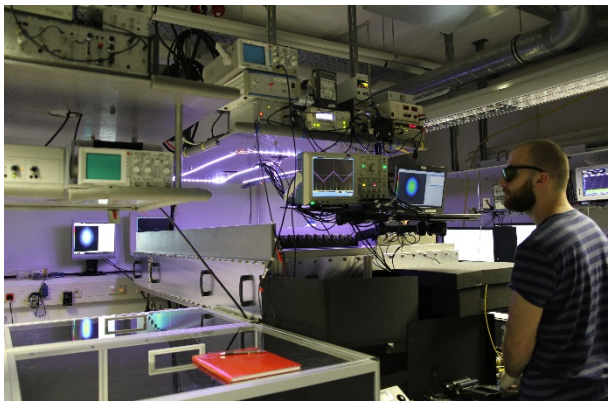


Figure 2: Quantum tomography of a NOON-state experimentally generated in two coupled waveguides.

[1] A. S. Solntsev et. al., Phys. Rev. X 4, 031007 (2014).
[2] F. Setzpfandt et. al., Laser & Photonics Rev. 10, 131-136 (2016)..

Fiber & Waveguide Lasers (Jun.-Prof. Jens Limpert)

The research group is working on the development of new concepts for solid-state lasers with focus on fiber laser technology. Research emphasis lies on fiber-optical amplification of ultrashort laser pulses, ultrashort pulse oscillators, few-cycle pulse generation and amplification, the design of new large core fibers, the simulation of nonlinear effects and the amplifier dynamics in active fibers, fiber-optical frequency conversion, picosecond µ-chip laser and the generation of high harmonics.



S. Wunderlich works on passive enhancement cavity for pulse stacking of an ultrashort-pulse fiberlaser system.

- Fiber optical amplification of ultra-short laser pulses
- Ultra-short pulse oscillators, few-cycle pulse generation and amplification
- Conception of novel large core diameter fibers
- Simulation of non-linear effects and amplification dynamics in active fibers
- Fiber optical frequency conversion
- Picosecond µ-chip-lasers
- High Harmonic Generation and Applications in Imaging and Spectroscopy

Ultrafast fiber lasers in the infrared spectral region

High-energetic laser pulses with pulse duration of a few femto-seconds to pico-seconds at simultaneously high average power and excellent beam quality are of central importance for various applications in research and industry. For example extremely challenging applications such as electron spectroscopy, diffractive imaging or particle acceleration are, due to the lack of high power laser sources, limited to demonstration experiments only. In this respect the fiber laser has proven to be an outstanding laser concept at 1 µm wavelength to meet the continuously rising requirements for the development of novel application fields. However, many applications would greatly benefit from a longer laser wavelength.

The fiber laser was established as high power laser based on fiber-doping with ytterbium. An alternative, promising material is thulium-doped fused silica, which provides a broad emission between 1800-2050 nm. The generation of ultrashort pulses in the 2 µm wavelength regime is currently investigated based on thulium-doped fibers for amplification.

A longer wavelength is – besides the application-oriented demand- also of interest for scaling peak- and average power in fiber lasers. The detrimental influence of important nonlinear effects are linearly or quadratically reduced with wavelength. In addition the mode-field diameter can be scaled quadratically for similar tolerances of the refractive index profile. In combination it should be feasible to scale the output power by an order of magnitude by switching the signal wavelength from 1 µm to 2 µm.

The in-house realization of highly efficient dielectric reflection gratings allowed for average powers of 152 W and peak powers of more than 200 MW at pulse duration of a few hundred femtoseconds [1]. The only limitation for further power scaling and diffraction-limited beam quality was the presence of detrimental atmospheric water absorption (figure 1) [2]. In a subsequent experiment in dry atmosphere the nonlinear compression in a solid-core fiber enabled pulse durations of 24 fs (less than 4 optical cycles, figure 2) at non-preceded average powers of 24 W [3]. Current research focusses on increasing the peak power by spectral broadening in hollow-core capillaries and subsequent pulse compression. These systems will reach several GW peak power and simultaneously high average powers of a few 100 W, which will eventually be used to address challenging and very promising application fields for the first time.

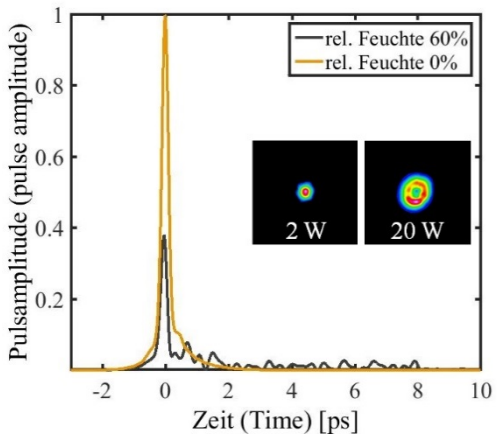


Figure 1: Pulse- and beam deformations by atmospheric water absorption.

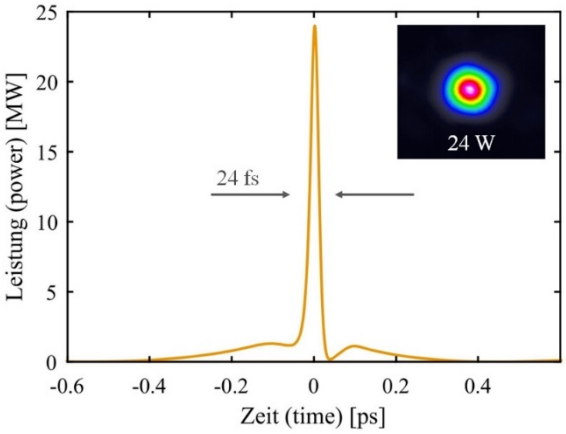
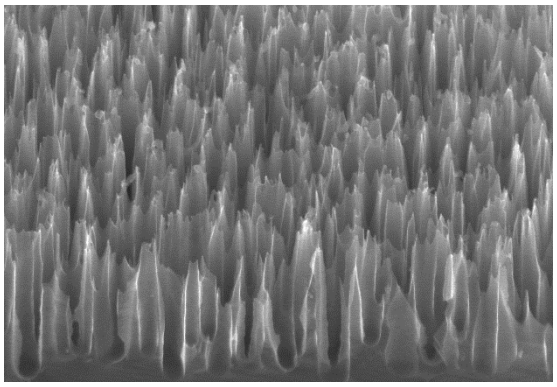


Figure 2: Compressed pulse with 24 fs duration and excellent beam quality.

[1] F. Stutzki et. al., Opt. Lett. 40, 9-12 (2015).
[2] M. Gebhardt et. al., Opt. Express 23, 13776-13787 (2015).
[3] C. Gaida et. al, Opt. Lett. 40, 5160-5163 (2015).

Microstructure Technology & Microoptics (Dr. E.-B. Kley)

The research group concentrates fundamentally on function and design of micro- and nano-optical elements as well as applications and technology developments for micro structuring.



This Black Silicon structure (so called Moth-Eye) has been used for light-trapping to enhance the absorptance of a sensor.

- Plasmonic resonant nanometric structures
- Resonant reflective monolithic gratings
- Transmissive, reflective and diffractive elements based on effective media
- Metallic and dielectric polarizers from IR to DUV range
- 3D nano-structuring of crystals with ion beam
- Optical and opto-electronic applications of anti-reflective fused silica and silicon surfaces
- Material-scientific aspects

<u>Asymmetric direction selective filter based on grating structures</u>

In order to improve the accuracy of highly integrated sensor assemblies using detectors made of semiconductors, e.g. to detect particles in gases or fluids, novel optical filters are of interest, which provide an asymmetric transmission behavior concerning the incidence angle. Because of the combination of filter element and detector, further requirements regarding structure and material arise. These are the possibility for integration on waver scale, e.g. using lithographic methods, and materials, which are compatible with common semiconductor technology.

A novel approach to realize the desired filter function utilizes the very special characteristics of resonant waveguide gratings. Their resonance is based on gratings with periods in the order of the wavelength of the used light, in combination with high index materials. In order to achieve an asymmetric behavior, an effective refraction index gradient inside each grating period is introduced. A possibility to attain this effective index gradient is the application of three grating ridges with increasing width.

Due to this asymmetric layout and a light propagation length of only one period, the required transmission behavior can be reached [1].
For the fabrication a 500 nm thick layer of amorphous silicon was structured using electron beam lithography and a chromium etch mask. The grating period of this sample (figure 1 and 2) is 750 nm, where the widths of the grating ridges are 72 nm, 140 nm and 250 nm. Optimizing the asymmetric transmission function residues of the chromium etch mask were exploited as absorbing structures.
The measurement of a sample at a wavelength of 850 nm (figure 3) exhibits a distinct asymmetric transmission and a maximum of up to 70% at incidence angles in an interval between -52° and -31°. On the contrary the transmission for positive angles is below 10%.

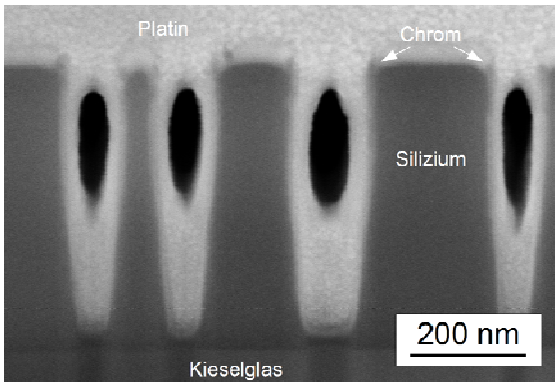


Figure 1: SEM image of a realized filter (cross sectional view).

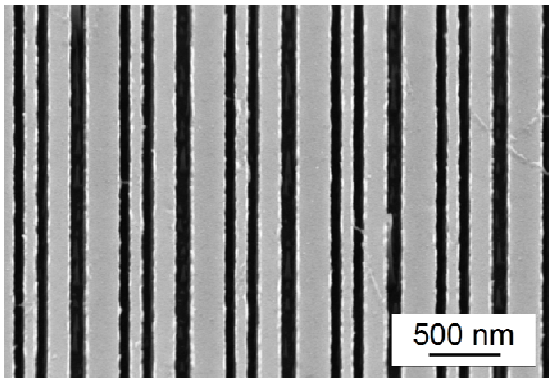


Figure 2: SEM image of a realized filter (top view).

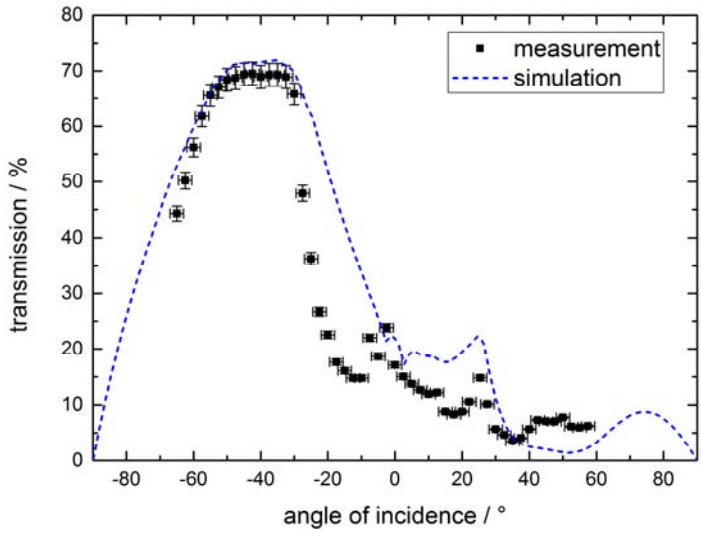


Figure 3:
Comparison between the simulated and measured transmission characteristic.

[1] Fraunhofer IOF, patent 102011084055.9

Applied Computational Optics (Prof. Frank Wyrowski)

In the Applied Computational Optics Group we develop solver of Maxwell's equations for different modeling problems. In the unified field tracing circle (see figure 1), the different modeling tasks are illustrated.

Several topics have been developed in cooperation with LightTrans GmbH and Wyrowski Photonics UG using the optics software VirtualLab Fusion.

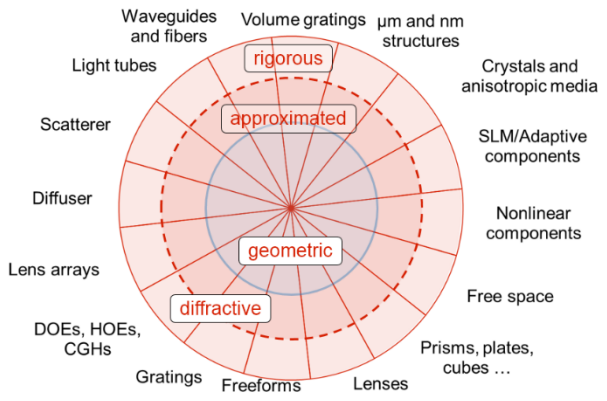


Figure 1: Physical optics modeling requires solution of Maxwell's equations. Fast solvers can be obtained for special components and different level of approximation.

- Flexible and fully vectorial laser resonator modeling
- Smooth field decomposition technique
- Modeling of optical components with multiple internal reflections
- Interpolation of wavefronts or surfaces by using B-splines
- Finite-element meshes for freeform design
- Field tracing in homogeneous anisotropic media
- Modeling of nonlinear effects, e.g. second harmonic generation and Kerr's effect
- Geometric field tracing in graded-index media
- Modeling of metamaterial
- Modeling of particle scattering
- X-ray interferometry
- Birefringence

Geometric field tracing in graded-index media and multi-mode fibers

The theory of geometric field tracing is derived from Maxwell's equations by using the geometric field approximation [1]. It traces smart rays, which include both ray information and field properties, e.g. polarization, intensity and coherence. Besides, the mesh concept is used to interpolate the detected electric field to achieve a well-sampled electromagnetic field. By using the concept of geometric field tracing, graded-index (GRIN) media can be modeled [2].

Example 1: Geometric field tracing in a GRIN lens

An x-polarized plane wave is focused by a GRIN lens (Lunburg ball lens) with radially graded refractive index. The results are shown in figure 1. Geometrical optics cannot calculate the field in the focal region, which is expressed as mesh degeneration in our algorithm. However, after the focal region the degeneration in the mesh disappears. Therefore, the field in the focal plane can be calculated by combining geometric field tracing with diffractive field tracing: (a) Geometric field tracing is used to trace the rays to 10 µm after the focal plane and a well sampled electromagnetic field is obtained; (b) Diffractive field tracing (inverse far field operator) traces the field inversely to the focal plane. The fields in both planes show elliptical shape because the polarization effect is included in both field tracing engines: When a linearly polarized field goes through a rotationally symmetric optical system, the output field shows a more obviously non-rotationally symmetric shape as the numerical aperture becomes larger.

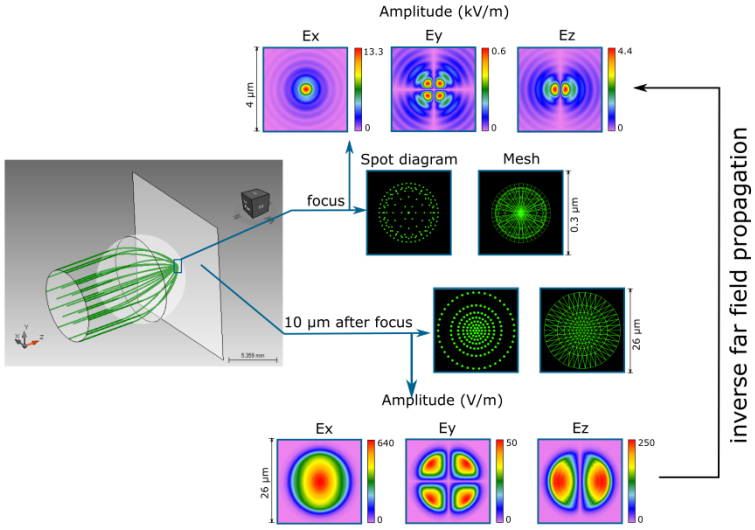


Figure 2:
The figure on the left shows that the ray paths go through the ball lens and focus in the rear vertex. The figure also shows the spot diagram, mesh, amplitude of electric field in the focus plane and 10 µm after the focus plane. The black array shows the calculation process: we use the inverse far field propagation operator to calculate the field in the focus (upper figures) from the bottom field.

Example 2: Geometric field tracing in multi-mode fibers with GRIN profile
In this example, we model an optical system with a multimode fiber: the light source is a VCSEL beam with two Gaussian Laguerre modes; the fiber is of graded index profile; the length of the fiber is just 4.4 mm. The result is shown in figure 2. The rays are curves and go through many focus points. Here we show the spot diagram, which gives the amplitude of Ex on each point: as we said in the beginning, we trace smart rays that contain not only ray information but also field properties. After applying the mesh concept, continuous fields are interpolated as shown in the figure on the bottom right.

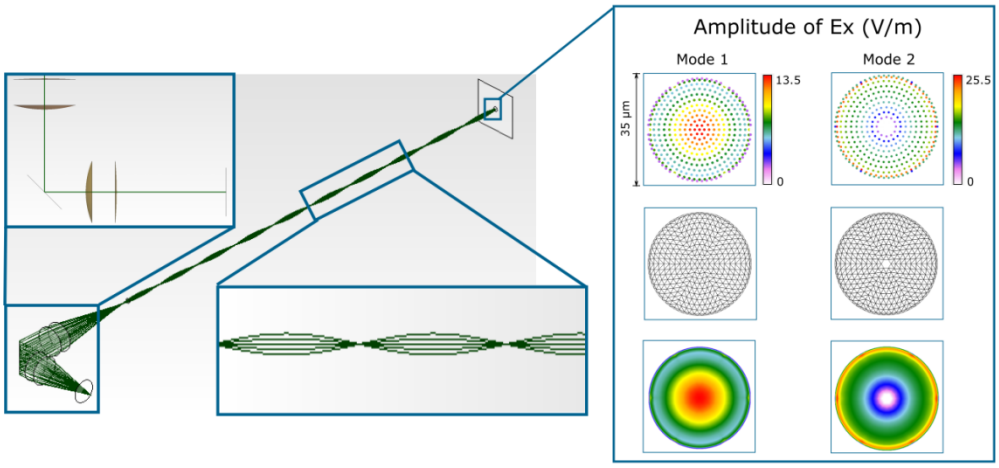


Figure 3: The figure on the left shows that the ray paths go through the coupling lens and multimode fiber. The figures on the right show the spot diagram, mesh and amplitude of Ex.

Geometric field tracing is quite efficient and can be used whenever geometrical optics constraints are fulfilled. As it is in the framework of unified field tracing, general optical systems can be modeled by combining geometric field tracing and diffractive field tracing.

[1] F. Wyrowski et. al, Proc. SPIE, volume 9360, page 963009, (2015).
[2] H. Zhong, et. al., Proc. DGaO (2015).

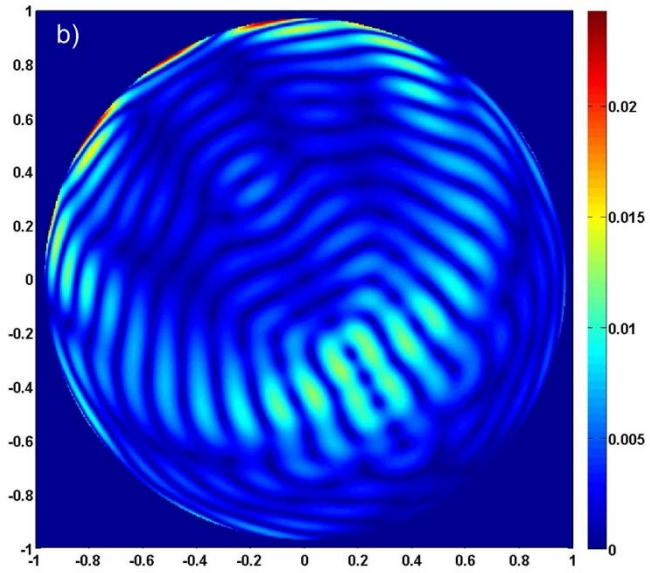
Theory of Optical Systems (Prof. Herbert Gross)

The endowed professorship Theory of Optical Systems aims to support small and medium-sized optical companies of the region around Jena in their development and training. Amongst others, this could be reached in the project “Freeform optics plus (fo+)”, which combines research on the brand new technology field of freeforms in optics but also vocational education and training.

In somewhat more general physical issues relating to optical systems, in particular the following topics of interest are:

- Simulation of diffraction effects
- Microscopic image formation
- Calculation algorithms of wave propagation
- Straylight and scattering in optical systems
- Modelling of illuminations systems
- Partial coherent imaging and beam propagation
- Point spread function engineering and Fourier optics

Generation of arbitrary illumination distributions
In recent years the development of fast algorithms for the design of freeform surfaces raised a lot of interest. The goal of these design methods is the calculation of reflective and refractive surfaces, which can transform arbitrary input and output intensities into each other.



Typical result of a benchmark test calculation after a fitting procedure with 225 Zernike polynomials.

- Design of modern optical system
- Aberration theory
- Quality evaluation of optical systems
- Measurement of the performance of optical systems
- Design of laser and delivery systems
- Design and evaluation of freeform optical systems for imaging and illumination
- Optimization methods in optical design
- Tolerancing of optical systems.

Despite the fact that there is a vast number of publications about freeform surface design methods for nonimaging applications, it is still hard to find fully detailed algorithms in the literature for the calculation of continuous lenses and mirrors, which can generate complex illumination patterns.
We developed a numerical method for the calculation of continuous freeform surfaces for collimated beam shaping. It is based on the decomposition of the design problem into two separate steps. At first a proper ray mapping is calculated via optimal transport. And in the second step the freeform surface is constructed by solving a linear advection equation. This provides us with an efficient and easy way to implement the calculation of freeform surfaces, which has a variety of applications like laser beam shaping for the acceleration of particles, creation of special structured beam profiles for metrology, trapping purposes or laser beam shaping for material machining with high quality cutting edges. But also in practical areas of incoherent illumination, where an efficient illumination control is desired such as street lighting or the automotive industry, freeform surfaces are also very useful but not easy to calculate.

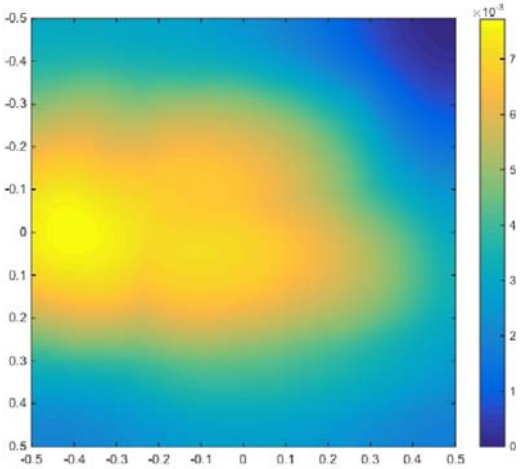


Figure 1: Surface sag of a lens transforming a collimated input beam into the IOF Logo.

Figure 2: Illumination pattern from a raytracing simulation.

In 2015, the two research groups of the **Center for Innovation Competence (ZIK) ultra optics** achieved the following:
For the research group *Manufacturing Technologies for Advanced Micro-and Nano-Optics* (Dr. U. Zeitner) an example of the works in 2015 will be presented in following:

Amongst others, in 2015 diffractive mask-aligner lithography has been used for printing structures that have a sub-micrometer resolution by using non-contact mode. As the diffractive photo masks require a polarized illumination we proposed a mask design that includes a wire-grid polarizer (WGP) on the top side of a photo-mask and a diffractive element on the bottom one to print a 350 nm period grating by using a classical mask-aligner in proximity exposure mode. Generating locally a linearly polarized illumination from an unpolarized incident beam is only possible by using a WGP on the top side of the mask. This configuration opens the possibility to use different linear polarization orientation on a single mask and allows to print high resolution structures with different orientation within one exposure.

Mask design

The diffractive element that generates the high resolution intensity distribution is located on the bottom side of the mask. The transfer of the diffraction grating during the lithography step is performed by using the two-beam interference lithography principle. In order to obtain a high interference contrast and a large undisturbed propagation depth of the two-beam interference it is essential to almost completely cancel the zeroth-diffraction order of the grating. This has been achieved by a special rigorously optimized design of the SiO_2 grating structures.

Polarizer design

Although wire gird polarizer (WGP) are challenging in fabrication, they have been chosen for their beneficial properties such as large acceptance angle and work over a large spectral band. It is, so far the optimal component to efficiently obtain linear polarized light with a wavelength in the UV range and allows integration into a mask. In some particular applications, a local variation of the direction of the polarizer may be required; which cannot be achieved by conventional solutions. To ensure durability also in harsh production environment, iridium is utilized as material for the polarizing grating bars.

For the exposure wavelength of the mask aligner at λ=365nm an extinction ratio of 120 at a TM-transmission of 80% can be theoretically expected. The experimentally realized wire grid polarizer has been characterized to have a TM transmission of 75.3% and an extinction ratio of 74 at the Mask-Aligner wavelength.

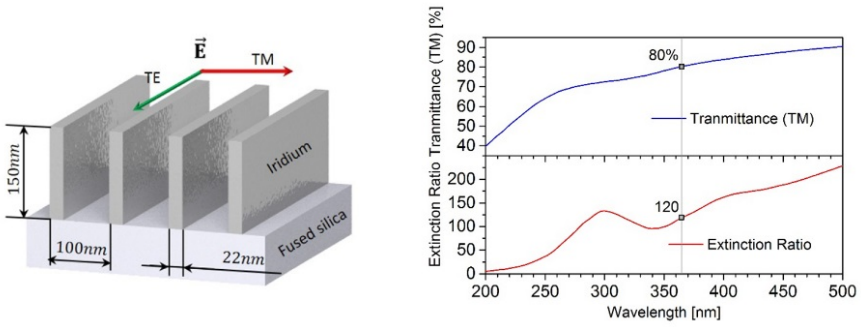


Figure 1: Left: Schematic view of the wire grid polarizer. The arrows show the electric field vector direction for TM (red) and TE (green) polarization. Right: Simulated transmittance of TM polarized light and extinction ratio for an iridium wire gird polarizer with a period of 100 nm a ridge width of 22 nm and a height of 150 nm

Results
The double sided mask has been used to print gratings with 350nm period in a conventional mask-aligner (MA8 Gen3, Süss MicroTec). The exposed and developed resist structures have been transferred into the silicon substrate by reactive ion etching (RIE).

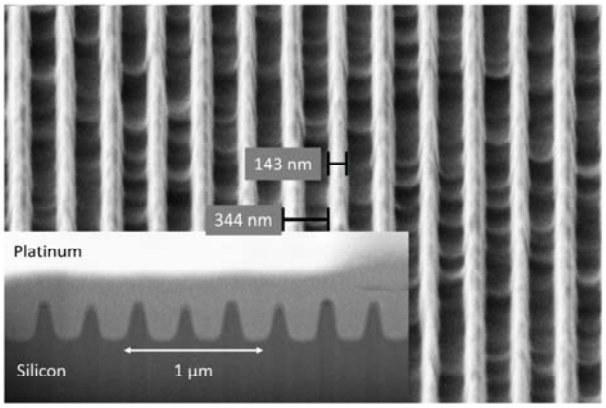


Figure 2:
SEM micrograph of a 350nm period grating printed by the double sided mask and transferred into the silicon wafer by RIE. The sub-window shows the grating profile obtained by FIB.

The mask design presented here has shown that it is possible to obtain sufficiently linear polarized light from an unpolarized UV incident beam by including a wire grid polarizer on the upper side of a photo-mask, and generate a high resolution intensity distribution pattern under the latter by using a phase-mask on its bottom side. This approach shows that such an approach can be used for the mass production of high resolution structures, using proximity lithography and a relatively small modification needed to the illumination setup due to the integration of the polarizer directly on the mask.

[1] Y. Bourgin et al., Optics Express, 23 (13), 16628-16637 (2015).

The works of the research group *Diamond-/Carbon-based Optical Systems* (Jun.-Prof. A. Szameit) , made in 2015, have found international recognition, which is emphasized in 16 original publications in prestigious scientific journals (including 1x "Nature", 1x "Nature Physics", 1x "Nature Communications", and 3x "Physical Review Letters"), 56 conference papers, 21 invited talks and six colloquia. In addition, the research group leader Alexander Szameit was dignified by the Rudolf Kaiser Award. Two results of last year are particularly emphasized in this report.
A highly regarded work has been published in the Science Bulletin about W-state generation [1]. Since their variety of possible applications, ranging from quantum computation to genuine random number generation, W-state class are of growing interest. The work represents an universal setup to generate high-order single photon W-states based on three-dimensional integrated-photonic waveguide structures. The focus lay on a specific class of states, where a single photon is shared among *N=8* optical modes and forms a W-state. Their challenging generation could be realized by using on-chip waveguide structures. Additionally, it has been presented a novel method to characterize the device's unitary by means of classical light only. In the end, a new world record has been drawn: we have succeeded in generating a W-State of 16th order by means of an integrated optical structure - until now, only one W-State of 4th order could be generated (the absolute world record is a state of 8th order in a system of trapped ions). [1]

The here presented second result is a new class of nondiffracting optical pulses possessing orbital angular momentum, published in [2]. By generalizing the *X*-wave solution of the Maxwell equation, we discover the coupling between angular momentum and the temporal degrees of freedom of ultrashort pulses. The spatial twist of propagation invariant light pulse turns out to be directly related to the number of optical cycles. Our results may trigger the development of novel multilevel classical and quantum transmission channels free of dispersion and diffraction. They may also find application in the manipulation of nanostructured objects by ultrashort pulses and for novel approaches to the spatiotemporal measurements in ultrafast photonics.

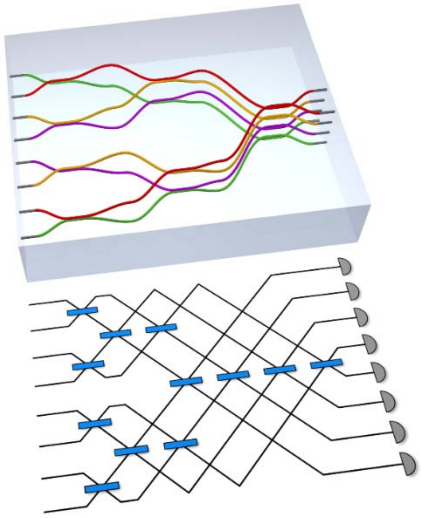


Figure 3:
Sketch of an integrated 8-arm-interferometer for the generation of N=8 W-states (top) and the schematic diagram of this interferometer (bottom).

[1] R. Heilmann, M. Gräfe, S. Nolte, A. Szameit, Sci. Bull. 60(1), 96-100 (2015).
[2] M. Ornigotti, C. Conti, A. Szameit, Phys. Rev. Lett. 115(10), 100401 (2015).

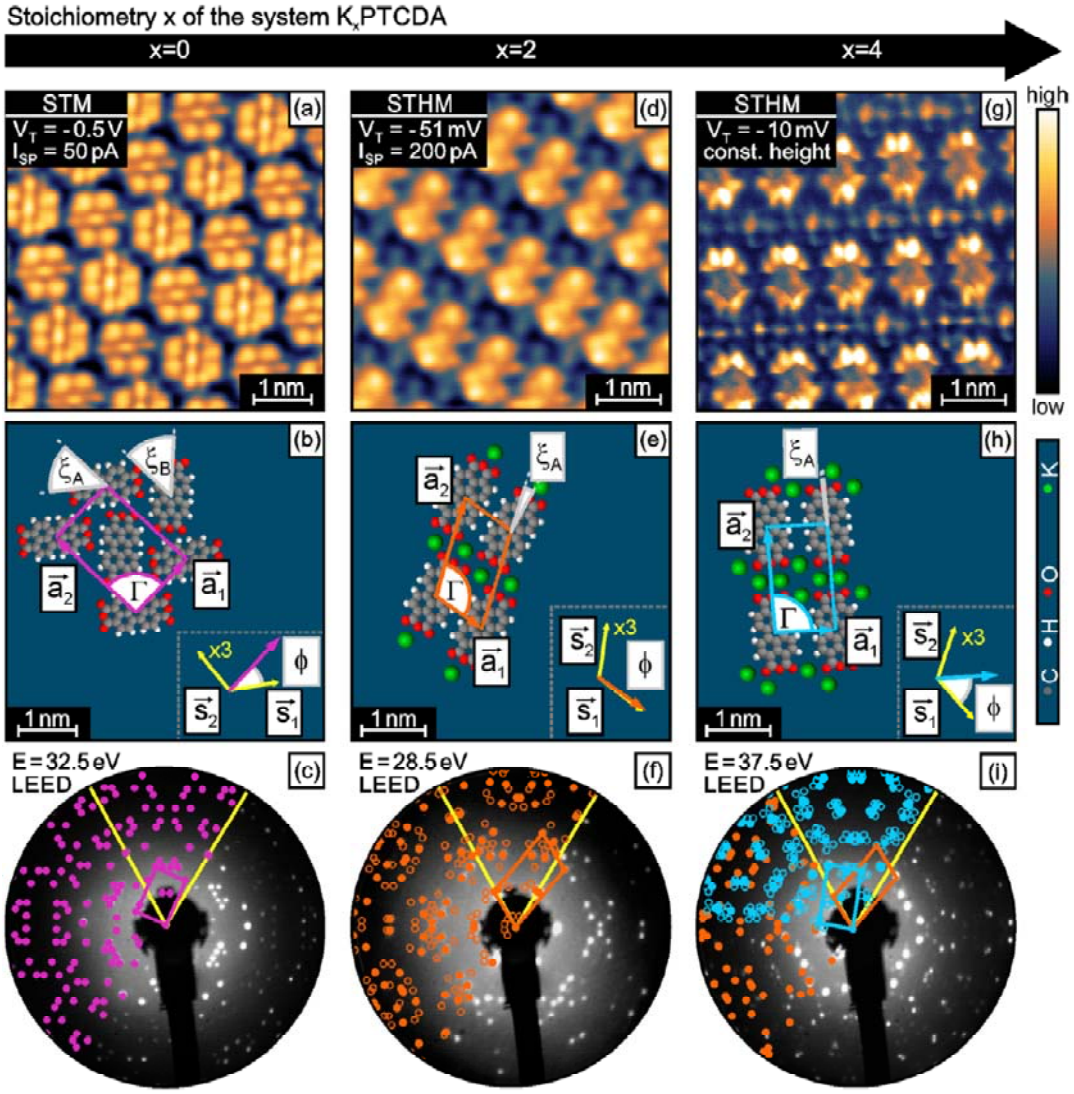
b) Cooperations

The IAP is cooperating with most of the departments of the Faculty of Physics and Astronomy at Friedrich Schiller University, 2015 in particular with the Institute of Optics and Quantum Electronics.
In our work we are connected to the most important research centers of Germany, like the German Electron Synchrotron (DESY) in Hamburg, the Max-Planck-Institute for Quantum Optics in Garching and the Ludwig-Maximilian University, as well as the Atomic Physics Group of the GSI Helmholtzzentrum für Schwerionenforschung, Karlsruhe Institute of Technology and Institutes of the Leibniz Association- such as the Institute for Astrophysics Potsdam (AIP) and Institute of Photonic Technology Jena (IPHT).
Traditionally, the IAP is linked closely to Fraunhofer Institute for Applied Optics and Precision Engineering (IOF). On the basis of this intermeshing between the two Institutes, one major goal is to develop an outstanding international center of excellence for micro- and nano-structured optics as well as optical systems. Therefore, the knowledge and equipment is used commonly, to face the research challenges and to assist also industrial partners in developing new products. Such a fruitful cooperation is the collaboration with eight leading Thuringian Photonics companies in the project “freeform optics plus (fo+)”, mostly financed by the BMBF-Initiative “Unternehmen Region”. The ambiguous aim is the development and commercial exploitation of innovative freeform optical systems by manufacturing demonstrators for special purposes.
In addition, the IAP maintains close contacts to Universities and research facilities nearly all over the world for years: major international collaborations exist with the Centre of Ultrahigh bandwidth Devices for Optical Systems (CUDOS) and Australian National University, as well as the University of Toronto, Vrije Universiteit Brussel, University of Science and Technology China, TU Bergakademie Freiburg, Universities in Russia, Serbia, Israel, Great Britain and USA.
In 2015, the German-Canadian International Research Training Group GRK 2101 “Guided light, tightly packed” has started. In which we are cooperating with the University of Toronto, Université Laval and the Université de Recherche (INRS) – the coordination lies in the hands of our partner Abbe School of Photonics here in Jena. In addition, efforts were made to win the China Changchun Institute of Optics Fine Mechanics and Physics Chinese Academy of Science (CIOMP) for a partnership in the training field.

7.4. Institute of Solid State Physics

a) Research areas and important results

The research group of **Prof. Dr. Torsten Fritz** is engaged in the research on nanostructures, surfaces of solids, and thin films of both organic and inorganic semiconductor materials.
Our main research interest lays in the discovery of structure-property-relations of structurally well-defined ultrathin epitaxial layers, organic quantum wells, K-doped organic super conductors, and carbon nanotubes. The main target of our research is the development of basic principles for the use of nano materials in prospective devices. For the analyses of the chemical composition and bonding at surfaces and in thin films we use surface analysis methods like photoelectron spectroscopy (XPS, UPS) and Auger electron spectroscopy (AES). The crystalline structure can be determined by electron diffraction (LEED, RHEED, XPD, and electron channeling). Scanning tunneling microscopy (STM) and atomic force microscopy (AFM) at ultra-low temperatures (T = 1.1 K) are used for high-resolution imaging of nanostructures and surfaces.
Our *in situ* optical spectroscopy, namely differential reflectance spectroscopy (DRS) is used to study organic (sub-)monolayers and heterostructures in terms of absorption spectroscopy to analyze the optical interaction between either the molecules itself, organic adsorbates and inorganic substrates, or molecules and dopants.



Self-assembled structures of distinct K_xPTCDA phases on Ag(111) for x = 0, 2, and 4. (a), (b), and (c) show the STM image, structural model, and LEED image of pristine PTCDA/Ag(111). STHM images associated with x = 2 (d) and x = 4 (g) exhibit features originating from both K and PTCDA. Note that the determination of the unit cell compositions, especially for x = 4, is not straightforward and relies on the comparison with DFT calculations. The deduced structural models are depicted for x = 2 (e) and x = 4 (h). In each LEED image (c), (f), and (i), the simulated reciprocal unit cell of the associated K_xPTCDA structure (x = 0 purple, x = 2 orange, and x = 4 blue) and the silver surface orientation along (01) and (10) (yellow) are superimposed. All possible rotational and mirror domains are considered for the simulation, and when taking multiple scattering into account (open circles), all visible spots are consistent with the model and none remain unidentified. The LEED image shown in (i) belongs to a substrate area simultaneously exhibiting domains corresponding to x = 2 and x = 4. Displayed quantities: V_T bias voltage; I_{SP} tunneling current; E beam energy; $\vec{a}_1$, $\vec{a}_2$ adsorbate lattice vectors; $\Gamma = \angle(\vec{a}_1, \vec{a}_2)$ adsorbate unit cell angle; $\vec{s}_1$, $\vec{s}_2$ substrate lattice vectors with unit cell angle of 120°; $\varphi = \angle(\vec{s}_1, \vec{a}_1)$ domain angle; $\xi_{(A/B)} = (\vec{a}_2, \vec{m}_{(A/B)})$ orientation of molecules A and B in the unit cell.

Important results obtained in 2015:

- Theoretical and experimental investigation of the charge transfer and the hybridization at an organic semiconductor / conductive oxide interface
- Discovery of several commensurate structures at electronically weakly interacting phthalocyanine/PTCDA heterointerfaces
- Identification of vibrational excitations and optical transitions of the organic electron donor tetraphenyldibenzoperiflanthene (DBP)
- Elucidation of the Complex Stoichiometry Dependent Reordering of 3,4,9,10-Perylene-tetracarboxylic dianhydride on Ag(111) upon K intercalation

The focus areas of the research of the solid state physics group of **Prof. Dr. Carsten Ronning** are:

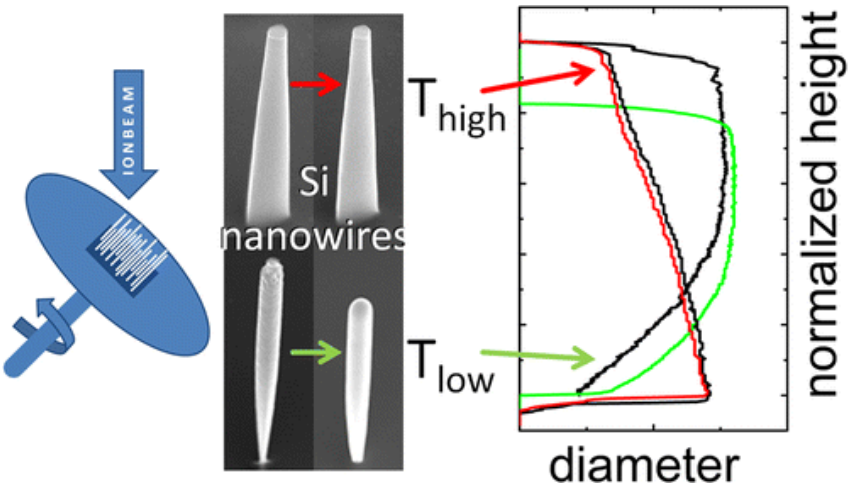
- Synthesis, doping, characterization, and functionalization of semiconductor nanowires
- Structural analysis of complex semiconductors in relation to their electronic properties
- Modification and characterization of phase change materials
- Synthesis of diamond-like materials for bio-medical applications
- Semiconductor physics: optical, electrical, and magnetic doping via ion implantation
- Synthesis and characterization of CIGS and CdTe thin film solar cells
- Photovoltaics
- Ion beam synthesis of nanoclusters

Important results obtained in 2015:

- Discovery of anomalous Plastic Deformation of Ion Irradiated Silicon Nanowires
- Determination of the nature of AX Centers in Antimony Doped Cadmium Telluride Nanobelts
- Observation of Enhanced sputter yields of ion irradiated Au nano particles
- Realization of phonon-assisted lasing in ZnO microwires at room temperature
- Measurements of the ultrafast dynamics of lasing semiconductor nanowires
- Understanding from atomic-scale structure to bandgap bowing for compound semiconductor alloys
- Determination of spatial variations in the chemical composition of CIGS thin film solar cells using high resolution X-ray fluorescence

The **Low Temperature Physics** group (Prof. Dr. Paul Seidel) focuses on the following topics:

- Modelling, fabrication, characterization and application of Josephson junctions and superconducting quantum interference devices (SQUIDs) including novel superconductors such as pnictides
- Cryogenic engineering and low temperature physics (e.g. design and optimization of cryostats)

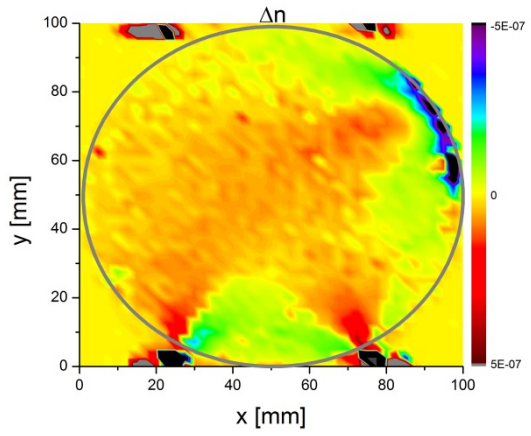


Anomalous Plastic Deformation and Sputtering of Ion Irradiated Silicon Nanowires. Silicon nanowires of various diameters were irradiated with 100 keV and 300 keV Ar+ ions on a rotatable and heatable stage. Irradiation at elevated temperatures above 300 °C retains the geometry of the nanostructure and sputtering can be gauged accurately. The diameter dependence of the sputtering shows a maximum if the ion range matches the nanowire diameter, which is in good agreement with Monte Carlo simulations based on binary collisions. Nanowires irradiated at room temperature, however, amorphize and deform plastically. So far, plastic deformation has not been observed in bulk silicon at such low ion energies. The magnitude and direction of the deformation is independent of the ion-beam direction and cannot be explained with mass-transport in a binary collision cascade but only by collective movement of atoms in the collision cascade with the given boundary conditions of a high surface to volume ratio.

- Experimental aspects of gravitational wave detection including the study of mechanical losses in crystalline and amorphous materials, modelling of thermal noise processes in precision instrumentation, study of thermo-mechanical and thermo-optical properties of matter at low temperatures
- Instrumentation for particle accelerators (e.g. cryogenic current comparators)
- Thin film physics and their applications in optical and electronic components

<u>Important results obtained in 2015:</u>

- Measurement of the stress induced birefringence in silicon at both cryogenic and room temperature and its correlation with crystal defects
- Different kinds of Josephson junctions with one or two pnictide electrodes in thin film technology as well as using a pnictide single crystal for basis electrode with high $I_C R_N$ products
- Modification of structural and superconducting / optical properties of thin high-T_c / STO films with selforganised grown Au-nanoparticles



Measurement of the stress-induced birefringence of a silicon test mass sample for a future gravitational wave detector. Using a special developed polarimeter it was possible to identify intrinsic stress-fields in the silicon sample and distinguish them from gravity induced fields (stress pattern arising from the mechanical support of the sample at the lower part of the figure).

The **Ion Beam Physics group** of Prof. Dr. Elke Wendler applies ion beams for analyzing and modifying solids. The main fields of work are:

- Ion-beam induced damage formation in covalent-ionic crystals
- Formation of nano-crystals by high-fluence ion implantation and annealing
- Combination of various ion-beam techniques for compositional analysis of solids and thin films
- Defect analysis in covalent-ionic crystals by ion channeling
- Investigation of relations between structure and physical properties in defective crystals

Important results obtained in 2015:

- Development of special technique for determination of scattering cross sections for NRA (Nuclear Reaction Ananlysis) applied to determination of fluorine in silica glass
- Evidence of high stability of InGaN / GaN MQW's to ion beam induced intermixing

The research group ***Laboratory Astrophysics and Cluster Physics*** (Dr. Cornelia Jäger) is generally focused on the formation, processing, and spectral properties of cosmic dust and astrophysically relevant molecules such as polycyclic aromatic hydrocarbons (PAHs), or complex organic molecules. Present projects in our group are dedicated to the stability of PAHs and ethynyl PAHs upon UV irradiation, the study of reactions between silicon, magnesium, iron, oxygen, carbon, small carbonaceous molecules, and C_{60} at very low temperature in helium droplets and cryogenic ices, the condensation of refractory solid materials at low temperature and density in the interstellar medium, and the processing, and stability of silicates, carbon particles, and cosmic ices in different astrophysical environments under UV and X-ray irradiation as well as ion bombardment. In 2015, we focused our work on:

- The condensation and characteristic of carbonaceous materials in complex ice layers at temperatures of ~10 K and densities of ~10^{-8} mbar, conditions prevailing in cold molecular clouds.
- Experimental studies on structural and spectral modifications of fullerene-like and iron-containing carbonaceous solids by UV and X-ray photons in the interstellar medium
- Investigation of the erosion of ice-covered carbon grains at the interface between dust and ice upon ion bombardment and identification as well as quantitative measurements of additionally produced carbonaceous molecules in the ice
- Stability studies of PAHs under astrophysical conditions
- Experimental studies on the simultaneous condensation and growth of siliceous and carbonaceous dust particles in the interstellar medium and identification of the molecular precursors for the low-temperature formation and growth of cosmic dust particles in the ISM
- Structural evolution of crystalline and amorphous silicates, that are major cosmic dust components in most astrophysical environments, in X-ray dominated regions like accretion disks

Important results 2015:

- Photoelectron photoion coincidence spectroscopy was used to measure the dissociative photoionization, adiabatic ionization energy, and the appearance energy of fragment ions of ethynyl-substituted PAHs. The stability of ethynyl-substituted PAH molecules upon photoionization was calculated. This group of PAH derivatives was found to be as photostable as the non-substituted species in regions of ionized hydrogen and may play an important role in the growth of interstellar PAH molecules.
- The ion-induced erosion of carbonaceous grains at the interface between oxygen-bearing ices and solid carbon combined with an additional formation of CO and CO_2 in the ice layers at 10K has been observed for the first time. Carbon erosion rates upon proton bombardment were quantitatively measured. In addition, the solid carbon material beneath the ice layer was structurally modified, which has strong consequences on the spectral properties of the remaining dust.

- The R2PI spectra of Al atoms solvated in helium droplets reveal vibrational progressions, which are assigned to Al–He_n vibrations. These vibrations suggest a relatively strong interaction between Al atoms in their excited state and the helium. The presented data do not provide evidence in favor of the formation of regular Al clusters or the formation of an aluminum foam in helium droplets.

b) Collaborations

The Surface Science group of **Prof. Dr. T. Fritz** strengthened their international cooperations in 2015. The ongoing collaboration with the group of Prof. Dr. T. Munakata (University of Osaka) was continued and even intensified not only by numerous exchange visits (founded via a PaJaKo project of the DAAD) between Germany and Japan but also by awarding a prestigious Visiting Professorship at Osaka University to Prof. Fritz.. In the USA we cooperate with the groups of Prof. Dr. O. Monti and Prof. Dr. N.R. Armstrong (University of Arizona). Within Europe we have intensive collaborations with the theory groups of Prof. Dr. E. Zojer (Graz University of Technology) and Prof. Dr. G.-P. Brivio (Universita di Milano-Bicocca). In Germany our collaborations include the group of Prof. Dr. C. Kumpf (Forschungszentrum Jülich GmbH), Prof. Dr. J. Kröger (TU Ilmenau), and the University Würzburg (Profs. F. Reinert and A. Schöll).

The group of **Prof. Dr. C. Ronning** collaborated in 2015 with various international groups. Special situations have been established with the groups of Prof. Dr. F. Capasso (U Harvard), Prof. Dr. M. Kats (U Wisconsin), Prof. A. Lugstein (TU Vienna), Prof. A. Fontcuberta i Moral (EPF Lausanne), and Prof. K. Bharuth-Ram (iThemba Labs, South Africa), which have been founded either by the DAAD or DFG. Further collaborations have been conducted with the groups at the University of Lund (Sweden, Prof. L. Samuelson), Australian National University Canberra (Australia, Prof. M. Ridgway), University of Southern California (USA, Prof. J.G. Lu), University of Florence (Italy, Dr. F. di Benedetto), University of the Basque Country (Spain, Prof. A. Rubio), ERSF Grenoble (France, Dr. G. Martinez-Criado, Dr. M. Burghammer & Dr. F. d'Acapito) and Imperial College (UK, Dr. R. Oulton & Prof. O. Hess). National collaborations involve partners from Bremen, Duisburg, Mainz, Leipzig, Braunschweig, and Erlangen within the frame of the DFG research unit FOR1616. In the field of photovoltaics, ongoing collaborations include groups at the HZ Berlin, FHI Berlin, Manz AG, and ZSW Stuttgart.

The Low Temperature Physics group of **Prof. Dr. Paul Seidel** is collaborating with Thuringian research institutions (TU Ilmenau, IPHT Jena, SUPRACON Jena, Innovent e.V. Jena, Helmholtzinstitut Jena). Within funded research projects joint research is carried out with the IFW Dresden, the GSI Darmstadt, the DESY Hamburg, the MPI Heidelberg and the CERN Genf. Long-term collaborations exist to the Karlsruhe Institute of Technology KIT and the research groups at the universities in Erlangen-Nürnberg, Hannover, Dresden, Gießen, Heidelberg, Tübingen as well as the Universities of Applied Science in Aalen and Jena. Scientific results have been obtained in close collaboration with national (Hannover, Tübingen, Golm, Garching) as well as international partners, such as the universities of Glasgow, Padova, Lyon, Tokyo, Pisa, Salerno, Roma, Moscow and others. Additional international partners in the field of superconducting materials and its application are the universities of Bratislava, Poznan, Twente, Donetsk, Kharkov, Osaka, Nagoya and Tokyo.

The **Ion Beam Physics group** cooperated in 2015 with Prof. Dr. Fadei F. Komarov (BGU Minsk), Prof. Dr. Maria Katsikini (U Thessaloniki), Dr. Katharina Lorenz (IST, U Lissabon), Prof. Dr. Johan B. Malberbe (U Pretoria), Dr. Alexander Yu. Azarov (U Oslo). National cooperations exist with Dr. Klaus Ellmer (HZ Berlin) and Dr. Jan Dellith (IPHT Jena).

In 2015, the ***Laboratory Astrophysics and Cluster Physics*** collaborated with Prof. Dr. S. Price, University College London, Dr. Lisseth Gavilan from Institut d'Astrophysique Spatiale (CNRS, Paris), Prof. Dr. E. Palumbo (INAF–Osservatorio Astrofisico di Catania), Prof. Dr. A. Kereszturi, Research Centre for Astronomy and Earth Sciences, Budapest, Prof. P. Scheier, University of Innsbruck, and Prof. E. Kovacevic (GREMI, Université d'Orléans). Strong collaborations with German groups exist with Prof.

Dr. P. Caselli (MPI für Extraterrestrische Astrophysik, München), Dr. S. Zhukovska (MPI für Astrophysik, München), Prof. Dr. S. Schlemmer (Cologne Laboratory Astrophysics Group), Prof. T. Giesen (Laboratory Astrophysics Group at the University Kassel), and Dr. Holger Kreckel (Max Planck Institute for Nuclear Physics, Heidelberg).

7.5. Institute of Solid State Theory and Optics

a) Research areas and results

Research activities of the institute cover the theoretical investigation of new materials and structures as well as the simulation of light propagation and localization in micro- and nanostructures and non-linearly driven self-organization of light for high intensities. One of the central topics is the deeper understanding of all the aspects of light matter interaction including the investigation of resonant phenomena as e.g. the formation of exciton polariton condensates. We are interested in how new effective optical materials properties can be created by nanostructuring and how molecular structures or the combination of different materials influence electronic and optical properties. All theoretical investigations were closely linked with or even based on high performance computing. Respective tools and software has been developed further. Theoretical studies were based on realistic and experimentally accessible parameters and respective results have often been checked in experiments.

In the Condensed Matter Theory group (Prof. Botti) research is now focused on the theoretical development and numerical implementation of many-body approaches for the description of electronic excitations. The tools used are based on density functional theory and many-body perturbation theory. A special focus is on the simulation of spectroscopic properties of "real" materials for energy conversion, storage and saving. The studied systems can range from simple bulk crystals to non-stoichiometric, doped, alloyed compounds, or to nanostructured materials and interfaces. At the same time, a "materials by design" approach based on global structural prediction and high-throughput calculations is followed to propose novel materials that are then further characterized with the same theoretical spectroscopy techniques.
In the Solid State Optics group (Prof. Peschel) research activities will cover all aspects of wave optics with a special focus on the nonlinearly induced self-organization of light in the presence of nonlinearities, on the interaction of electromagnetic waves with nanostructures and on the efficient modeling of electromagnetic problems. Research activities comprise not only fundamental questions of theoretical physics as e.g. the existence and dynamics of localized nonlinear states, but also cover rather applied issues as light harvesting in solar cells or the optimization of colored pigments. Other research activities are focused on the simultaneous numerical description of electromagnetic fields and of the excited optical material using large scale parallel computing.

b) National Collaborations

- IAP FSU Jena
- IFK FSU Jena
- IPHT Jena
- FhG IOF Jena
- FAU Erlangen
- TU Berlin
- University of Würzburg
- Martin-Luther-University Halle-Wittenberg
- Humboldt-Universität zu Berlin
- Max-Planck-Institut für Eisenforschung, Düsseldorf, Germany
- Leibniz Institut für Analytische Wissenschaften (ISAS), Berlin
- Festkörperphysik, TU Berlin
- Physik, Uni Leipzig

- Uni Heidelberg
- FHI Berlin
- Uni Paderborn
- Uni Osnabrück

International cooperations see chapter 9.6.

7.6. Otto Schott Institute of Materials Research

a) Research areas and results

Chair of Metallic Materials

Alloy Development

Alloys are newly developed or alloy compositions and processing conditions varied for particular applications so that simultaneously a series of properties is adjusted to the required property profiles. In 2015 brazes for joining metallic parts (Fe-based and Cu based alloys) were in the focus of interest. Alloy compositions are selected with the aid of thermodynamic data bases and the corresponding software. A high temperature levitation furnace with cold wall crucible is used to melt the alloys from the pure elements at temperatures of up to 2500°C. The alloys are then modified by thermomechanical treatment. Characterization of the alloys is performed with respect to static and dynamic mechanical properties (yield strength, tensile strength, deformability, hardness, fatigue strength), thermodynamic/thermophysical properties (heat capacities, heat conductivities) and functional properties such as wettability.

Thermodynamics of interfaces

The ”contact conditions” and the thermodynamic state at migrating solid/liquid interfaces are investigated experimentally employing solute driven melting. The experiments are accompanied by further developing interface thermodynamics models that are coupled with kinetics (trans-interface diffusion, solute redistribution) at the interface. The models are valid for all kinds of migrating solid/liquid interfaces. The models aim for a better understanding of microstructural evolution in metal alloys that are processed under extreme conditions and under conditions that are far off equilibrium such as additive manufacturing (selective laser melting). Massive transformation and the transition from massive transformation and diffusion controlled transformations has become a new field.

Microstructural evolution

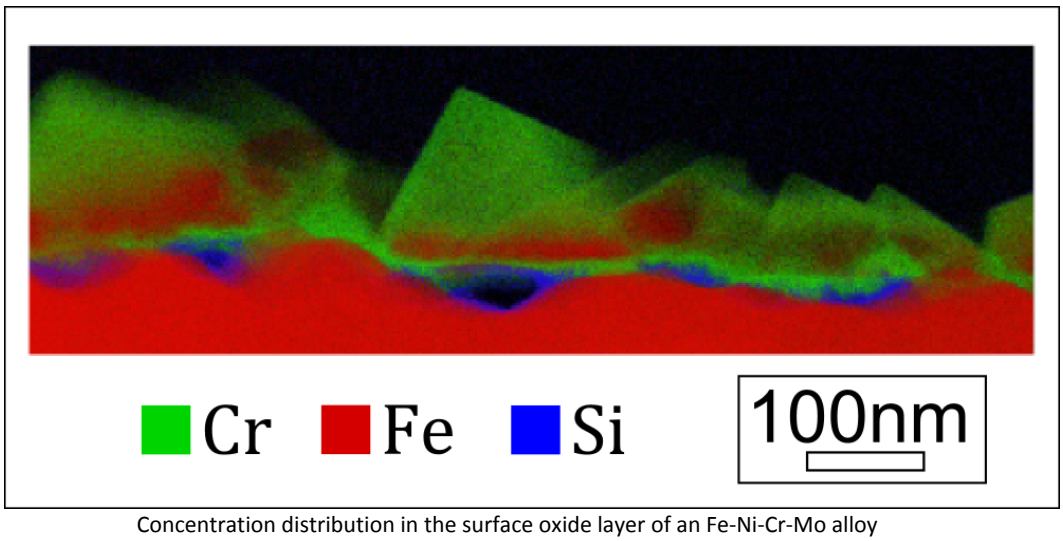
The microstructure of materials as it forms by solidification from the melt and during thermomechanical treatment is crucial for the properties of the respective part. Precise, and generalized prediction of microstructural parameters and concentration distributions is nowadays in a state that it can more and more be applied during materials’ development in combination with experiments. Models for microstructural evolution include microsegregation models for technical alloys, dendritic growth models that are free of numerical artifacts (see figure below), different types of rapid solidification models and recrystallization models. Experimental techniques that are available at the Metallic Materials chair have been extended by an Electromagnetic Levitator. This device enables us to have droplets of metals floating in an electromagnetic field in inert gas atmosphere. Such droplets can be highly undercooled and solidified at high solidification front velocities up to the order of 10m/s.

Experimental microstructures are characterized using optical microscopy, scanning electron microscopy and transmission electron microscopy. The materials under investigation include laboratory materials produced from highly pure elements, but also technical multicomponent alloys that are further developed with industrial partners. In 2015, in addition to long term alloy development projects investigations on thermoelectric materials were in the focus. These materials are promising candidates for energy conversion and ”harvesting” of waste energy. New methods for generating materials with high interface density and anisotropy were implemented successfully

First event where a droplet was floating in the new electromagnetic levitator.

Implant materials

Nickel-Titanium shape memory alloys are, among others, applied cardio vascular (stents, occluders) or other implants (dental braces) that are supposed to remain in the human body for time spans of months or years, and partly without any temporal restriction. We investigate the thermomechanical treatment with the purpose to optimize on the one hand structural properties such as superelasticity or phase transformation temperatures, and on the other hand functional properties such as bio- and hemocompatibility. In 2015 the focus was on the formation of surface oxide layers, their mechanical behavior, and the release of ions into body fluids. All these features need to be known if an infection free implantation is to be carried out. The surface oxide layers are characterized by a combination of Glow Discharge Optical Emission Spectroscopy and Transmission Electron Microscopy. This combination of characterization methods proved to be very efficient, so that it is now also applied to other materials, e.g. stainless surgical steel.

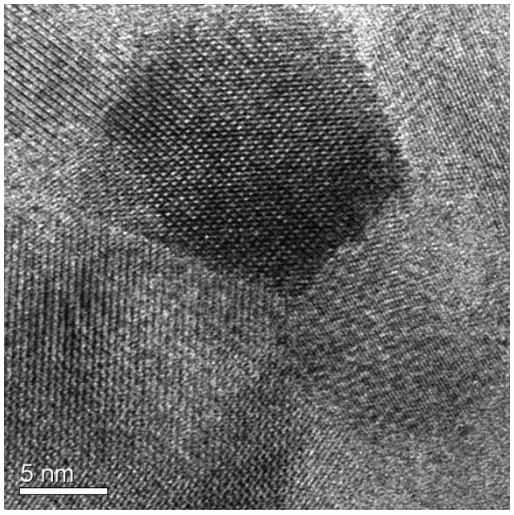


Concentration distribution in the surface oxide layer of an Fe-Ni-Cr-Mo alloy

Structure of nanomaterials with ultrafine grains

Continuous minimization of structural features over the past decades has lead to the discovery of qualitatively new materials properties in different classes of alloys. Until present it is challenging to characterize such structures to an extent that the mechanisms of their formation and their stability can be modeled and understood. In the past we developed methods to determine grain size distribu-

tions and grain orientation distributions in the transmission electron microscope. Bright field and dark field images are considered with a variety of methods using high resolution imaging and electron diffraction. In 2015 we made progress in clarifying phase transformation mechanisms in complex alloys with high temperature and low temperature phases, where the latter ones are stabilized by nanostructuring.



Nanocrystalline structure of a Co-Sm alloy that is a candidate material for hard magnets with high energy density and pronounced stability at high temperatures (high resolution transmission electon microscopy image).

Chair of Materials Science

Correlation between materials' structures and properties and their biological behavior – materials for healthcare/biomaterials

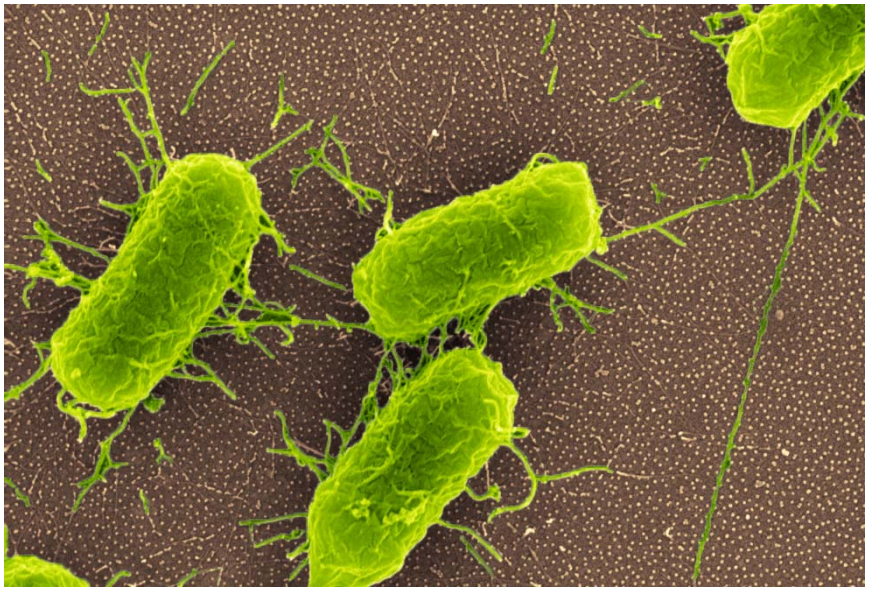
In this basic science field, new materials for biomedical applications with defined properties (e.g. nano and micro structured titanium thin films, ceramic nanomaterials, biopolymer nanofibers, bone cements with advanced mechanical properties) were developed, and their structure and properties were characterized. In the next step, the biological properties of the new materials are investigated (e.g. protein adsorption, cell proliferation, bacterial adhesion and biofilm formation, in-vivo testing). The research also focuses on transferring the scientific results into practical applications.
The most significant results in 2015 are:

- Delivery of drugs from silica and graphene-based nanoreservoirs
- Control of the adhesion of bacteria on nanostructured (titanium and gold) and dental composites
- Control of the protein adsorption on polymer surfaces
- Creation and understanding of protein nanofibers
- Controlling the mechanical properties of fiber-reinforced calcium phosphate cement by tailoring the interfacial shear strength between fibers and matrix
- Enhancing the bone formation in vertebral bodies (sheep) by implantation of bioactive, fiber-reinforced calcium phosphate cement

Antimicrobial biomaterials

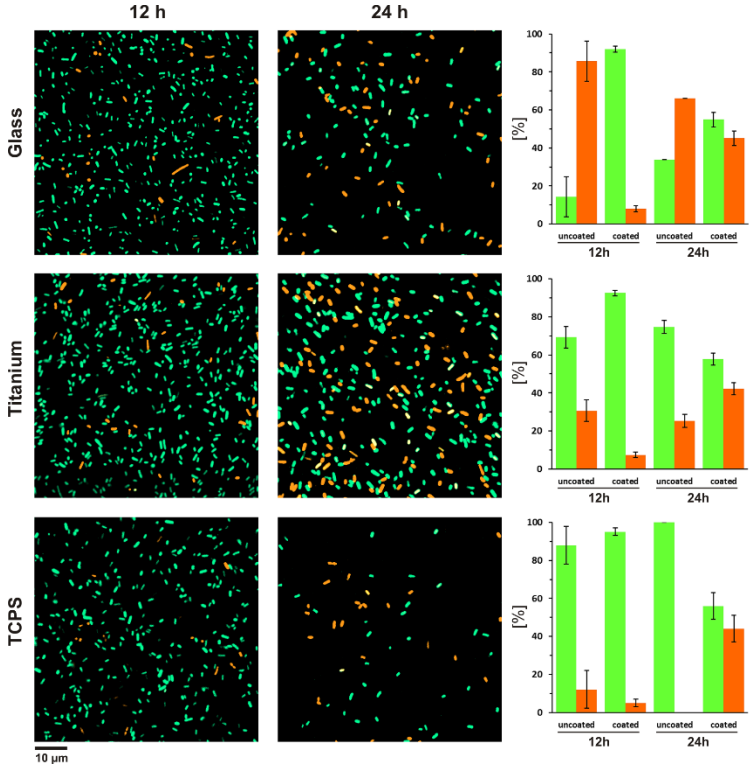
Aim of the research group *Antimicrobial Biomaterials* is to create specific biomaterials surfaces that inhibit the adhesion of microorganisms and, thus, lower the risk of implant-associated infections.
One approach was the physical structuring of gold surfaces on the nanometer scale (creation of defined surface nanostructures using nanoparticles). The adhesion of the clinically relevant pathogenic microorganism *Escherichia coli* was reduced by up to 39 % after 9 h on the structured surfaces com-

pared to unstructured control samples. Using innovative techniques, such as high resolution electron microscopy (SEM) in combination with a focused ion beam (FIB) gave a first insight into the mechanisms of the antimicrobial effect. In the further work, these nanoparticles will be modified, e.g. with quaternary ammonium compounds. In that way, the surface will be chemically nanostructured as well. This project is a cooperation with the Leibniz Institut for Natural Product Research and Infection Biology (Hans Knöll Institute), Jena.



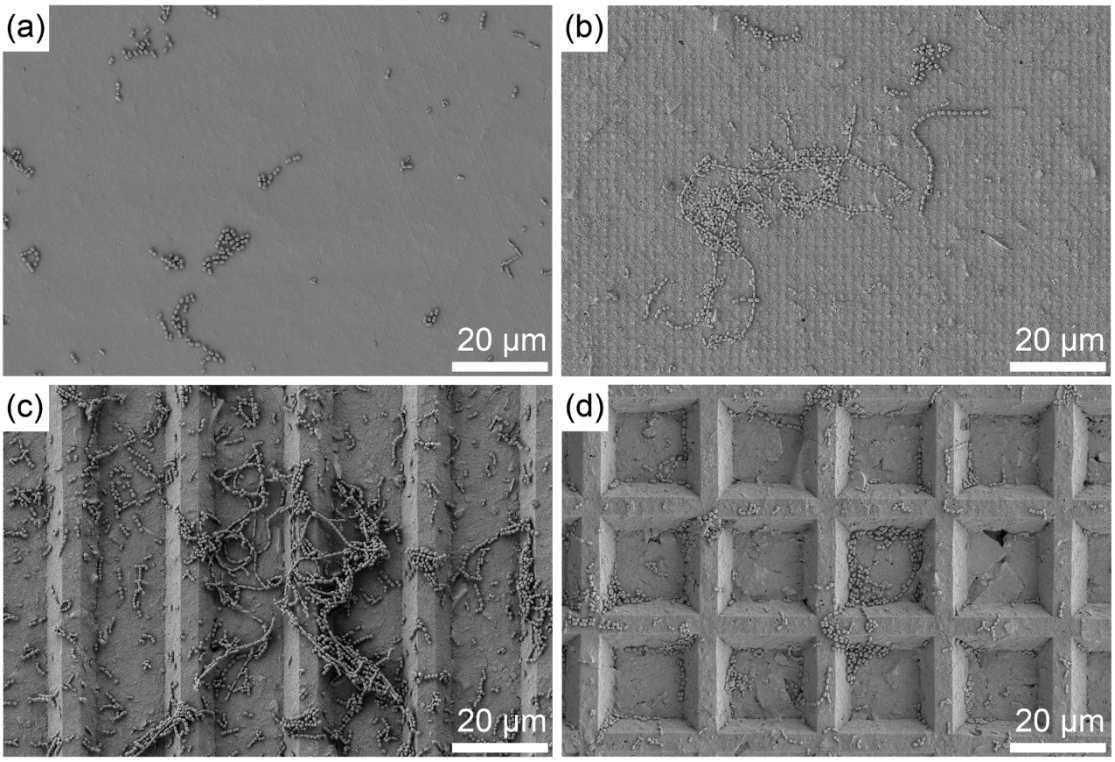
Scanning electron microscopy image of Escherichia coli cells adherent to gold surfaces nanostructured with gold nanoparticles (© CMS).

In cooperation with the Center of Excellence for Polysaccharide Research, Institute of Organic Chemistry and Macromolecular Chemistry (FSU), zwitterionic cellulose with a regioselective functionalization possessing a uniform charge distribution was used as novel coating material for biomaterials surfaces. Considering the uncoated and coated support materials, live/dead staining revealed a significant antimicrobial effect after 24 h. Moreover, the coatings possessed antimicrobial activity depending on the support materials (glass, titanium, tissue culture poly(styrene)).



CLSM images of the surfaces coated with zwitterionic cellulose carbamate after incubation with E. coli and subsequent live/ dead staining of E. coli on zwitterionic coatings on glass, titanium, and tissue culture poly(styrene) surfaces. The obtained results are shown in the right part of the figure.; live-green, dead-orange.
[Figure taken from: Elschner, Lüdecke et al. 2015 Macromol. Biosci. 2015, DOI: 10.1002/mabi.201500349]

Microstructured dental composite surfaces were created in cooperation with the Clinic for Prosthetic Dentistry and Dental Materials, University Hospital, Jena, and tested for their bacterial adhesion properties. It was shown that these microstructures statistically significantly influenced the adhesion of oral bacteria, i.e. *Streptococcus mutans*, originating from human saliva.



REM images of micro-structured dental composite surfaces with adherent oral bacteria cells.
[Figure taken from: Frenzel, Maenz, Lüdecke et al. Dental Materials In press]

Drug delivery systems (DDS) are needed for multiple applications e.g. the treatment of diseases. Two high potential materials were combined to create an advanced DDS for controlled release: thermoresponsive copolymer hollow spheres wrapped with graphene oxide (GO) nanosheets. The well-characterized GO/copolymer composite was loaded with the drug vancomycin (VAN). The composite showed high drug encapsulation efficiency and temperature-sensitive drug release. The GO nanosheets effectively prevented drug leaching and promoted sustained release from the copolymer hollow matrix. These GO wrapped copolymer hollow spheres introduced new opportunities for graphene-based materials in controlled DDS.

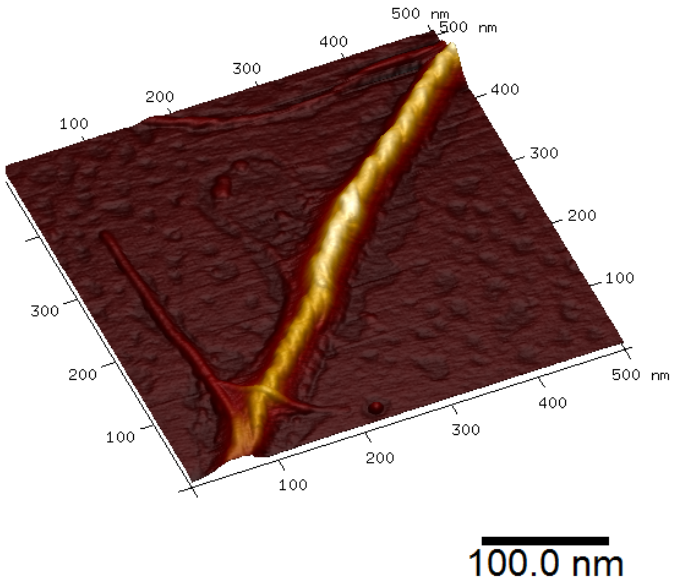
Main results of the research group *Antimicrobial Biomaterials* in 2015:

- Creation of nanostructured gold surfaces significantly reducing microbial adhesion
- Novel coating material for biomaterials surfaces based on a zwitterionic cellulose derivate with antimicrobial effect depending on the support biomaterial
- Control of microbial adhesion on microstructured dental composite surfaces
- Creation of antibiotic-loaded graphene oxide/copolymer composite materials for controlled drug delivery

<u>Materials for tissue engineering</u>

We made good progress in the project *Novel functional materials based on self-assembled protein nanofibers* funded by the German Science Foundation (DFG). The aim is to create/develop a new generation of plasma protein-based nanofibers biomaterials by combining different proteins. Investigations of their assembly mechanisms, structure and properties should lay the foundation for

their further application. Nanofibers have been created by mixing the plasma proteins hemoglobin, serum albumin, fibronectin and fibrinogen. It was further shown that especially the combination of ethanol and high temperature as denaturant is a good choice to initiate the self-assembly process. Structure, mechanical properties, stability and the change in the secondary structure of the observed self-assembled fibers formed by mixing fibrinogen and hemoglobin as well as serum albumin and hemoglobin were characterized. The analysis of the environmental influence on the secondary structure revealed a different behavior for hemoglobin compared to serum albumin and fibrinogen. Further, we found evidence that hemoglobin influences the formation of albumin fibers. Additional, tip-enhanced Raman spectroscopy results showed that protofibrils (small fibers that are present in the initial state of the fiber formation) are formed by serum albumin and hemoglobin. The observed self-assembled fibers have different stabilities in PBS, pure ethanol and water.



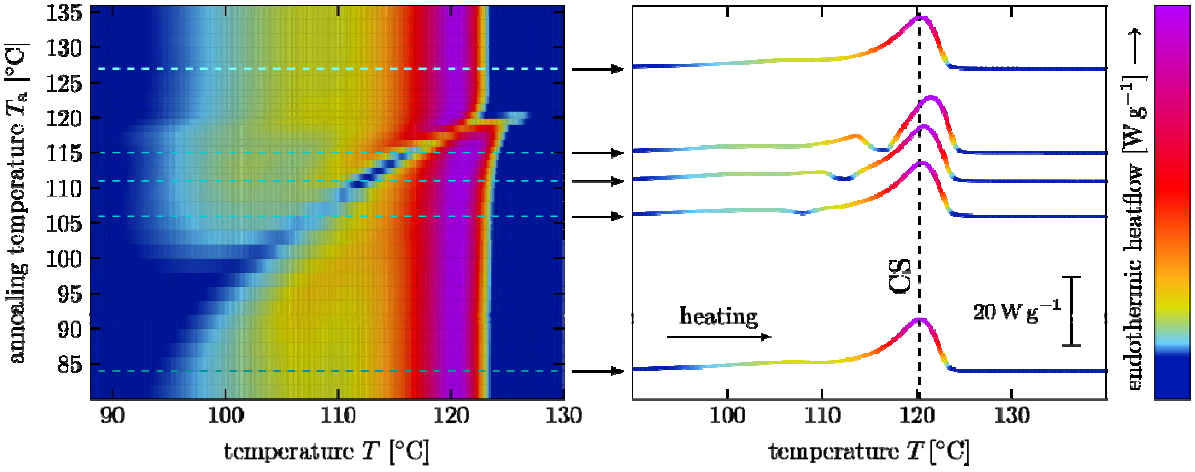
Atomic force microscopy height image of a self-assembled fibrinogen – hemoglobin fiber after an assembly time of seven days. This fiber exhibited a left-hand twisted structure

Soft matter physics

The aim of this research field is to find new approaches for the nanostructuring of functional polymers by applying methods of polymer physics and especially polymer thermodynamics. The research focuses on polymer surfaces as well as the polymer bulk. Furthermore, polymer surfaces are functionalized to control and create new surface properties. The investigated polymers are synthetic polymers (thermoplastic, homo- and copolymers) and biopolymers (proteins and polysaccharides). Also, these polymers are used for the preparation of carbon nanotube/polymer nanocomposites, which establishes close ties to the group's expertise in long-fiber-reinforced composites. We are mostly interested in the interactions of carbon nanotubes with different polymer matrices (semi-crystalline homopolymers and block copolymers) and to control them (crystallization, templating). The main results in the research field soft matter physics in 2015 were:

- Investigation of lamellar thickening in amphiphilic double-crystalline block copolymers by one-step and two-step annealing
- Investigation of co-crystallization in blends of double-crystalline block copolymers and their corresponding homopolymers with varying molecular masses
- Investigation of crystal thickening in blends of double-crystalline block copolymers and their corresponding homopolymers by one-step annealing
- Investigation of the dispersing mechanism of carbon nanotubes in high molar mass block copolymers
- Alignment of carbon nanotubes in melt drawn high molar mass block copolymer films

- Fabrication of graphene coated hollow polymeric spheres for drug delivery
- Investigation of the pharmacokinetics of these structured nanocomposite carrier systems
- Creation of laterally structured homopolymer and/or block-copolymers, e.g., of varying lamellae width, to investigate the structural impact on the site-specific adsorption of macromolecules

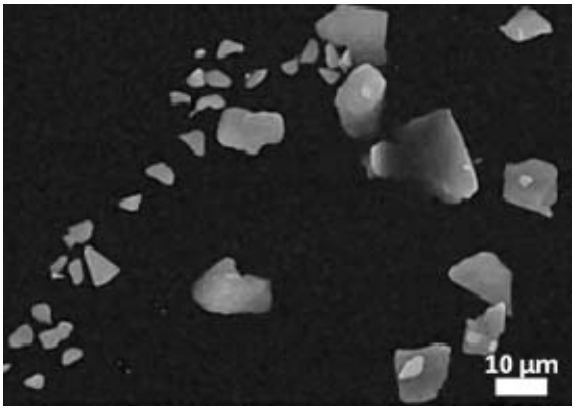


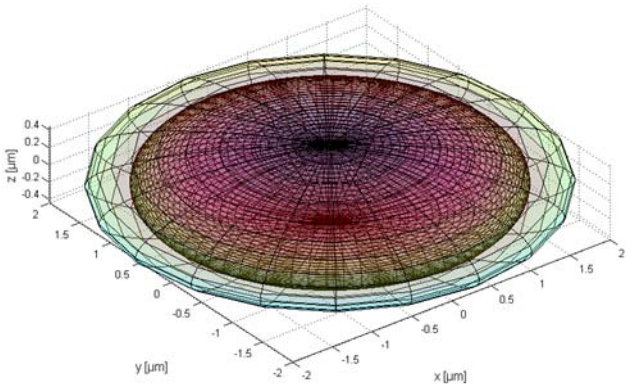
Contour diagrams of differential scanning calorimetry (DSC) heating curves after one-step annealing at varying annealing temperatures (T_a) in the PE-melting range (left). Selected DSC heating curves were additionally displayed in conventional diagrams (right).

<u>High-performance polymer-based composites by high additive integration – structure-property correlation for particle composites</u>

Polymer-based composites are found in nearly all fields of life due to their versatile processing techniques and diverse useful applications. For instance, functional additives enable the adjustment of essential properties like thermal stability, thermal conductivity, fire behavior or antistatic properties. Up to now, it is a challenge to embed shear-sensitive flaky particles into a polymer matrix. In particular, our part in the joint project (PADES) is focused on the development of a non-destructive quality assurance system to monitor the successful embedding of shear-sensitive flaky particles. Major activities and findings in this research topic in 2015 are:

- Geometrical modeling of the composite (polymer and flaky particles) and a prediction of their permittivity to assess the feasibility to measure a potential destruction of the embedded flaky particles were carried out
- A methodology was developed to determine the morphology of the primary flaky particles and embedded flaky particles using scanning electron microscopy and image analysis software
- A model-based concept developed by Gerhard Ondracek for microstructure-property correlation was used
- The prediction revealed that depending on the initial permittivities of the raw materials (particle and matrix) as well as the filler content, filler orientation and aspect ratio a resolution of approximately 5/100 is required to measure a potential destruction (reduction of an aspect ratio from 1/20 to 1/10) for the intended filler content (30 vol% … 70 vol%) and for an isotropic orientation
- Feasibility study and preliminary investigation to measure the permittivity of different composites with shear sensitive flaky particles of different content using the cavity perturbation technique
- Significantly different permittivities were found for the different filler contents





(left) Scanning electron microscopy image of flaky primary particles. (right) Geometrical model of a flaky primary particle – assumption for the inner spheroid: constant diameter and height of the flaky primary particle, assumption for the outer spheroid: constant volume and height of the flaky primary particle.

3D characterization of materials and interfaces with tomographic methods

The 3D characterization of materials and interfaces is carried out from the nanometer level to the micrometer level and can be performed with tomographic methods, e.g. X-ray tomography, confocal laser scanning microscopy, and FIB-SEM. The raw data obtained by different methods can be visualized and processed for 3D evaluation. By identifying and quantifying the 3D structure, it was possible to determine the structure-property relationships of multiphase materials.
The most important results of the work in 2015 were:

- 3-D characterization of granular ceramic materials
- 3-D characterization of intraocular lenses
- 3-D characterization of bone formation after implantation of a bioactive, fiber-reinforced calcium phosphate cement in a sheep animal model
- 3-D characterization of bone formation after implantation titanium implants in osteochondral defects in a sheep animal model
- 3-D reconstruction of data sets achieved by FIB-SEM

Computational Materials Science

Development of simulation methods

This research area of the Sierka group focuses on the development and applications of computational methods for investigating structure, properties and reactivity of complex materials – nanoparticles, thin films, surfaces and interfaces. Many chemical and physical properties of these materials arise from processes and features at multiple scales, both spatial and temporal. Therefore, our work involves simulations of material properties using information or models from different levels of theory: quantum mechanics, molecular mechanics and dynamics, mesoscale and continuum mechanics levels. The spectrum of the methods currently developed in the group ranges from quantum chemical methods for extended systems and hybrid methods through to global structure optimization algorithms. These methodological developments are applied within research projects conducted in close collaboration with experimental groups from different disciplines of chemistry and physics.

Simulation methods for large molecules, surfaces and solids: The basis for research projects within this area is the TURBOMOLE quantum chemical program package, initially developed in the group of Reinhart Ahlrichs at the University of Karlsruhe and at the Forschungszentrum Karlsruhe. With almost 20 years of continuous development TURBOMOLE has become a valuable tool used by academic and industrial researchers. It is used in research areas ranging form materials science, inorganic and organic chemistry to various types of spectroscopy, and biochemistry.

Our research in this area is devoted to the extension of the methods available within the TURBOMOLE program to periodic systems such as surfaces, interfaces and bulk solids. The main features of this new implementation are sparse storage of real space integrals and density matrices, the use of resolution of identity (RI) approximation and hierarchical approaches for numerical integration of exchange-correlation terms within density functional theory methods. The key component is the new formulation of RI approximation for the Coulomb term, which treats molecular and periodic systems of any dimensionality on an equal footing. This project plays a crucial role in future developments and applications of the TURBOMOLE program package to surfaces, interfaces and bulk systems.

Global structure optimization methods: This research area is devoted to the development of global optimization methods and their application for design of novel materials. In general, efficient structure optimization methods are important prerequisite for computational studies of structure and properties of materials. Local optimization methods locate the nearest local minimum or a saddle point and need a reasonable initial starting point. Global optimization methods are able to locate the global energy minimum independent of the initial structure. Therefore, such methods are well suited for the design of novel materials and for structure determination of systems, which are difficult to access experimentally. The DoDo program package developed within this project uses genetic algorithm (GA) as the global optimization method. It proved efficient for automatic structure resolution of both molecular systems, surfaces and interfaces. The current application area within this project is the design and structure determination of novel low-dimensional materials by a combination of calculations and experiments.

Structure and properties of low-dimensional materials

Low-dimensional materials can be defined as compounds of unusual structure that extend to less than three dimensions. Examples are two-dimensional surfaces, thin films and interfaces, one-dimensional nanotubes and nanowires as well as zero-dimensional nanoparticles, large molecules and clusters. Interests in such materials range from material science and nanotechnology through to astrophysics.

The key prerequisite for understanding the chemical and physical properties of existing low-dimensional materials and for designing new ones is a detailed knowledge of their atomic structure. However, such materials frequently present complex structures to solve. This is because on one hand the structural information is difficult to access experimentally and on the other hand the accuracy of theoretical tools that can be applied to extended systems is often limited. The results of our research show that often only a close collaboration between theory and experiment makes possible the successful atomic structure determination of low-dimensional materials. In particular, the application of global optimization methods at an ab initio level of theory has proved very useful in an automatic structure resolution of such systems.

Nanoparticles and clusters: Nanoparticles are of great scientific interest as they often display properties intermediate between bulk materials and atomic or molecular structures. In addition, one of the fundamental issues of materials science is how the structure, properties and reactivity of a material change with its increasing aggregation state – from small molecules and clusters through nanostructures to the three-dimensional bulk phase.

In this research area studies of nanostructured metal oxides aggregates are carried out using atomistic modeling tools. The use of global optimization methods is essential for the determination of atomic structures of such nanoparticles, since their structures often differ fundamentally from their bulk counterparts.

Thin films, surfaces and interfaces: Two-dimensional thin films, surface layers and interfaces play a crucial role in many modern technologies, e.g., electronic semiconductor devices, optical coatings, solar cells and batteries. The knowledge of the atomic structure of such materials is of great im-

portance for their successful applications and for improving their functionality. Our results within this project demonstrate that a successful structure resolution of two-dimensional materials can often only be achieved by a combination of theory and experiment.

Nanostructured coordination compounds: This project involves scientific collaboration with the group of M. Scheer at the Institute of Inorganic Chemistry, University of Regensburg. Here, the focus is on exploration of possible synthetic routes and structural characterization of coordination compounds with unusual main group elements ligands. Particularly important is the ligand-induced stabilization of otherwise unstable species. Our contribution is the computational support and theoretical interpretation of experimental data. The development of efficient computational methods is of particular importance since the chemical compounds investigated within this project usually contain several hundred atoms.

Surface Engeneering

Colloids, Surfaces and Interfaces

Laser materials processing
Nanoparticles: Functional nanoparticles are of increasing importance in the development of hybrid materials for energy and environmental technology and biomedical applications. Our research focuses on the synthesis of functional ceramic nanoparticles using the CO_2 laser vaporization (LAVA) process. The highly flexible LAVA method offers the possibility to convert almost any oxidic ceramic compound into nanoparticles and nanopowders. Thus, phase-pure oxides, defined adjustable mixed oxide crystals (e.g. perovskites, spinels) and defect structures (e.g. doped semiconductors) as well as intra-particle dispersion ceramics (e.g. Al_2O_3-ZrO_2) and inclusions of nanocrystallites in nanostructured glass matrices (e.g. Fe_xO_y in amorphous silicon)can be prepared as nanoparticles. The obtained spherical nanoparticles can be integrated into high-performance composites and hybrid systems by technological production processes. Here, besides conventional and generative processes for the fabrication of nanoporous or dense sintered structures in particular Mother Nature serves as an inspiration for innovative approaches for the synthesis of biomimetic composite structures. The targeted control of material properties combined with the various ways of processing the nanopowders thus opens up completely new possibilities to develop innovative functional and hybrid materials. Their fields of applications include energy technology (e.g. nanoporous electrode materials for lithium-ion batteries or novel semiconductor materials for dye sensitized solar cells), environmental technology (e.g. porous hybrid structures for the photocatalytic purification of water and air in the visible part of the electromagnetic spectrum), and biomedical applications (e.g. piezoelectric materials for bone regeneration, superparamagnetic nanoparticles which can be surface modified for diagnostics or functionalized with drugs for tumor therapy, or novel functional ceramics for artificial joints).

Surface modification: The broad palette of different types of lasers and their laser beam parameters provides a flexible and versatile tool for the generation of functional surfaces that are of great potential for applications in the fields of optics, energy technology and biomaterials.

Laser structuring: The precise structuring of materials surfaces in the µm- and nm-range is predominantly realized using CO2 lasers and ultra-short pulsed laser systems as radiation sources. The utilization of lasers as a tool is particularly based on the detailed investigation of the interaction processes between the laser radiation and the different types of materials. In the field of CO2 laser materials processing extensive equipment is provided by a specific Q-switched CO2 laser and well-established modulators to realize µm-structures at the surface of metals, glasses, ceramics and polymers. These structures can subsequently be functionalized on a further hierarchical level by using additive manufacturing processes (2-photon-polymerisation, selective laser sintering) as well as by the pulsed laser deposition technique. Further research focusses on the investigation of laser-induced periodic surface structures (LIPSS) that emerge during the illumination of all types of materials with ultra-short

intensive laser pulses. The structural size of the resulting periodic pattern is in the order of the wavelength of the incident laser radiation, whereby the alignment is determined by the laser beam polarization. Therefore, a key aspect of the investigations is the generation of LIPSS with tailored properties based on a well-defined control of the electrical field vector. This allows to design e.g. a novel class of advanced photonic materials with broadband, omnidirectional and polarization-independent properties for applications in the visible and near-infrared wavelength range.

Pulsed Laser Deposition (PLD): The PLD technique offers a flexible and versatile tool to cover any desired substrate material with functional thin layers. For this purpose, a focused pulsed laser beam is used for the ablation of the target material, the transfer into the plasma state and finally for the deposition on the substrate. The focus of the investigations is on the deposition of amorphous and crystalline metal oxide layers (e.g. TiO2, ZnO) on smooth and structured bulk materials as well as on textile substrates, which facilitates the realization of novel approaches aiming the development of textile dye-sensitized solar cells and catalytically active textile structures. Due to the high absorption of the infrared radiation by the ceramic materials the powerful Q-switched CO2 laser is used as radiation source. Generally, the deposition can be performed either under ultra-high vacuum or by applying specific gas atmospheres (inert and reactive gasses). The PLD chamber provides a CO2 laser based substrate heating device and is equipped with a target holder cooled by liquid nitrogen. The latter enables the Matrix-assisted pulsed laser evaporation (MAPLE) technique that can be used to transfer nanoparticles, polymers and biological materials from the target to the substrate.

Rapid prototyping: In the context of Selective Laser Sintering (SLS) of materials the great potential of CO2 lasers for laser materials processing is used to generate 3-dimensional free form geometries from polymeric, ceramic and metallic materials. While conventional sintering techniques require time-consuming diffusion processes for compaction, SLS bases on the melting of the single particles. Therefore, a main objective of the research activities is related to the fundamental investigation of the influence of the interaction process between laser radiation and material that is remarkably determined by the laser beam parameters (intensity, mode of operation, pulse duration) and the materials properties (absorption, heat conduction). Moreover, layered composites are realized by the combination of different types of materials such as ceramics and metals or ceramics and polymers with the primary aim of tailoring layered composites with optimized mechanical properties.

Bioinspired Materials

Surfaces: Morphological, physico-chemical, or bioorganic surface modifications of biomaterials were realised to affect the interaction between the living body and an implanted material, resulting in bioactive, osteoconductive surfaces or in porous scaffolds for tissue engineering. Furthermore, surface treatments are of interest in dental restoration, where the materials surface has to adhere effectively to the tooth.

Biomineralisation: Simulated body fluids (SBF) with a composition similar to the inorganic part of the human blood plasma were used for in vitro bioactivity tests. Beyond that, SBF was used to precipitate biomimetic apatite with a composition, morphology, and growth orientation equal to the mineral part of the vertebrate bone. The photoluminescence of annealed biomimetic apatite might be of specific interest for histological probing and monitoring of bone re-modelling. SBF solutions with modified ion concentrations and increased supersaturation were used to accelerate the formation of apatite and to coat various materials with bioactive calcium phosphate.
The wet-chemical synthesis of nano-sized, bioactive or resorbable calcium phosphate powders is of particular interest for the development of load-bearing orthopedical implants. Ionic substitutions were performed to affect the solubility of the material and to enhance its bio-acceptance. The mechanical properties of sintered calcium phosphates were significantly increased by vacuum synthesis technologies. Biomimetic techniques were used to synthesise hydroxy apatite powders with a bone-

like composition. Sol-gel processes were used to prepare bioactive sodium titanate ceramics and SiO_2-CaO-glasses, respectively.

Hybride structures: Ice templating represents a process to prepare ceramic scaffolds with an aligned and open porosity. In this process ceramic slurries are frozen directionally from a temperature controlled cooling finger. Adjusting the velocity of the ice front to a certain level leads to lamellar ice crystal growth. The ceramic particles are repelled at the tip of the growing ice crystals and they are enriched between them. Subsequent sublimation of the ice leads to a structured green body that finally has to be sintered. Structural sizes and mechanical properties of sintered ceramic scaffolds depend on the solid content of the suspensions and on the applied ice front velocity. With increasing solid content the porosity decreases from 80% for 10 vol-% suspensions to 50% for 30 vol-% suspensions. This porosity is independent on the applied ice front velocity. For a given porosity the onset ice front velocity influences the pore widths and ceramic lamella thicknesses. With increasing velocity the structural sizes decrease. Simultaneously, the compression strength of scaffolds increases by more than twofold due to the reduced amount of critical size defects. Sintered tricalcium phosphate scaffolds were impregnated with the biodegradable biopolymer PCL. Only a small amount of polymer was used to solely infiltrate the micro pores and to coat the ceramic lamellae with a thin polymer film. The infiltrated samples show a damage tolerant non-catastrophic failure mechanism which can be explained by the formation of cold drawn PCL fibers bridging micro- and macrocracks. Moreover, the compressive and flexural strength of the impregnated samples increases by approximately 100%.

<u>Surface machining / Surface metrology</u>

- Analyses of materials removal principles, subsurface damage, surface generation (micro geometry, shape and dimensional accuracy) for different machining processes
- Precision machining (especially brittle materials: ceramic materials, glass materials, crystalline materials) by grinding / ultrasonic assisted grinding, lapping / ultrasonic machining and polishing
- Surface measurement with tactile and optical methods (Multisensor-Coordinate measuring machine, tactile profilometer, Coherence correlation interferometry, scattering light sensor)

b) National Collaborations

Chair of Metallic Materials

- Clausthal University of Technology
- Max-Planck-Institute of Iron Research
- RWTH Aachen University
- Karlsruhe Institute of Technology, IAM
- German Aerospace Center DLR

Chair of Materials Science

- Barat Ceramics GmbH, Auma
- Biomolecular NMR Spectroscopy, Leibniz Institute for Age Research, Fritz Lipmann Institute, Jena
- Biopharm GmbH, Heidelberg
- Center of Excellence for Polysaccharide Research, Institute of Organic Chemistry and Macromolecular Chemistry, Friedrich Schiller University Jena
- Center of Medical Optics and Photonics (CeMOP), Friedrich Schiller University Jena,
- Clinic for Prosthetic Dentistry and Dental Materials, University Hospital, Jena
- Department of Conservative Dentistry, Friedrich Schiller University Hospital Jena
- Department of General, Visceral and Vascular Surgery, Friedrich Schiller University Hospital Jena
- Department of Otolaryngology and the Institute of Phoniatry and Pedaudiology, Friedrich Schiller University Hospital, Jena

- Ernst Moritz Arndt University of Greifswald, Greifswald
- Experimental Rheumatology Unit, Department of Orthopedics, Friedrich Schiller University Hospital, Eisenberg
- Federal Institute for Materials Research and Testing (BAM), Berlin
- Fine Ceramics Technologies (FCT), Rauenstein
- Fraunhofer Institute for Applied Optics and Precision Engineering (IOF), Jena
- Fraunhofer Institute for Ceramic Technologies and Systems (IKTS), Hermsdorf
- Friedrich-Loeffler-Institut – Bundesforschungsinstitut für Tiergesundheit, GreifswaldGerman Electron Synchrotron (DESY), Hamburg
- Glatt Ingenieurtechnik GmbH, Weimar
- GRAFE Color Batch GmbH, Blankenhain
- Hybrid Materials Interfaces Group, Faculty of Production Engineering, University of Bremen
- IBU-tec advanced materials AG (IBUtec), Weimar
- Institut für Industriebau und Konstruktives Entwerfen (IIKE), Technical University Braunschweig
- Institute for Technical Chemistry and Environmental Chemistry (ITUC), Friedrich Schiller University Jena
- Institute of Animal Experimentation, Friedrich Schiller University Hospital, Jena
- Institute of Geosciences, Friedrich Schiller University Jena
- Jena Center for Soft Matter (JCSM), Jena
- Jena School for Microbial Communication (JSMC), Jena
- Laboratory of Organic and Macromolecular Chemistry (IOMC), Friedrich Schiller University Jena
- Leibniz Institute for Natural Product Research and Infection Biology, Hans Knöll Institute (HKI), Jena
- Leibniz Institute of Photonic Technology (IPHT), Jena
- Materialforschungs- und –prüfanstalt (MFPA), Weimar
- Mathys Orthopädie GmbH, Centre of Excellence Ceramics, Mörsdorf
- Max Planck Institute for Infection Biology, Berlin
- Moje Keramik-Implantate GmbH & Co. KG, Petersberg
- Online Fluid Sensoric (OFS) GmbH, Ronneburg
- Potsdam Institute for Clima Impact Research, Potsdam
- Schmuhl GmbH, Liebschüt
- Technical University of Braunschweig, Braunschweig
- The Free University of Berlin
- University Hospital of Bonn
- University Hospital of Münster, Münster
- University Medical Center Greifswald, Greifswald

Colloids, Surfaces and Interfaces

- University of Würzburg, Department for functional materials in medicine and dentistry
- Federal Institute of Materials Research and Testing, BAM Berlin
- Clausthal University of Technology, Institute of Non-Metallic Materials
- University Bremen, FB4, Technical Thermodynamics
- TU Berlin, Microelectronics, Micro-structure and Connection

Computational Materials Science

- Universität Regensburg
- Humboldt-Universität zu Berlin
- Fritz-Haber-Institut der Max-Planck-Gesellschaft

- Karlsruhe Institute of Technology
- Ruhr-Universität Bochum

International cooperations see chapter 9.7.

7.7. Institute of Optics and Quantum Electronics

Preface

The Institute of Optics and Quantum Electronics (IOQ) is one of the major optics institutes of the Department of Physics and Astronomy of Friedrich Schiller University in Jena. The mission of the institute is typical for university institutes and consists of the two pillars teaching and research. However, the faculty of IOQ shares also numerous administrative responsibilities within the department, the university, and at extra-university institutes.

IOQ consists of five professorships: Nonlinear Optics (Prof. G. G. Paulus), Quantum Electronics (Prof. C. Spielmann), Relativistic Laser Physics (Prof. M. C. Kaluza), Atomic Physics of Highly Charged Ions (Prof. T. Stöhlker), and Laser Based Particle Acceleration (Prof. M. Zepf). In addition, there is the X-ray group of emeritus Professor E. Förster. Furthermore, the institute hosts a junior professor in the field of Experimental Attosecond Laser Physics (Jun.-Prof. A. Pfeifer) supported by the Carl Zeiss Foundation.

The central theme of research is the interaction of extremely intense laser radiation with matter. The laser intensities covered extend over more than seven orders of magnitude from extremely non-perturbative to relativistic strong-field laser physics. Accordingly, the institute is home of several high-power lasers that range from few-cycle laser pulses at kilohertz repetition rates to 100-TW pulses. Unique is the Polaris laser system, the worldwide first all diode-pumped solid-state PW-class femtosecond laser. Characteristic projects are the generation, investigation, and application of XUV and soft-X-ray radiation in spectroscopy and microscopy, the acceleration of electrons and ions, and strong-field QED and ionization dynamics.

IOQ has a strong partnership with the Helmholtz Institute Jena, an institute of the Helmholtz Association (HGF) on the campus of Friedrich Schiller University and directed by Prof. T. Stöhlker. Both institutes jointly operate some of the large-scale facilities mentioned above. The Helmholtz Institute Jena is also instrumental for establishing and supporting collaborations with the national laboratories run by HGF, in particular DESY, GSI and HZDR.

Concerning teaching, the institute contributes to the course program at the undergraduate and graduate level. Besides physics majors, this includes the education of prospective teachers and students with physics as a minor subject. At the graduate level, IOQ contributes to the department masters programs in physics and photonics. Most of our graduate courses are taught in English and service also the department's International Masters in Photonics in the framework of the Abbe School of Photonics. In addition, the scientific staff of the institute and the research assistants offers recitations and lab courses. IOQ has significant outreach activities. Examples are public lectures and support for high-school research projects.

The IOQ is active in a number of national and international networks. In Jena these are the university centers Abbe Center of Photonics and the Center of Medical Optics and Photonics. A formative role has played the Collaborative Research Center SFB/TR-18 funded by the German Science Foundation. This center ties the institute's research activities in relativistic laser plasma physics. The renewal of this project in 2012 has been a major milestone. On the European level, the institute is a member of LaserLab Europe and contributes to the large-scale projects Extreme Light Infrastructure (ELI) and High Power Laser Energy Research (HiPER).

Research Projects at the Chair Nonlinear Optics

The Chair of Nonlinear Optics pursues three main research lines: strong-field and attosecond laser physics, XUV- and X-ray physics, and relativistic optics.

The longest history certainly have our activities in the first pair of fields. However, our research interests and techniques have changed considerably over the years. One major example are our ion-beam

experiments which allow the investigation of species rarely, if at all, investigated before. Examples are fundamentally important molecules such as H_2+, but also atomic ions which allow using very high intensities. A respective example will be discussed below. Another new aspect of our work is to use more and more other, in particular longer wavelength than the familiar Titanium:Sapphire wavelength around 800nm. In this respect we benefit from a strategic decision made seven years ago when we purchased a 10-mJ booster amplifier that can be used as a driver laser for a parametric amplifier that generates significant photon flux in the short- and mid-wavelength infrared regions. On the other hand, we also experience the limitations of our laser system. The, as compared to simple effusive gas jets, very dilute ion density in the interaction region leads to event rates often below one Hertz. The acquisition of highly differential data then becomes quite laborious.

An invariant of our work has remained the generation of few-cycle pulses and their application to investigate the sub-cycle, i.e. attosecond dynamics of elementary processes such as ionization and dissociation. We were very delighted when the German Science Foundation decided to start a priority program (SPP 1840 *Quantum Dynamics in Tailored Intense Fields*) exactly in this field on the initiative of colleagues in Hannover, Jena and a few other places. We successfully defended two projects in this program: The measurement of the absolute phase at long wavelengths and the investigation of asymmetric molecular ions in phase-dependently asymmetric laser fields.

Closely connected to strong-field laser physics are our efforts in cross-sectional nano-scale imaging. Our unique approach is to implement optical coherence tomography (OCT) in the extreme ultraviolet (XUV) spectral regime. Successful proof-of-principle experiments at synchrotrons have earned us a considerable research grant (BMBF-VIP) two years ago. Recently, we succeeded to implement XUV-OCT (XCT for short) based on high-harmonic generation. The beauty of the method is that it takes advantage of the hallmark of high-harmonic generation which usually is a problem for imaging applications: the extremely broad bandwidth of the high-harmonic spectra. Currently, we are working on a sophisticated apparatus for XCT that should even enable first real-world applications. The progress in our and other groups working on XUV imaging and technology has encouraged us to apply for funding for a state-funded Collaborative Research Group. The collaboration with and under the umbrella of the Helmholtz-Institute Jena was vital to our success.

Another important activity is our work on high-definition X-ray polarimeters in collaboration with the X-ray group. Originally started in the framework of a program to detect the laser-induced birefringence of vacuum, the remarkable success of this research thread has resulted in numerous applications quite different from the one that initiated the project. Particularly prominent are the works on X-ray quantum optics based on Mössbauer spectroscopy. Our polarimeters achieve extremely high extinction ratios (up to 10^{10}), which enables the detection of scattered photons against the huge background of synchrotron radiation.

We are pushing for a further increase in polarization purity by different means. A particularly attractive approach is the use of diamond crystals. The small lattice constant and the low atomic numbers suggest that it might be possible an achieve new levels of performance. However, as compared to silicon channel-cut crystals, the challenges are tremendous.
Last but not least the work on relativistic optics. When tens of terawatt laser power is focussed on solid surfaces with intensities such that the electrons oscillate with relativistic speeds, the reflected laser radiation is modulated due to the Doppler effect and, particularly, due relativistic retardation. Outcome harmonics, coherent XUV radiation. For various reasons, this type of broad-band XUV generation is believed to be a particularly promising method. However, people believe so since more than 20 years … We still believe this, too. More importantly, however, we found and we still find a lot of fascinating physics in this process.

<u>Ionization dynamics of ions in intense laser fields</u>

Ionization of atoms in strong field is of fundamental interest in atomic physics and of particular relevance for many phenomena like laser-based electron or ion acceleration by ultra-intense laser pulses. When atoms are exposed to super-intensive or relativistic laser intensities, they will be ionized to high charge states. In the optical regime, the ionization probability depends highly nonlinear on the field strength. Therefore, for a pulsed field, the electrons are ionized in a very narrow time interval. In particular the accurate modeling of the ionization dynamics of multi-electron systems over a large range of charge states and intensities is a challenging task.

In a recent paper, we analyzed the momentum spectra after multiple ionization of atomic ions by nearly circularly polarized laser pulses. For the experiment we use our high-power, high-repetition rate laser system together with the ion beam apparatus. The fragments resulting from the laser ion interaction are measured with a position- and time-sensitive detector. The full three dimensional momentum of each ionized fragment can be determined. Further, a method to deconvolve the measured momentum distribution of multiply ionized ions and reconstruct the electron momenta from the ion momentum distributions after multiple ionization up to four sequential ionization steps was developed. This technique determines the saturation intensities as well as the electron release times during the laser pulse. As a result, the typically large experimental uncertainties in the intensity determination are removed such that detailed tests of strong-field ionization theories can be performed.

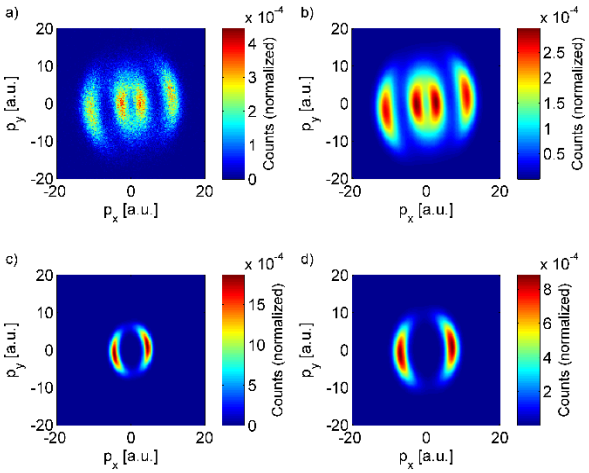


Figure 1 : Deconvolution method for the double ionization of single charged neon ions: a) Measured ion distribution of Ne^{3+}, b) Simulated momentum distribution for double ionization from the deconvolution method, c) and d) Reconstructed momentum distributions for the first and second ionization based on deconvolution.

Reference

[1] P. Wustelt, M. Möller, T. Rathje, A. M. Sayler, T. Stöhlker, and G. G. Paulus, Phys. Rev. A 91, 031401(R) (2015)

XUV coherence tomography with laser-based sources

Optical coherence tomography (OCT) is a well-established method to retrieve three-dimensional, cross-sectional images of biological samples in a non-invasive way using near-infrared radiation. The axial resolution of OCT with broadband visible and near-infrared sources typically reaches axial (depth) resolutions in the order of a few micrometers.

We developed soft-X-ray coherence tomography (XCT), which takes advantage of the fact that the coherence length can be significantly reduced if broadband extreme UV (XUV) and soft X-ray (SXR) radiation is used. XCT can display its full capabilities when used in the spectral transmission windows of the sample materials. For instance, the silicon transmission window (30-99 eV) corresponds to a coherence length of about 12 nm, thus suggesting applications for semiconductor inspection. In the water window at 280-530 eV, a coherence length as short as 3 nm can be achieved and highlights possible applications of XCT for life sciences.

Since 2013 the Project is supported by the German Federal Ministry for Education (BMBF) within the VIP (Validierung des Innovationspotentials) program. Our setup utilizes a variant of a Fourier-domain OCT setup that completely avoids a beamsplitter. Broadband XUV light is focused on the surface of the sample. The reflected spectrum is measured either with a grating spectrometer, consisting of a gold transmission grating and a toroidal mirror (spectrometer-based OCT), or with a photo diode (swept-source OCT) and a tunable source. The top layer reflection assumes the role of a reference beam. A Fourier transform including dispersion correction of the reflected spectrum needs to be computed for retrieving the structural information. A 3D-image can be captured by scanning the focus over the sample. A proof-of-principle experiment has been performed at synchrotron sources successfully and has been published now [1].

Since XCT exploits the spectral broadness of the light source to achieve axial resolution it can be regarded as a perfect application for laser-driven high-harmonic generation sources due to their intrinsic broad bandwidths. In fact, the bandwidth of HHG would have disadvantages for other imaging methods such as confocal microscopy or coherent diffraction imaging. In addition, HHG enables XCT to become a table top nanometer imaging technique. Thus we developed a suitable HHG source in pulses with an energy of 1.8mW, a pulse duration of 50fs, and a wavelength of 1300nm driven by an OPA. In 2015 we could show that XCT works with laser-based sources for the first time. We were able to achieve three-dimensional tomographic images of structured samples. Due to the spectral filtering with thin aluminum foils, which is needed for HHG sources, the broadness of the spectrum is limited by the filter's absorption edge and thus the axial resolution of the method is about 20 nm in the silicon transmission window. We improved the lateral resolution by an order of magnitude in comparison to the synchrotron measurements down to 10µm. A laser-driven XCT scan is shown in Fig. 2. 1900 single measurements were taken in an area of about 900x500µm. The measurement time was 9 hours, which is only a factor of three slower than a comparable synchrotron scan. Next steps are further improvements in lateral resolution and enabling material-sensitive contrast to reconstruct the compounds the layers consist of.

Reference

[1] S. Fuchs, C. Rödel, A. Blinne, U. Zastrau, M. Wünsche, V. Hilbert, L. Glaser, J. Viefhaus, E. Frumker, P. Corkum, E. Förster, G. G. Paulus, Sci. Reports 6, 20658 (2016)

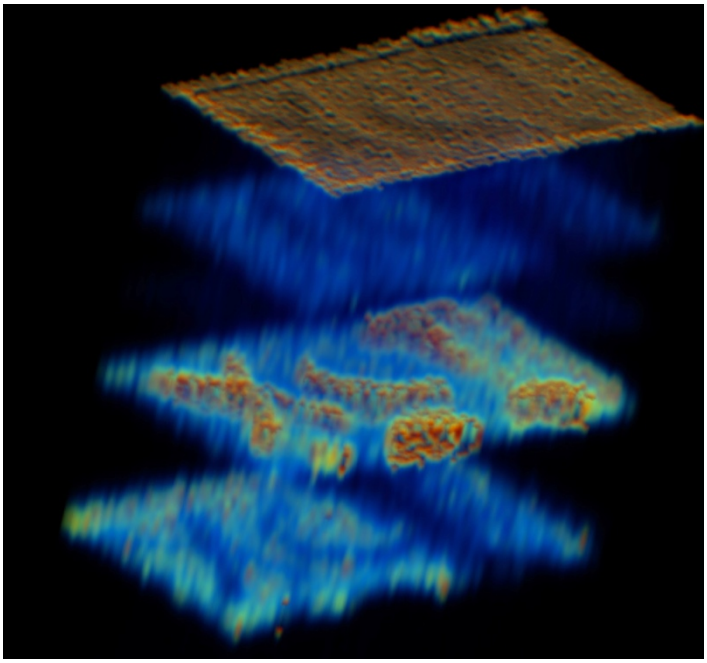


Figure 2: Three-dimensional image taken with laser-based XCT. The lateral dimension is 900 x 500µm. The axial dimension is 300nm. The sample consists of buried 5nm thick gold structures embedded in silicon. The structure is clearly visible with a lateral resolution of about 15µm.

Relativistic surface high-harmonic generation

The generation of broadband coherent extreme ultraviolet (XUV) radiation using ultrashort laser pulses opens the way to new areas of research and technology. Most prominently, high-order harmonic generation (HHG) has facilitated attosecond pulses which provide an instrument of unprecedented temporal resolution. In the past years, the relativistic process of HHG from plasma surfaces (SHHG) became an efficient mechanism to generate intense XUV pulses. However, for applications such as coherent diffraction imaging, the seeding of free-electron lasers, or time-resolved spectroscopy of electronic processes, a continuous long-term operating XUV source needs to be realized. The main issue in case of SHHG is the technical implementation of the target's replacement after each laser pulse since the surface is destroyed during the process. Typically, rotating glass discs are used

which provide targets for a couple of hundreds to thousands of shots. Based on this disc target configuration, the first demonstration of consecutively measured relativistic SHHG over 25 seconds at a repetition rate of 10 Hz were realized by our group a few years ago. However, in order to provide a target surface for continuous high-harmonic generation over hours of operation, we now implemented a new target design of spooling tapes at the 40-TW laser system "Jeti" [3]. Several hundred meter of tape can be wound up on a target holder with adjustable spooling velocity. Hence, a continuous generation of hundred thousands of XUV pulses can be achieved. In an experiment we used two different tape materials: acrylic glass tape and commercially available video tape. With these we demonstrated relativistic SHHG in a continuous operation mode over runtimes of up to one hour at a repetition rate of 1 Hz (Fig. 3). XUV spectra ranging from 20 eV to 70 eV were consecutively recorded with a calibrated spectrometer and yielded an average energy in the µJ range. With energy fluctuations of about 80%, the stability of SHHG signal from tape targets still needs to be improved. Nevertheless, the usage of a spooling tape advances relativistic surface high-order harmonic generation from single-shot mode to a long-term operating XUV source and might become an essential part of a future attosecond beam line.

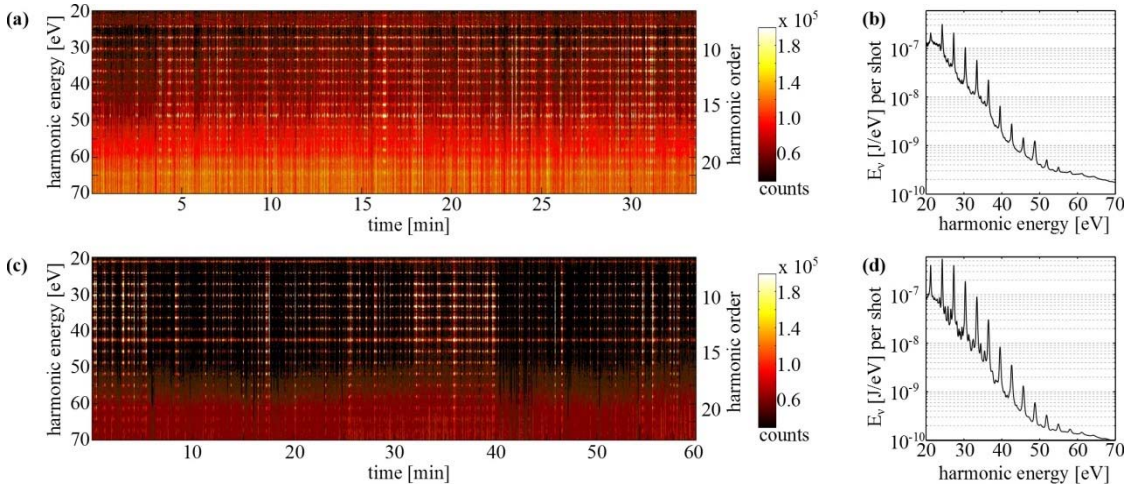


Figure 3: (a) XUV spectra from a VHS tape are consecutively measured during a continuous operation mode at a repetition rate of 1 Hz. Each vertical line corresponds to a single spectrum. The color map indicates the number of shots on the CCD camera. (b) Shows the temporally averaged and calibrated energy spectrum. (c) Measured XUV spectra and (d) averaged spectral energy for a comparable long-term operation over one hour using an acrylic glass tape.

Reference

[1] J. Bierbach et al.: Long-term operation of surface high-harmonic generation from relativistic scillating mirrors using a spooling tape, Optics Express 23, 9 (2015)

Research Projects at the Chair Quantum Electronics

The research of the Quantum Electronics group is focused on the generation and application of ultrashort laser pulses in a wide spectral range, from the near infrared to the x-ray. The ultrashort laser pulses in the visible range are mainly employed to study the dynamics of molecules in the gas phase, stimulated Raman back scattering in a plasma, the nonlinear response of nanostructured samples, and demonstrate remote lasing in air. Major emphasis is also put on the development of new methods to increase the conversion efficiency and/or flux of laser driven XUV sources based on high harmonic generation and their application in high resolution imaging. In the following the most important results and findings achieved in the last two years are briefly described.

Molecular nonlinear optics

Molecular gases can be used in nonlinear optics in the same way as noble gases, offering additional degrees of freedom, e.g. rotations or vibrations. In case of spectral broadening in hollow-core fibers

(HCF) additional stimulated Raman Scattering (SRS) is observed compared to pure self-phase modulation in a noble gas-filled hollow-core fiber. Using spectrally broadened pulses in SF6 we investigated high-harmonic generation in an argon-filled hollow-core fiber using the compressed pulses in addition with temporal pulse shaping and performance of optimization experiments. In our experiments the additional contribution from SRS is beneficial for enhancing the XUV yield by a factor of 2 compared to the usage of argon for spectral broadening and selective optimization of a single harmonic while suppressing the others. Several applications, e.g. Coherent Diffraction Imaging with high harmonics, demand a compact, monochromatic high flux XUV source. Our results offer an easy approach to increase both demands by changing the gas for spectral broadening to a molecular gas.

Nonlinear optics in gas-filled anti-resonant hollow-core fiber

The interaction of intense laser pulses with matter is a vivid research area as it not only aims at investigating fundamental physical questions but also offers a variety of applications. The central idea of this project is to examine nonlinear optical properties of atomic and molecular gases in the interaction with ultrashort infrared laser pulses. Here, the laser-matter interaction is confined to gas-filled novel anti-resonant hollow-core fibers (ARHF), which enable efficient guiding of intense light inside the fiber. The specially desgined fiber is provided by the IPHT Jena in the frame of a collaboration. Our experiments with Kr-filled ARHF have shown more than an octave spectral broadening from extreme UV to IR in 20 cm of the fiber. The major advantages of ARHF are low loss, large-mode field diameter with effective single mode guidance from near IR to deep UV with bandgaps in between as shown in Fig.1. This project will offer, besides answers to fundamental physical questions concerning the interaction of intense ultrashort mid-IR pulses with matter, provide a tunable ultrashort (down to a single optical cycle) source of near- to mid-IR radiation, which has applications in diverse areas of imaging.

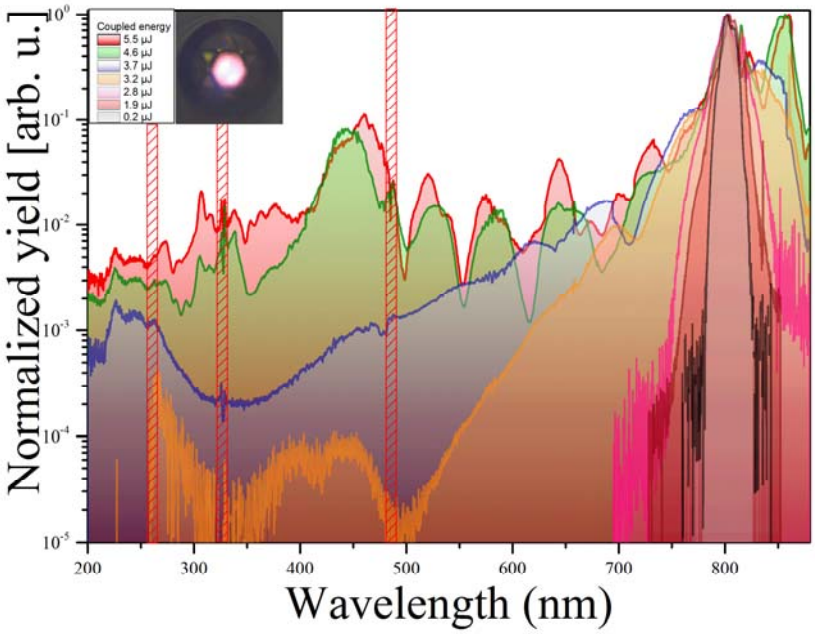


Figure 1. Spectral broadening evolution for energy scans from 0.2 µJ to 5.5 µJ at 6.6 bar pressure of krypton; the vertical columns show the bandgap region of the fiber; inset shows the near field image of the evacuated fiber output.

Stimulated Raman Backscattering

In the last few years we have witnessed a tremendous progress in the field of generation of ultraintense ultrashort laser pulses and their application e.g. particle acceleration. To fulfil the increasing demand for higher peak power we have to develop a new class of amplifiers based on stimulated Raman backscattering (SRBS) in a plasma. This novel approach has the potential for realizing pulses

on the petawatt level and above. Amplification by SRBS is a three wave interaction where a plasma density wave is resonantly excited by the ponderomotive force of the beat wave produced by counter-propagating pump and probe laser beams. The Manley-Rowe relations require that the seed frequency is lower than the pump frequency for amplification to occur.

Several possible processes for this frequency shifter have been considered, but most of them have either a low conversion efficiency or are not stable enough to be implemented in high-power petawatt systems like PHELIX at GSI. A promising candidate –molecular Raman scattering- was studied first at JETI-40 and also at PHELIX. To increase the interaction length and drive a parametric conversion processes axicons with different apex angles as well as different Raman active media were systematically studied. As a result redshifts we were able to generate 50-500 nm redshifted pulses with an excellent beam quality and stability. Based on our previous experimental and theoretical work we have designed a high energy experiment, which took place at the GSI Darmstadt in 2015.

In this beam-time we cooperated with Prof. T. Kühl (GSI Darmstadt) and Prof D. Jaroszynski (University Strathclyde UK) and have successfully applied our seed beam concept in the experiment. The SRBS process was then successful tested and a scaling study from low to high energy was performed. Possible targets for large scale laser systems were tested for application. Critical laser parameters were identified for later application at PHELIX and could enhance the amplification by a factor of ten. Important feedback to theoretical modelling and understanding of competing growth mechanisms was given.

Interaction of ultra-intense laser radiation with dielectric nanostructured targets

In collaboration with the Institute of Solid State Physics (FSU Jena) and GSI (Darmstadt) we have investigated experimentally interaction of sub-relativistic and relativistically intense femtosecond laser pulses with nanostructured solid dielectric targets. Interaction of ultra-intense laser radiation with nanostructured targets is one of the hot topics in modern strong field physics due to promises of new regimes in generation of ultra-hot and ultra-dense plasmas for applications in particle acceleration and hard X-ray generation. Experiments were carried out with two types of nanostructures made of ZnO and designed by the group of Prof. C. Ronning from the Institute of Solid State Physics. An array of nanowires (NWs) and a pile of NWs chaotically arranged along the surface were grown by the vapour transport method on a ZnO:Al layer deposited on a silicon wafer (Fig. 2 a,b).

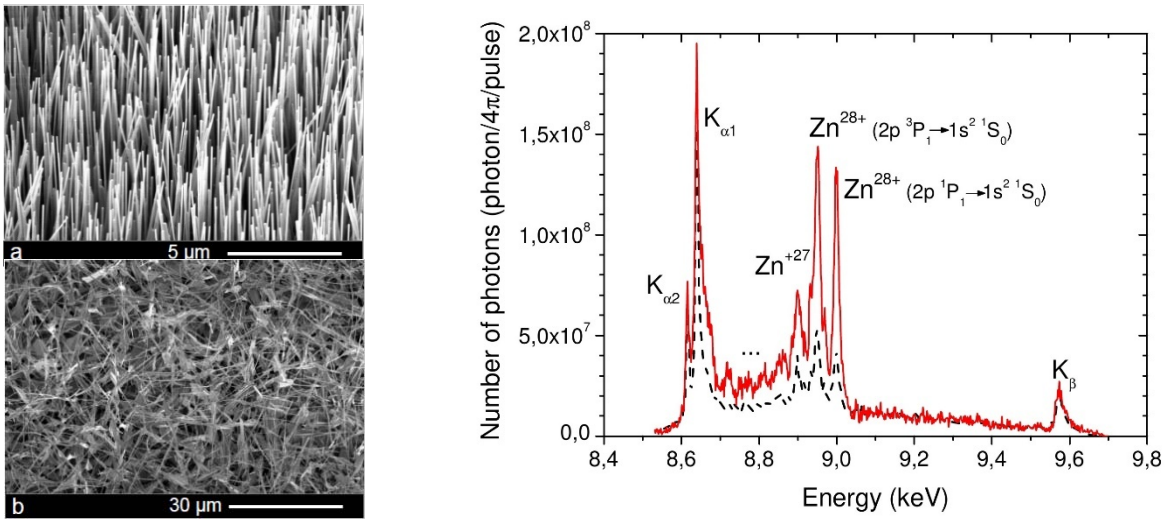


Figure 2. SEM images of the ZnO nanostructured samples: a – "grass-like"; b – "spaghetti-like". c – X-ray spectra at relativistic intensities for nanostructured (red solid line) and polished (black dashed line) targets.

Experiments at sub-relativistic (~10^{17} W/cm^2) intensities were conducted at 1 kHz Ti:Sapphire laser system delivering 60 fs pulses with several mJ energy. More than order of magnitude enhancement in comparison to a polished ZnO sample of hard x-rays flux in the 150-350 keV region of quanta energies and high flux of relativistic electrons (with energies above 800 keV) is demonstrated. Relativistic

regime of interaction with the nanostructured targets was investigated at JETi-40 multi-TW laser system operating in FSU Jena and delivering 30 fs, 600 mJ pulses at 800 nm wavelength. Second harmonic generation with conversion efficiency about 25% was used to improve temporal quality of the intense pulses. Characteristic X-ray emission from transitions in high charge state ions generated in the targets was measured with high resolution X-ray spectrometers. Charge states up to He-like ions of Zn (Zn^{+28}) are generated. The corresponding K_α emission line of He-like Zn has intensity close to the intensity of K_α emission from neutral Zn atoms, pointing on very high density of highly charged plasma. The obtained flux of photons at K_α wavelength in He-like Zn (corresponding to ≈ 9 keV energy of quanta) is 2.6 times higher for nanostructured samples (Fig. 3c) in comparison to the polished ZnO target.

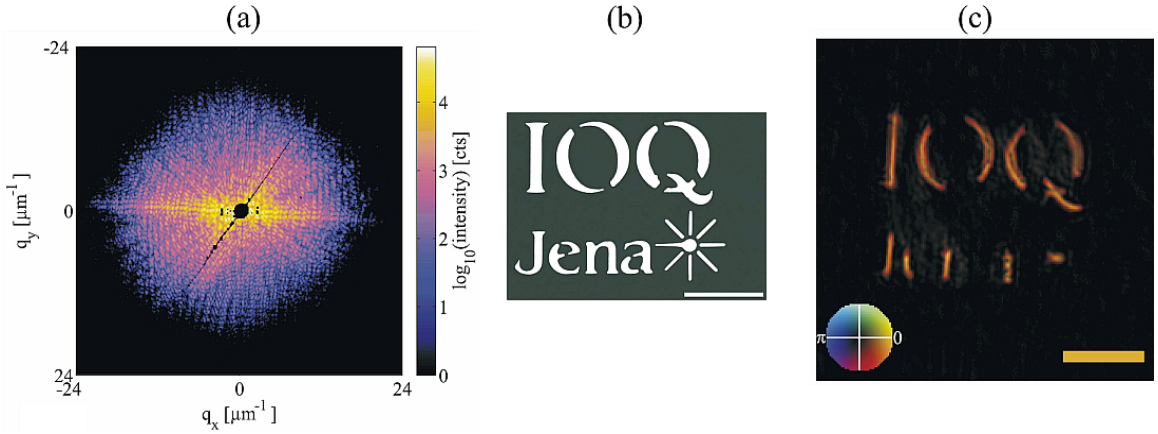


Fig. 3 (a) Measured diffraction pattern at 33.2 nm wavelength and a numerical aperture of 0.8. (b) STEM image of the sample used. (c) Reconstruction of the sample with 26 nm spatial resolution. The scale bars in (b) and (c) are 1μm.

Standoff lasing in nitrogen and air initiated by femtosecond laser filaments

In collaboration with Prof. M. Shneider from the Princeton University, USA, we have developed theoretical and numerical model of a time-dependent plasma-chemical dynamics in laser filaments generated by a high power femtosecond laser source in nitrogen gas or air. The model is based on self-consistent solution of Boltzmann kinetic equation for the electron energy distribution function, rate equations for electronic excitations in molecular nitrogen and different atomic and molecular species and laser equations describing evolution of a spontaneous and stimulated emission. We have identified different mechanisms of pumping electronic excited states in molecular nitrogen and conditions when single-pass lasing from femtosecond filaments can be realized. We have shown that the filamentation laser wavelength and polarization are the key parameters which determine the possibility to realize a standoff single pass nitrogen laser in the atmosphere.

Coherent ultrafast diffraction imaging at the Abbe limit using a compact high average power high harmonic source

Recent progress in the development of high-average power high harmonic sources (HHG) opens possibilities for novel applications in the soft X-ray and extreme ultraviolet spectral range. Especially applications such as imaging benefit from the high photon flux that is available from such sources. At the same time the longer driving wavelength and relatively long driving pulses guarantee narrow harmonic lines, which are essential for high resolution coherent diffraction imaging. In a joint experiment with Profs. Limpert and Tünnermann (Institute of Applied Physics FSU Jena) and Prof. U. Kleineberg (Max Planck Institute for Quantum Optics Munich) we used such a high power HHG source, which is driven by a ytterbium-doped fiber CPA system operating at 1030 nm central wavelength, we recently demonstrated coherent diffraction imaging down to 26 nm spatial resolution at a numerical aperture of 0.8. As sample we used a thin silicon nitride substrate coated with a 200 nm thick gold layer and the institute's logo written as aperture using a focused ion beam. The coherent diffraction imaging setup consists of two multilayer coated focusing mirrors that refocus the XUV light onto the sample and spectrally select the 31st harmonic at 33.2 nm wavelength. The achieved resolution thus compares to less than one wavelength which is in good agreement with the Abbe lim-

it for the NA used as well as the achievable resolution induced by the relative bandwidth of the harmonic line ($\Delta\lambda/\lambda=1/220$). Further we could demonstrate real-time imaging using one second integration time at a resolution of 65 nm.

Our experiment demonstrates the capabilities novel high-average power HHG sources have and that their excellent radiation properties allow for imaging close to highest possible resolution in a reasonable time. The achieved relative resolution marks a new record for any coherent diffraction imaging experiment reported in literature. By extending the wavelength used for imaging from the 37eV range towards the water window by scaling strategies, we hope to be able to do CDI and digital inline holography in the water window to image biologic specimen in the near future.

Research Projects at the Chair for Relativistic Laser Physics

The research at the chair for relativistic laser physics is aiming at the development and optimization of novel laser systems, both reaching ultra-high average and peak powers. Furthermore, these laser systems are applied for fundamental and applied research towards the realization of novel concepts for the acceleration of particles and the generation of ultra-short radiation pulses. Hence, generating and applying laser pulses suitable for driving high-intensity, relativistic interactions is a central goal of our research. Furthermore, our group has pioneered a number of ground-breaking experiments enabling by the end of 2015, a total of 25 scientists, students, and engineering staff were working in this group.

Development of High-Power Laser Systems

The laser system POLARIS, which has been developed entirely within our group, is one of the large-scale research infrastructures at the Institute of Optics and Quantum Electronics and at the Faculty of Astronomy and Physics. It is also embedded within the Helmholtz-Institute Jena.

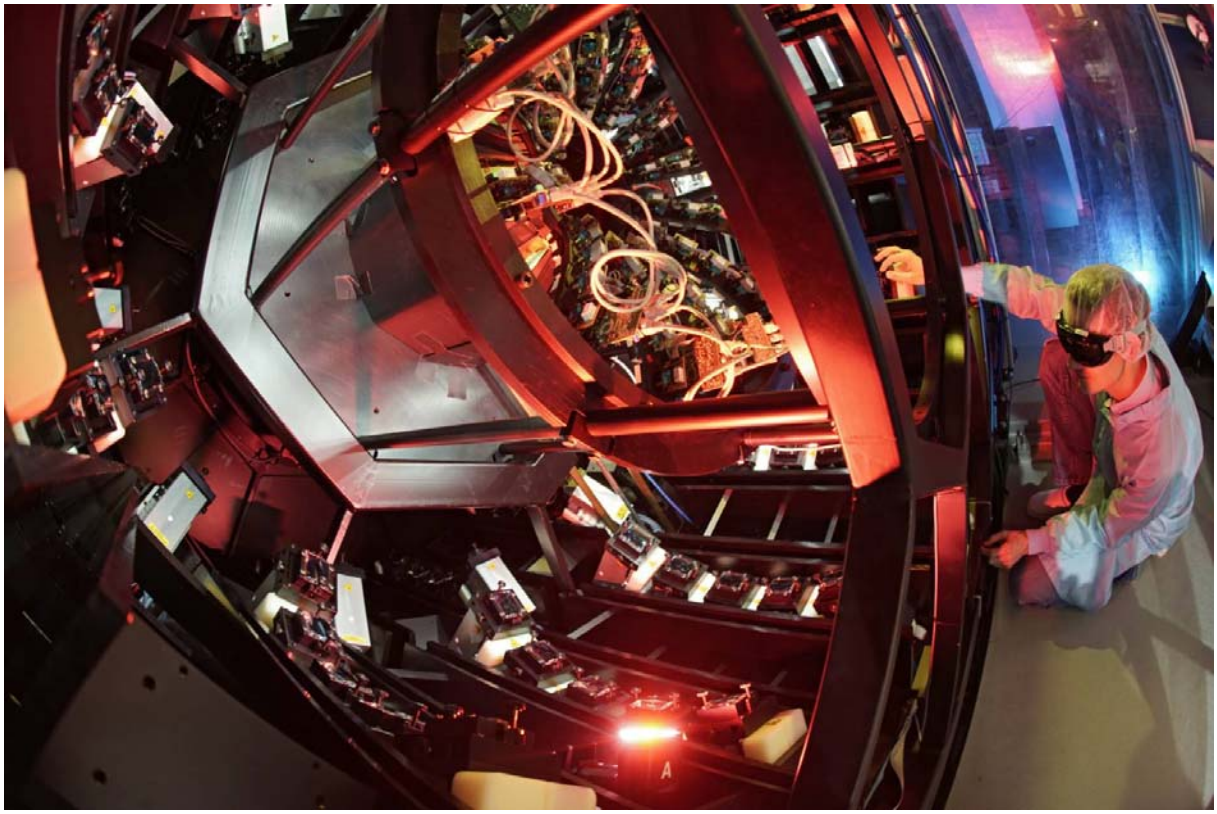


Fig. 1: View into the last amplifier of POLARIS after the upgrade in 2015 [photo taken by Jan-Peter Kasper, FSU Jena].

During 2015, a substantial upgrade of the laser system has been completed. Here, the increase of the peak power – both by an increase in pulse energy and a reduction in pulse duration – has been the

main focus of our research together with an improvement of the system's stability. By the end of the year, it was finally possible to increase the pulse energy delivered by the final amplifier A5 of POLARIS to a new record value of 54.16 J – this is an increase by more than a factor of three as compared to the year before. By carefully pre-shaping the frequency spectrum of the laser pulses of POLARIS, a spectral bandwidth of more than 20 nm (FWHM) could be achieved after the last amplifier, which is sufficient to reach pulse durations after compression below 100 fs. To reach these results, several changes in the architecture of POLARIS' amplifier stages was necessary. A new amplifier that was developed off-line has now been included permanently in the POLARIS amplifier chain. The double-CPA architecture including a stage for contrast improvement by crossed-polarized wave (XPW)generation that has been developed and tested before has also been implemented permanently into the system. Taking these individual improvement steps together helped us to secure the world-leadership of POLARIS still being the most powerful, fully diode-pumped laser system worldwide, which can also be used for high-intensity experiments.

Further improvements of the temporal contrast of the laser pulses could be achieved. For the first time, a complete theoretical description of the processes responsible for the generation and amplification of amplified spontaneous emission (ASE) was formulated and compared to different types of laser systems, giving an excellent agreement between the theoretical predictions about the highest achievable level of pulse contrast depending on the active medium and the measured data [1].

The generation of ultra-high contrast pulses at the second harmonic of POLARIS has been characterized in detail [2].

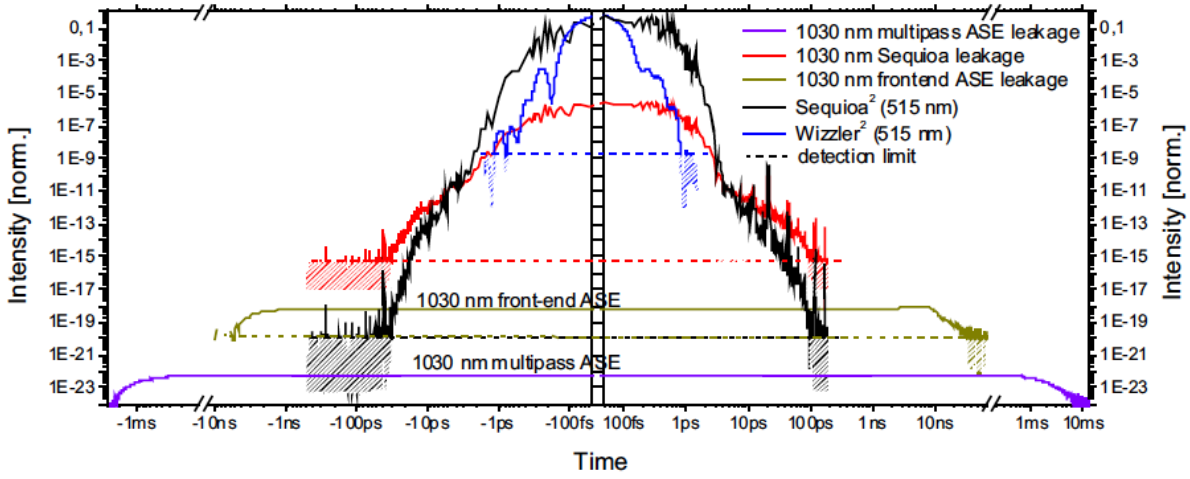


Fig. 2: Measurement of the temporal contrast of POLARIS pulses after frequency doubling. Image from [2].

These pulses could be successfully used for the first time in experiments on ion acceleration from ultra-thin foils. Here, signatures from two different acceleration mechanisms, namely target-normal sheath acceleration, TNSA, and radiation pressure acceleration, RPA, in the so-called light sail regime, could be distinguished and studied in detail.

In collaboration with the Otto-Schott-Institute of Materials Research (OSIM), new laser materials suitable for the application as the active medium in diode-pumped laser systems have been developed over the last few years. At IOQ, their performance with respect to laser operation has been investigated and characterized. As one of the final results of the research group ALASKA, in which IOQ and OSIM have closely collaborated, a novel Yb-doped laser glass has been developed and large-scale glass melt on the basis of this material have been realized in collaboration with Vitron Spezialwerkstoffe GmbH. These materials are very promising with respect to their thermo-mechanical properties and their laser properties, in particular the absorption cross-section and the life time of the upper laser level, which makes them promising candidates for diode-pumped applications [3,4].

Laser-Driven Particle Accleration

Using both the 30 TW Ti:Sapphire laser system JETI and the >100 TW Yb:glass laser system POLARIS, a number of experiments on laser-driven particle acceleration have been carried out in 2015.

At the JETI system, a worldwide unique combination of 30-TW laser pulses together with a few-cycle optical probe pulse could be exploited in several experiments. First, experimental investigations of the laser-driven plasma wave, which is responsible for the acceleration of electrons in a laser-wakefield accelerator, could be carried out with unprecedented detail. Under certain conditions, the shape of the plasma wave changes prior to the injection of electrons into the plasma wave's wake-field. This could be studied for the first time in experiments using gas jets [5].

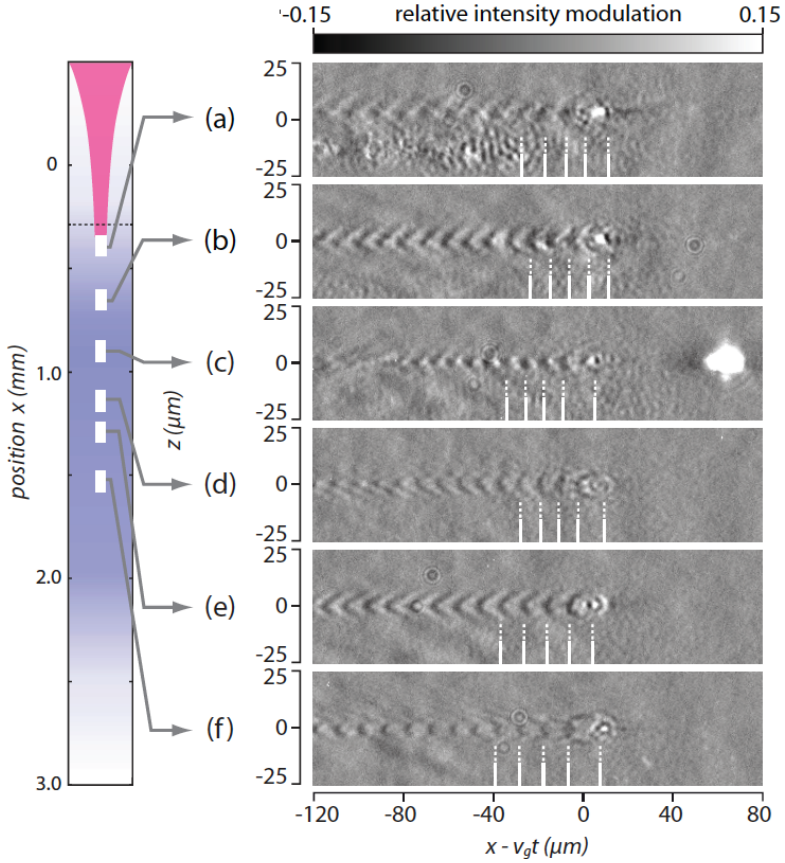


Fig. 3: Evolution of the plasma wave in a laser wakefield accelerator driven by JETI. Image from [5].

When gas cells are used as a target, significantly reduced turbulences in the gas flow lead to a more homogeneous plasma distribution, which eventually leads to a higher stability in the electron acceleration process from shot to shot. These findings could be supported by images obtained with our few-cycle probe pulses. Furthermore, when the injection process of electrons into the plasma wave could be triggered locally by field-ionization, this stability could be improved even further, which could be verified by images of the plasma wave at a later stage of the acceleration. This information gave – for the first time – a clear indication that the shape and evolution of the plasma wave is indeed responsible for the stability of the electron pulses and that this can be actively influenced by the experimental conditions. These findings are of great importance for the foreseen applications of laser-generated electron pulses.

Solid hydrogen was used successfully for the first time as the target material in experiments on laser-driven ion acceleration with the POLARIS laser. Both high maximum energies (up to 21 MeV) and a significantly higher conversion efficiency from laser energy to protons could be observed.

This is both due to occurance of only a single ion species during the interaction (i.e. protons) and a plasma density, which lies between the values which can be achieved with low-density gas-jet targets and solid metal targets, which could be used as an alternative. Furthermore, modulations in the energy spectra could be observed and explained to be a result of a collisionless shock being generated at the boundary of the solid target surface and a low-density corona surrounding the solid-hydrogen target under the vacuum conditions used in the experiment [6]. These results represent a significant

advance for laser-ion acceleration, since the observed efficiency for proton acceleration was significantly higher than what had been reported with any other target materials so far.

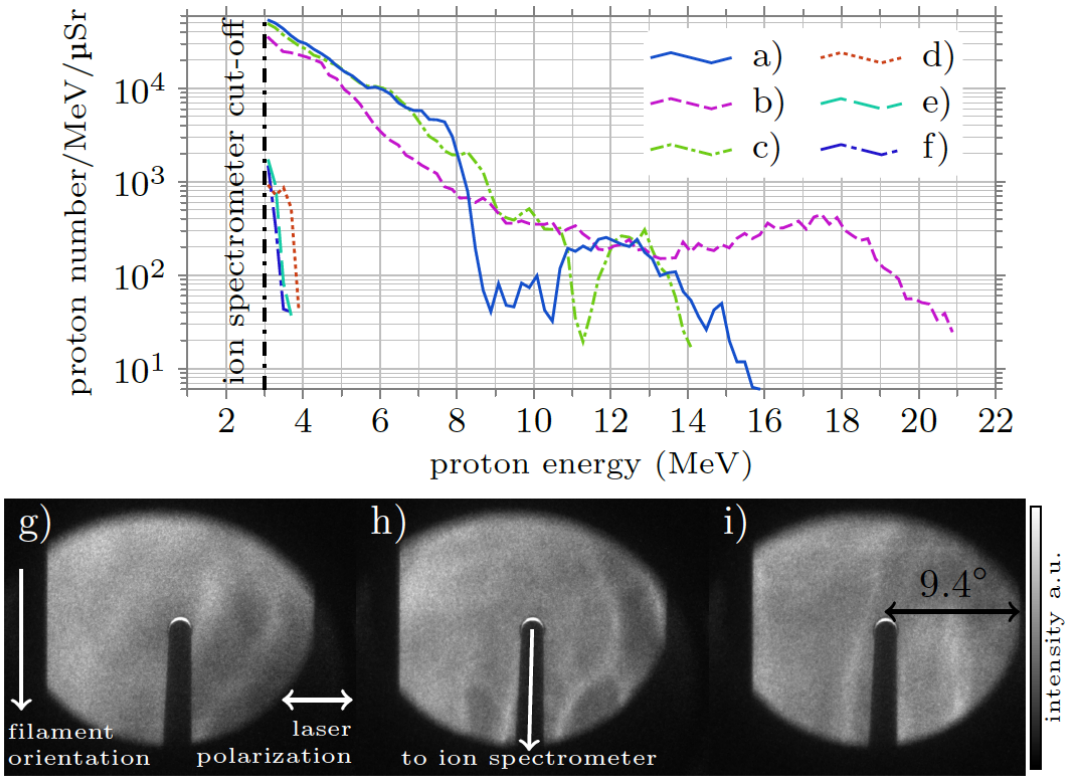


Fig. 4: Energy spectra and beam profiles of laser-accelerated protons from a solid hydrogen target. Image from [6].

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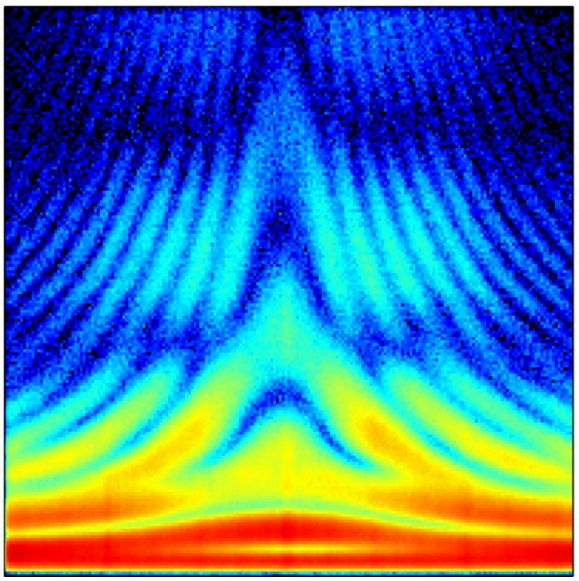
Research Projects at the X- ray optics group

<u>High Purity X-Ray Polarimetry for Nuclear Resonant Scattering</u>

The analysis of the polarization state of x-rays is a versatile tool at 3rd generation synchrotron sources in many scientific fields reaching from solid-state physics to life sciences. These experiments are usually performed with the linear polarization of the undulator radiation. Therefore, the sensitivity to polarization changes is limited by the degree of polarization of those sources. In the last years, the x-ray optics group developed a polarimeter based on monolithic channel-cut crystals, which increases the sensitivity to such polarization changes considerably. Using six consecutive Bragg reflections at an angle of 45° inside a channel-cut crystal, polarization purities reaching ten orders of magnitude were

realized up to now. Together with the method of nuclear resonant scattering, x-ray polarimetry offers new possibilities in solid-state physics, but also in the investigation of fundamental effects. One of these phenomena is the subluminal propagation of x-ray pulses inside a thin film cavity with embedded iron-57 nuclei, which we discovered together with the group of Ralf Röhlsberger from DESY in Hamburg and Jörg Evers from MPI of Nuclear Physics at Heidelberg [1]. This effect was only accessible by a high-purity x-ray polarimeter, which was developed especially for the investigation of the iron isotope 57. Photons, that are resonantly scattered, experience a change in polarization depending on the magnetization of the sample. If the plane of diffraction of polarizer and analyzer are perpendicular to each other, these resonantly scattered photons can pass the analyzer, whereas the photons that are not resonantly scattered are suppressed by more than eight orders of magnitude. Thus, only the scattered photons are accessible, which were analyzed in arrival time and energy afterwards. The strong reduction of the group velocity by four orders of magnitude increases the interaction of the x-rays with the sample considerably. For that reason, it could be possible to detect a non-linear behavior of x-rays in thin film samples in the future.



Propagation of x-ray pulses inside a sample enriched with the iron isotope 57. In the vertical direction, the temporal structure of the x-ray pulses is determined by a beat pattern. The horizontal direction shows the deviation of the photon energy from the nuclear resonance of iron-57. Close to the resonance (in the middle) the x-ray pulses are delayed by about four orders of magnitude.

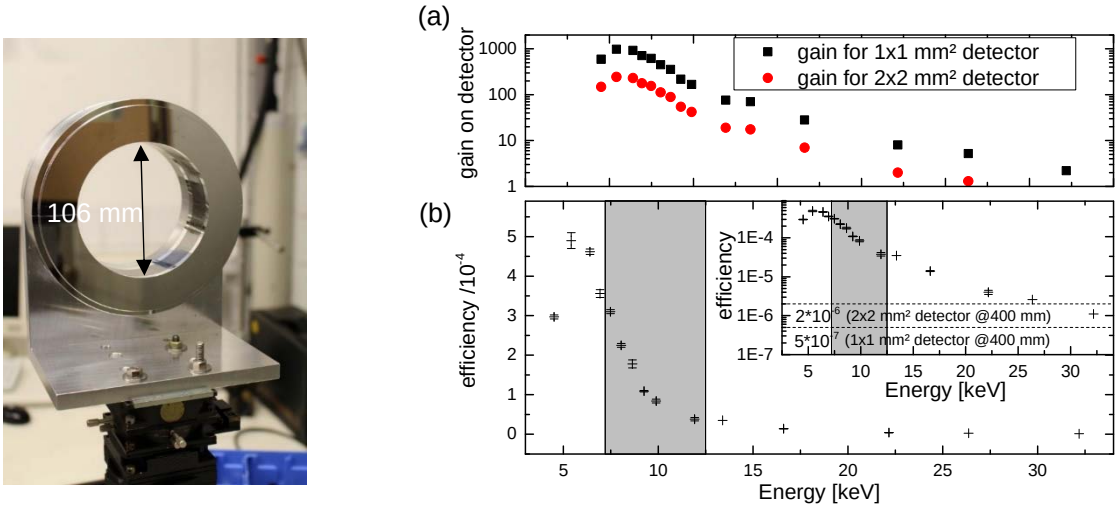
Reference

[1] K. S. Schulze, R. Loetzsch, I. Uschmann, G. G. Paulus et al.: „Tunable sub-luminal propagation of narrowband x-ray pulses"; Physical Review Letters, 114, 203601 (2015)

High efficient X-ray optics for spectroscopy of highly charged ions

Precision x-ray spectroscopy of highly charged ions at traps and storage rings provides for example a unique tests of relativistic and quantum electrodynamical effects in strong electromagnetic fields. The spectral resolution of such experiments is limited to date by the spectral resolution of semiconductor detectors. There are two pathways under investigation to overcome these limits: first by the use of crystal spectrometers and second the use of detectors with higher spectral resolution. Such high resolution detectors could be microcalorimeter. With these detectors, very high energy resolution in the order of a few eV in the energy range up to 100 keV could be obtained. The drawback is the limited solid angle and thus detection efficiency, which limits the use of these detectors for spectroscopy of weak transitions. To increase the detection efficiency of these devices, collecting X-ray optics can be used. The potential of such crystal optics is investigated. This includes the evaluation of different crystal-optical schemes by simulations and the development of crystal machining techniques, to obtain the desired crystal reflection properties.

Maximum collection efficiency is achieved by first maximizing the diffraction efficiency of the crystals, which is done by using so called mosaic crystals and second bending the crystal to a full cylinder ring. By doing so, the detection efficiency on the microcalorimeter detector could be increased by 1 to 2 orders of magnitude. We build a prototype optic for the use in the energy range between 7 keV and 12.5 keV and are working the adaption of the scheme for higher energies.



Left: Photograph of an optic based on a toroidally bent highly oriented pyrolythic graphite crystal. **Right:** Measured efficiency of this optic (b). In the top panel (a) the gain in detection efficiency for a small detector with this optic is shown for comparison.

Ultrafast electron kinetics in short pulse laser-driven dense hydrogen

Dense plasma states are relevant for a wide variety of astrophysical objects such as stars and planets throughout the universe. However, our knowledge on dense plasma states is still very limited and joint efforts of astrophysics and planetary physics, laser and plasma physics and high pressure physics have to be performed in order to get more insight into the behavior of matter in this region.

In the experiment dense cryogenic hydrogen is heated by intense femtosecond infrared laser pulses. Three-dimensional particle-in-cell (PIC) simulations predict that this heating is limited to the skin depth, causing an inhomogeneously heated outer shell with a cold core and two prominent temperatures of about 25 and 40 eV for simulated delay times up to +70 fs after the laser pulse maximum. Experimentally, the time-integrated emitted bremsstrahlung in the spectral range of 8–18 nm was corrected for the wavelength-dependent instrument efficiency. The resulting spectrum cannot be fit with a single temperature bremsstrahlung model, and the best fit is obtained using two temperatures of about 13 eV and 30 eV. The lower temperatures in the experiment can be explained by missing energy-loss channels in the simulations, as well as the inclusion of hot, non- Maxwellian electrons in the temperature calculation. We resolved the time-scale for laser-heating of hydrogen, and PIC results for laser–matter interaction were successfully tested against the experiment data. Furthermore we state that our method is sensitive to the scientifically interesting regions of increased ionization at high density, while the cold dense plasma background, as well as ionized dilute residual hydrogen gas, does not contribute.

This work was carried out by researchers from the universities of Jena and Rostock and the European XFEL in close collaboration with DESY / FLASH and the Hamburg Center for Ultrafast Imaging (CUI). Experimental and theoretical work was performed by researchers from the US research centers SLAC and Lawrence Livermore Lab, the Helmholtz Institute Jena, and University of Oxford.

Funding by the BMBF (FSP 302) and by the Volkswagen Stiftung (U. Zastrau) is acknowledged.

Reference

[1] U. Zastrau, V. Hilbert, E. Förster et al.: „Ultrafast electron kinetics in short pulse laser-driven dense hydrogen“, Journal of physics / B **48**, 224004 (2015) DOI: 10.1088/0953-4075/48/22/224004

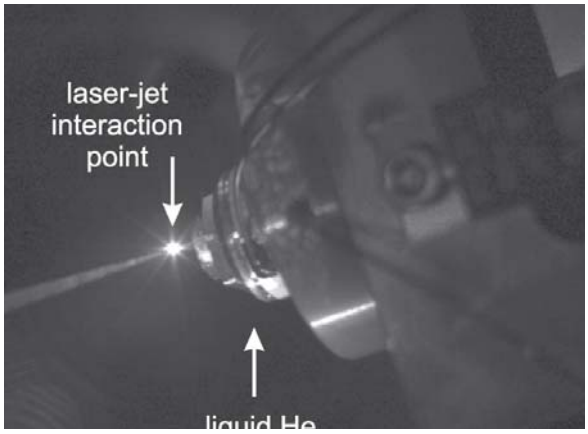


Figure. The liquid hydrogen jet operational in high vacuum, as viewed from a long-range microscope outside the vacuum chamber.

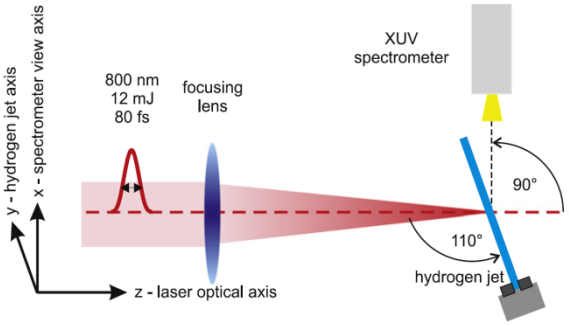


Figure. Schematic of the experimental setup. The optical fs-laser is focused onto a cryogenic hydrogen jet at an angle of ~110°. The laser is horizontally polarized along the jet direction. Soft x-ray emission is recorded by an XUV spectrometer at 90°.

Research Projects Related to the Professorship Atomic Physics with Highly-Charged Ions

Experimental studies on polarization correlations in elastic hard X-ray scattering

Elastic photon-atom scattering has been studied experimentally in a strong-field scenario: an incident beam of hard X-rays was scattered from a high-Z target. Investigations on elastic hard X-ray scattering started in the 1930s [1] and since then, many experimental and theoretical results were published [2,3]. In the majority of those works, the differential scattering cross section for an unpolarized incident photon beam is considered. More detailed investigations, which also involve the polarization of the incident or the scattered beam's polarization, are very rare [4], as such measurements require dedicated polarized hard X-ray sources and polarimeters. These technological difficulties were overcome in recent years with third-generation synchrotron radiation facilities on one hand, and large-volume, solid state Compton polarimeters on the other. In the experiment that we present in this report, these novel technologies were combined, so that for the first time, a hard X-ray elastic scattering experiment could be performed, where the incident beam was linearly polarized and the linear polarization of the scattered beam was measured. The High Energy Material Science Beamline P07 [5] at the synchrotron radiation source PETRA III at DESY, Hamburg provided a linearly polarized 175-keV photon beam which was scattered from a thin gold foil. The scattered radiation was analyzed with a 2D Si(Li) strip polarimeter [6], which was mounted at different scattering angles in the polarization plane of the incident beam. At 175 keV, the dominant contribution to the elastic scattering amplitude comes from Rayleigh scattering, i.e. the scattering from bound electrons. Recent theoretical studies on this process were performed with particular focus on polarization effects, see e.g. [7,8]. The polarimeter and preliminary results for the measured polarizations are shown in figure 1.

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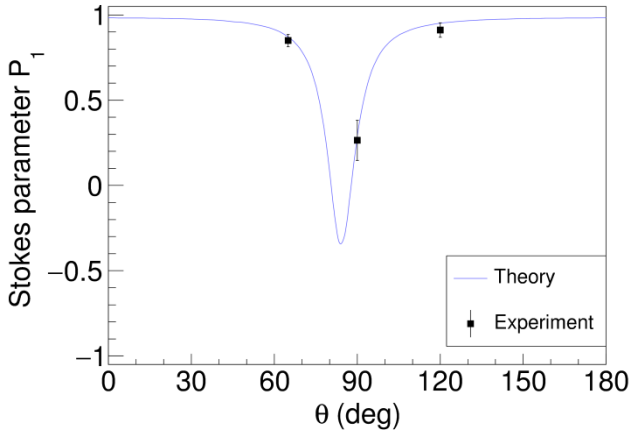

Figure 1: Polarimeter (left) and preliminary results for the Stokes parameter P_1 of the elastically scattered photons (right). Theoretical predictions (Rayleigh scattering) were provided by A. Surzhykov, V. Yerokhin and S. Fritzsche [9]. They correspond to an incident beam's Stokes parameter P_1 of 0.979.

Novel detectors for X-ray spectroscopy

During the last decade significant progress was achieved in the development of novel detector concepts for precision X-ray spectroscopy as well as X-ray linear polarimetry. On the one hand cryogenic microcalorimeters offer the prospect to combine the excellent resolution of crystal spectrometers (which have a very limited wavelength acceptance range) with the large acceptance range of Ge- or Si(Li)-detectors (which have poor energy resolution) [1]. On the other hand thick-crystal highly-segmented semiconductor detectors have proven to be ideally suited for hard X-ray (Compton) polarimetry [2]. Our working group is employing these innovative detector concepts for studies of hard X-ray interactions and for probing the atomic structure in the presence of extreme field strengths.

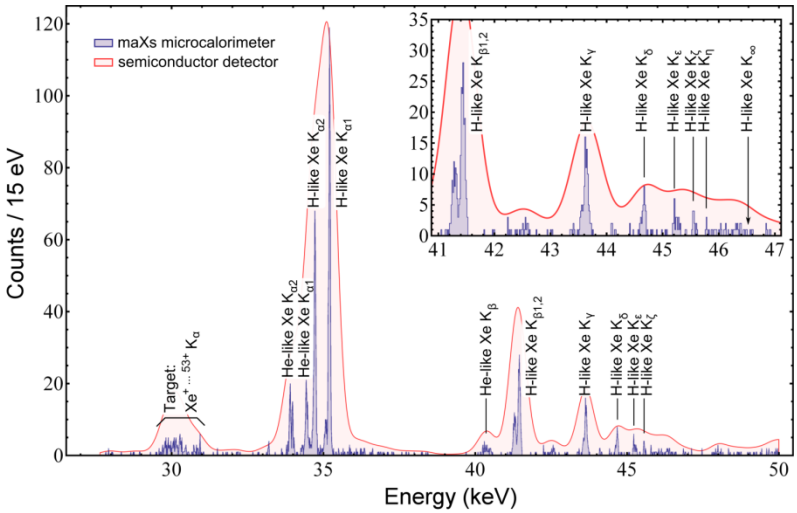

Figure 2: The spectrum of X-rays emitted from the collision of bare Xe ions with a Xe gas target. The data obtained with the maXs microcalorimeter are contrasted to the signal from a standard semiconductor detector. The increase in spectral resolution achievable with a microcalorimeter is remarkable [4].

In collaboration with the group of Prof. Enss from KIP, University of Heidelberg a prototype of the maXs microcalorimeter [3] was tested at the experimental storgare ring (ESR) of GSI, Darmstadt. There, a beam of bare xenon ions was interacting with a xenon gas target. The X-rays that were arising from the collisions of the highly carged ions with neutral matter were recorded by the maXs ca-

lorimeter and a standard semiconductor detector. The obtained spectra are presented in figure 2 [4] and demonstrate the superior spectral resolution achievable with a microcalorimeter.

In addition, the development of a new Compton polarimeter consisting of a planar Si(Li) crystal with 32 segments on each side is advancing. Until recently, the application of such polarimeters for X-ray energies below 70 keV was hampered by the high level of electronic noise [5]. However, now a reduction of the electronic noise by at least a factor of two was demonstrated (see figure 3) and we expect the comissioning of the new detector in 2016.

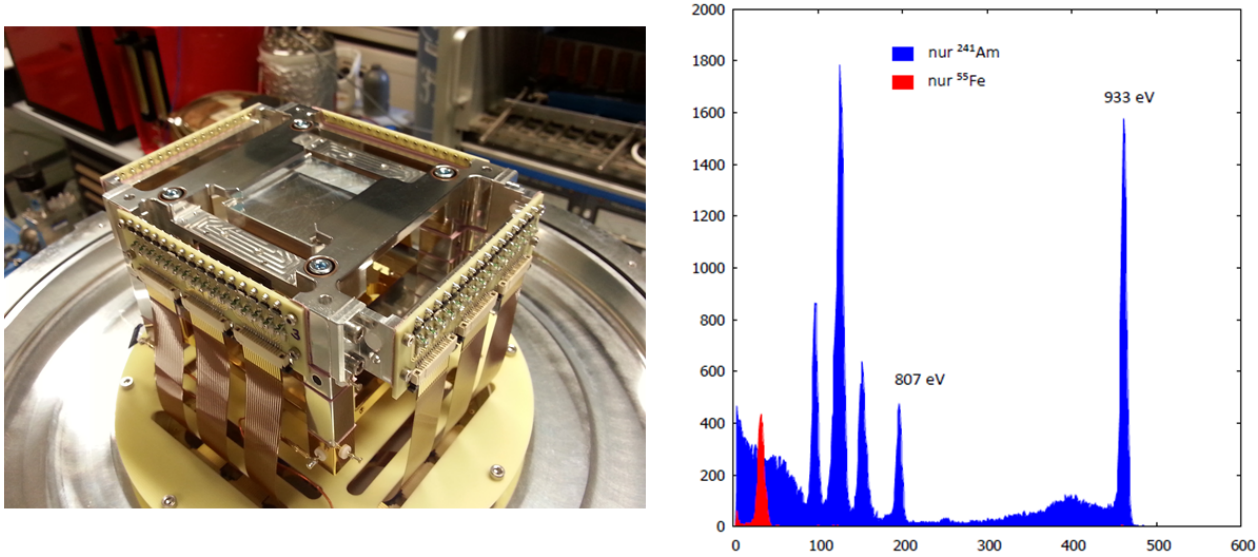

Figure 3: *Left side:* Detector crystal and crystal holder of the new Compton polarimeter. *Right side:* Photon spectra recorded by one segment of the detector. The energy resolution is at least a factor of two better than for previous detectors of the same type.

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Compton Polarimetry of Hard X-Rays with Two CdTe-Equipped Timepix Detectors

The understanding of the processes that occur within laser-produced plasmas is enhanced considerably by investigations of the electromagnetic radiation emitted by the plasma. In particular, polarimetric measurements can be expected to provide valuable insights into the relativistic dynamics and directionality of high-energy electrons inside the interaction. These properties depend on the characteristics of the various heating mechanisms that transfer energy from the photon pulse to free target electrons. Because of their charge, however, the latter are unable to readily leave the interaction volume – in contrast to the bremsstrahlung photons, which carry detailed information of the electron characteristics.

In this regime of pulsed, high-intensity sources of hard X-rays, single-photon spectroscopy is unfortunately often hampered by the pileup of several photons that are absorbed in the unsegmented, large-volume sensors routinely used for the detection of high-energy radiation. A promising escape is offered by detectors based on the Timepix chip, which can be equipped with high-Z sensor chips and feature a 55 µm segmentation. We constructed and tested a Compton polarimetry setup of two Timepix devices, which are positioned around a passive scattering target and record a fraction of the photons that were Compton-scattered by an angle of ≈ 90° [1]. A schematic of the assembly is displayed in figure 4. Both detectors utilize CdTe (Z ≈ 50) sensor chips of 1 mm thickness, and are thus able to detect photons up to several 100 keV.

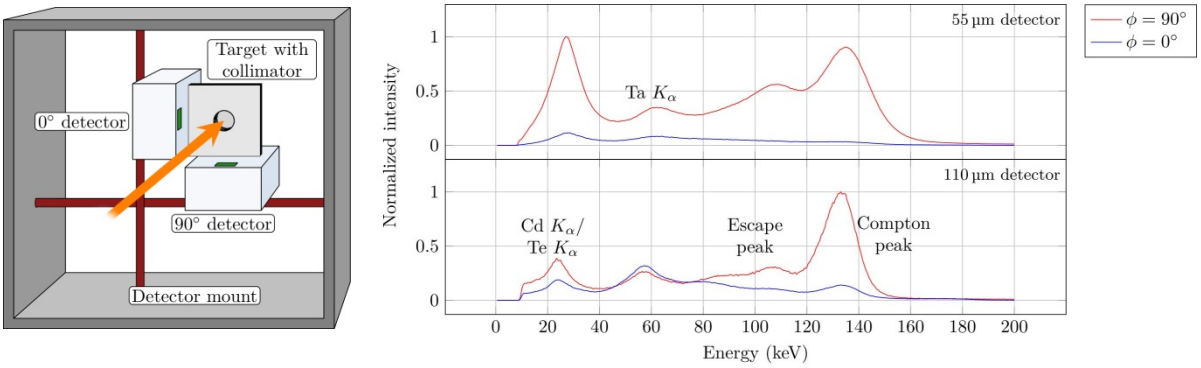

Figure 4: *Left:* Schematic of the two-detector Compton polarimeter setup. Impinging radiation is scattered within a target, whose material can be selected to fit the incident photon energy. A set of tantalum collimator plates limits the polar scattering angle of the detected photons to 90±4°.
Right: Spectra of radiation scattered by a PMMA target at a polar angle of θ ≈ 90°, as registered by the two Timepix detectors of the Compton polarimeter setup. To rule out sensitivity differences as the sole cause of the observed intensity contrast, the detector positions were exchanged for a second data acquisition. The spatial variation of the scattered intensity is clearly visible.

By design, the Timepix devices implement a dedicated set of digitization electronics for each of their approximately 16 000 pixels. This means that in order to efficiently use the energy resolution afforded by the Time-over-Threshold (ToT) mode of the system, pixel-to-pixel variations of the detector response have to be corrected by a pixelwise calibration. We successfully calibrated two sensors for high-energy X-ray and γ radiation of energies up to 662 keV, where a relative resolution FWHM/E of about 5 %, comparable to that of γ spectroscopy scintillators, was achieved.

With the detectors' energy calibration at hand, we conducted a characterization experiment at the PETRA III facility at DESY, which provided X-rays with a polarization near 100 %. Sample spectra are shown in figure 1 and illustrate the pronounced anisotropy of the scattered intensity. Comparison with the results of a combined Rayleigh–Compton polarimetry measurement [2] revealed a polarimeter quality of 98.0±1.2 %. This value was confirmed with remarkable accuracy by a Monte Carlo simulation of the setup.

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[2] K. H. Blumenhagen, In preparation

Cryogenic Current Comparator for Storage Rings and Accelerators

The First Cryogenic Current Comparator (CCC) for a non-destructive highly sensitive monitoring of nA-beams was developed in the 90s. In recent years this system was optimized for lowest possible noise-limited current resolution in combination with a high system bandwidth of about 200 kHz. This improved CCC consists of commercial state-of-the-art SQUID components, niobium shielding and a toroidal niobium pick-up coil with nanocrystalline NANOPERM® core material [1].

The existing CCC has been installed and tested in the Antiproton Decelerator (AD) at CERN in cooperation with GSI, HIJ and Friedrich Schiller University Jena, to measure the low-intensity coasting beam. Modifications were required for this implementation in order to adapt the AD beam parameters. The signal slew rate during AD injection exceeds the slew rate of CCC-system because the current suddenly jumps from 0 to ≈ 12 µA. To solve this problem a low pass filter was inserted between the pick-up coil and the primary coil of the matching transformer. Figure 5 shows the different wiring diagrams and Figure 6 the corresponding noise spectra.

From the first serial setup of resistor and capacitance follows an additional noise contribution around the resonant peak. This is why a parallel connection of resistor and capacitance was chosen for the final setup at AD which is more stable but also with an additional noise contribution and a signal bandwidth of 1 kHz [2].

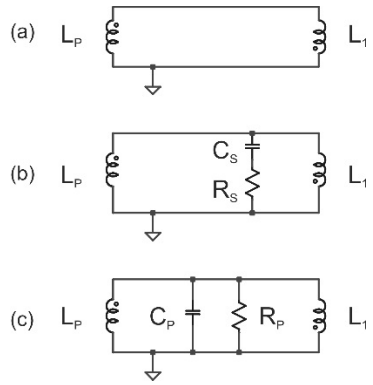


Figure 5: Connection scheme of the tested filter setup in the input circuit between pick-up coil L_P = 104 µH and primary coil L_1 = 104 µH of the matching transformer while the upper scheme is the original one. C_S = 10 µF, R_S = 1 Ω, and C_P = 10 µF, R_P = 0.225 Ω at 4.2 K.

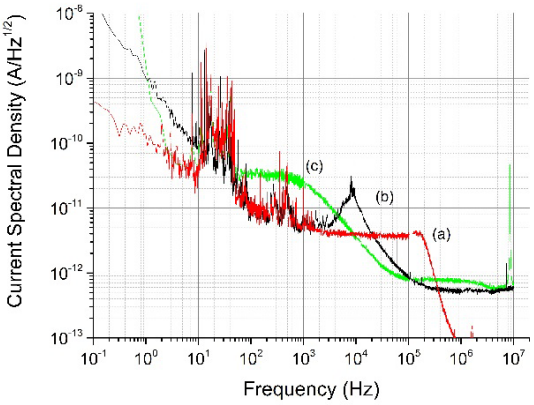


Figure 6: Current noise of the CCC in the original configuration without filtering in the input circuit (a), with serial connection of R_S and C_S (b), and with parallel connection of R_P and C_P (c) between the pick-up coil L_P = 104 µH and the primary coil L_1 = 104 µH of the matching transformer.

Figure 7 shows a beam commissioning cycle measured successfully with the CCC. During this measurement the beam got lost during the first cooling plateau. This moment is clearly visible in the measurement and proofs that the CCC can be an important tool for beam measurements [3].

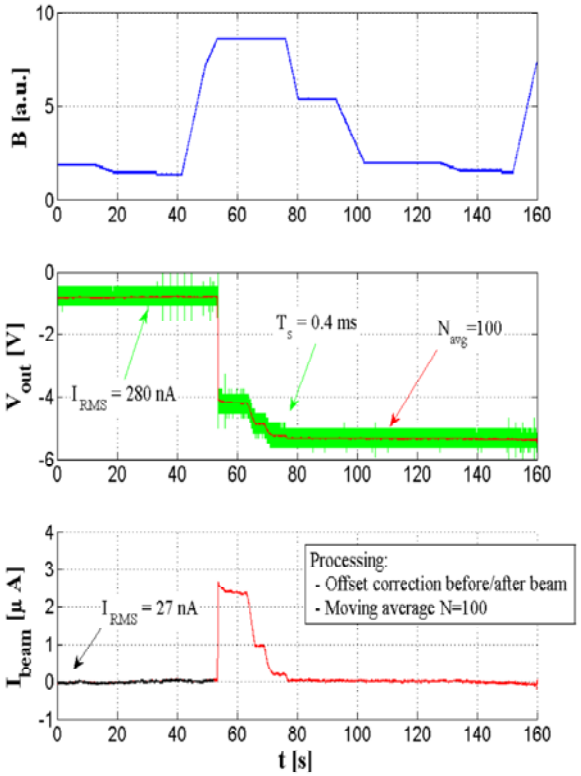


Figure 7: Top Plot: Magnetic Cycle of AD Dipoles in arbitrary units. Middle plot: SQUID/FLL raw signal of beam current (in green), and same signal filtered with a moving average (in red). Bottom plot: calibrated beam current measurement after filtering and baseline recovery (before beam injection and after beam extraction) [2].

Within the FAIR project (Facility for Antiproton and Ion Research) an improved SQUID-based CCC is intended to be used as diagnosis device for ion beams. In July 2015 a three-year BMBF joint project (development, sensor optimization and test of cryogenic current comparators for use on novel ion sources, accelerator systems and storage rings) with Helmholtz Institute Jena, GSI Darmstadt, IPHT Jena and TU Darmstadt was started.

References

[1] Phys. Scr. T166 014057 (2015)
[2] R. Geithner et al., Proc. IBIC 2015, Melbourne, Australia. MOPB013 (2015)
[3] M. Fernandes et al., Proc. IBIC 2015, Melbourne, Australia. WEPF04 (2015)

Research projects in the attosecond physics group

The research field of the attosecond physics group is physics on extremely short time scales. Many important processes in atoms, molecules and in condensed matter occur within a timespan on the order of attoseconds. Prominent examples include coherent charge migration in atoms and molecules, decay of atoms with inner-shell vacancies, and photoionization.

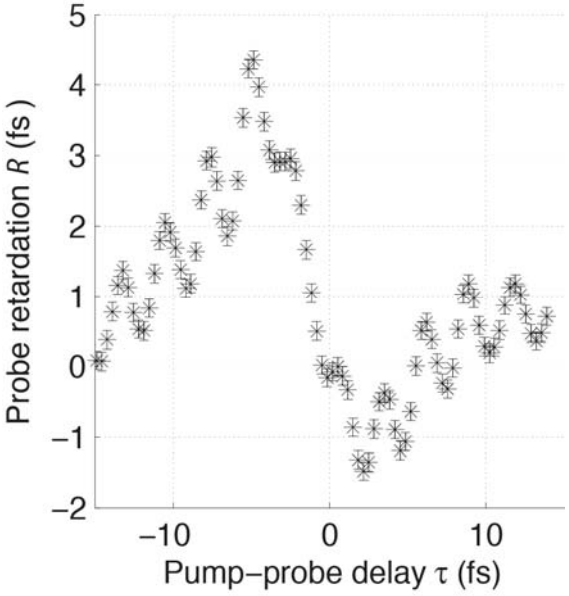
The most important experimental tools both for the preparation of these processes and for their observation are intense laser pulses that consist of only a few optical cycles. The field strengths of these laser pulses are comparable to the inner-atomic Coulomb fields, and hence allow to liberate electrons from their parent ions and thereafter steer them by means of the laser field. Demanding requirements to the laser source are not only very short pulse durations and very high intensities, but also stability of the carrier-envelope phase of the laser pulses, meaning that the electric waveform of the pulses is identical to one another. A well-suited laser source is available in collaboration with the group for non-linear optics.

A research direction that is presently very active aims to establish the field of subcycle nonlinear optics. The principle is to introduce subcycle dependence in pump-probe experiments with infrared pulses, and to exploit the timing of the subcycle behavior to gain new insight into ultrafast processes. The basic concept is the use of spatial-temporal coupling schemes (especially pump-probe geometry at low crossing angle and wavefront rotation) in subcycle-resolved measurements.

Subcycle-resolved probe retardation

A new method was developed which delivers time-resolved information about strong-field processes that occur in dielectric solids during one laser cycle. The method is based on the well-known effect “weak-wave retardation”, which means that a weak probe pulse in the presence of a strong pump pulse is retarded in time. A close-to-collinear alignment of pump and probe beams facilitates the detection of sub-cycle dynamics; the retardation of a probe pulse in a strong-field pumped, bulk dielectric is measured with sub-cycle resolution in the pump-probe delay.

The probe retardation is determined by imaging the fluorescence from a head-on collision of the probe pulse with a reference pulse inside a cuvette filled with Fluorescein. In front of the sample, a beam splitter steers a fraction of the pump and probe pulses to a camera, which measures the intensity to give an absolute time reference for the subcycle-resolved probe-retardation measurement. The subcycle dependence of the probe retardation (see figure) reflects the fast dynamics of the nonlinear material response in the strong field.



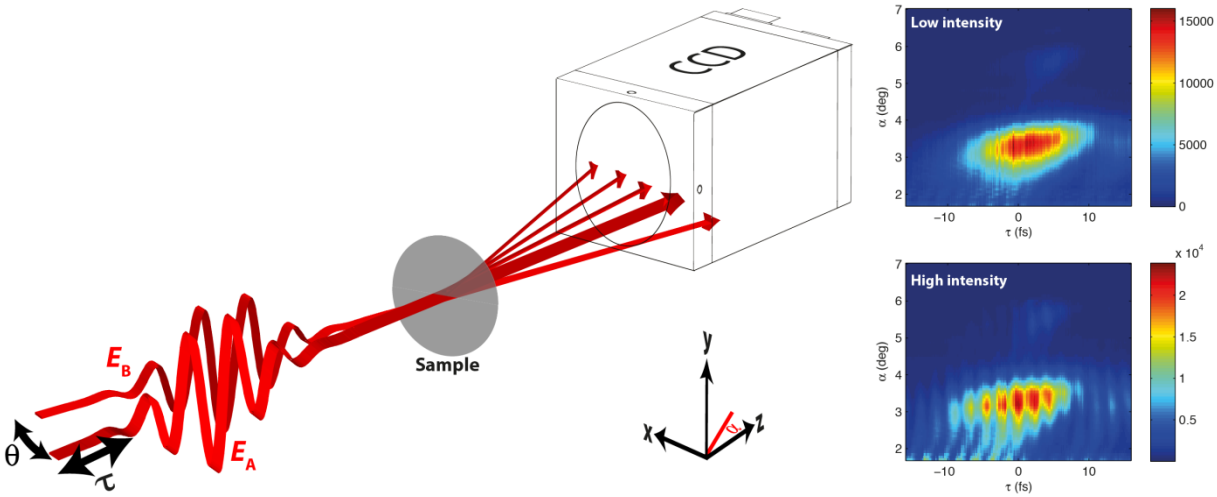
Comparisons to model calculations show that the measurement is sensitive to the timing of the electronic Kerr response. When conduction band states are transiently populated at the crests of the laser field, the measurement is also sensitive to the interband dephasing time.

References

[1] A. P. Pati, I. S. Wahyutama, and A. N. Pfeiffer, "*Subcycle-resolved probe retardation in strong-field pumped dielectrics*", Nat. Commun. 6, 7746, (2015)
[2] J. Reislöhner and A. N. Pfeiffer, "*The role of delay times in subcycle-resolved probe retardation measurements*", Physica E 76, 223, (2016)

Subcycle-resolved self-diffraction

The separation of a waveform into an envelope and a carrier wave frequently underlies the treatment of short pulse phenomena. The carrier-envelope offset phase (CEP) has little importance for pulses that comprise many cycles, but becomes a decisive quantity in the few-cycle regime. The position domain analogue to a few-cycle pulse can be realized by passing a laser beam through a grating with only a few grooves. The few-groove grating can be formed by crossing two beams under shallow angle. Diffraction of the two beams on the grating they form is referred to as self-diffraction. The groove-envelope offset phase (GEP), defined here as the phase between the grooves and the spatial envelope of the beams, can be tuned by delaying one beam, where a delay of one optical cycle translates into a GEP shift of 2π.



While subcycle dependence in nonlinear optics is usually encountered in collinear two-beam geometries (an example is interferometric autocorrelation), it is usually not observed in noncollinear geometries, because the wavefronts intersect each other multiple times. The junction of the two geometries, the regime of close-to-collinear geometries, is not very well explored. In this regime the dependence on the spatial phase, which is typically neglected in nonlinear optics, must be included.

Femtosecond laser pulses are focused onto a thin sample of borosilicate glass, see Figure. The intense laser pulse A passes the sample with a variable peak intensity of I_A = 10 – 25 TW/cm^2 at a variable delay τ, the weaker laser pulse B passes the sample with a peak intensity of I_B = 0.6 TW/cm^2. For low intensity, the first and the second orders of diffraction do not show significant subcycle dependence on τ. In the region between beam A and the first diffraction order, the intensity is strongly modulated with τ at the periodicity of the optical cycle. For high intensity, the modulation in between the diffraction orders is similar to the observation at lower intensity, but in addition there is a strong subcycle modulation on the diffraction orders themselves, which is absent for the lower intensity.

These observations make it possible to distinguish certain mechanisms for subcycle dependence. Interference of neighboring diffraction orders is a universal mechanism that can be observed both at low and high intensities. The observations at high intensities point to more complicated strong-field effects.

Reference

[1] A. P. Pati, J. Reislöhner, C. G. Leithold and A. N. Pfeiffer (submitted)

Spectrally resolved self-diffraction

There are currently many open questions regarding the response of dielectric solids to short laser pulses with intensities close to the damage threshold. It is a challenge both for theory and for experiments to distinguish between models for strong-field phenomena, such as the optical Kerr effect and plasma contributions. To investigate if the relevant strong-field phenomena can be distinguished based on spectral signatures, a setup for spectrally resolved self-diffraction was built.

Quantum path interference is a feature that can potentially reveal the contribution of distinct mechanisms to the total nonlinear response. Intensity scans in the intensity regime close to the damage threshold will be carried out and be compared to model predictions.

b) National Cooperations

Prof. U. Schramm, Dr. H.-P. Schlenvoigt, Dr. Stefan Kraft, Dr. Karl Zeil (HZDR Dresden)

Dr. R. Röhlsberger (DESY Hamburg) – Nuclear Resonant Scattering

Dr. A. Fleischmann (Universität Heidelberg) – Röntgenspektroskopie hochgeladener Ionen

Prof. T. Kuehl, University of Mainz, GSI, Germany

Prof. J. Jacoby, University Frankfurt, Germany

Prof. U. Kleineberg, University of Munich (LMU) and Max Planck Institute of Quantum Optics, Munich, Germany

Dr. U. Stiel, Max Born Institute, Berlin, Germany

7.8. Institute of Theoretical Physics

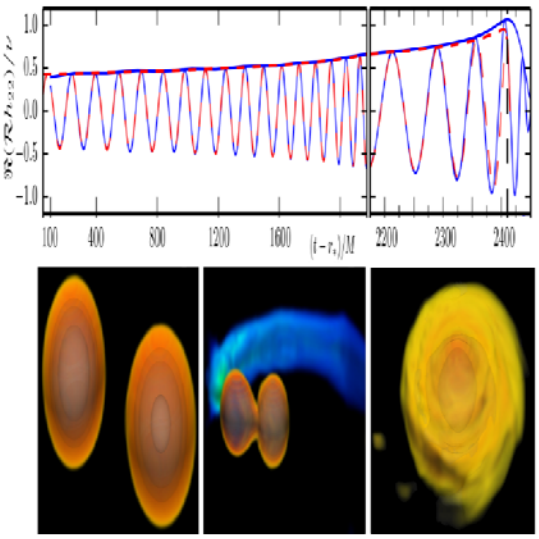
a) Fields of research and results

Gravitational Theory

1. Soliton-theoretic methods for rigorously solving initial and boundary value problems of the Einstein- and Einstein-Maxwell equations have been further developed and applied to problems of colliding plane gravitational waves, black holes and rotating discs.

2. The research group "Conformal Methods" studies field equations in conformally compactified coordinates. The main emphasis is put on the development of novel numerical techniques based upon pseudo-spectral methods in order to achieve extremely high accuracy of the resulting numerical solutions. In 2015 methods were further developed and refined, in particular in order to tackle problems in the realm of the ADS/CFT-correspondence, see also research report concerning gauge/gravity dualities below. In addition, in 2015 we concentrated on the analysis of quasi normal modes and the late time tail behavior which appear in the context of solutions to linear wave equations on hyperboloidal slices in given black hole space times. In particular, mathematical techniques were refined and extended in order to compute highly accurately the quasi normal mode and tail amplitudes from given initial data of the Teukolsky-equation. Furthermore, with specifically designed adaptations of our pseudo-spectral methods applied to spatial differential equations we were able to obtain highly accurate, strongly perturbed non-uniform black string solutions and corresponding results that are very much relevant in the collaboration with J. Kunz-Drolshagen (University of Oldenburg).

3. The focus area of Numerical Relativity is the solution of the classical field equations of general relativity for astrophysical systems. Topics were black holes and neutron stars, as well as gravitational waves generated in various binary and collapse scenarios. Newly studied were systems with significant eccentricity, as well as systems with spinning neutron stars which had not been accessible be-

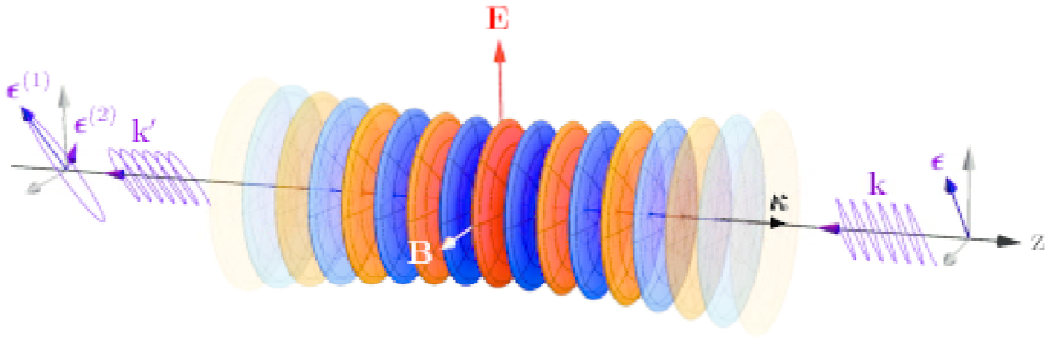


fore. A new numerical infrastructure for the evolution of extreme gravitational fields with pseudospectral methods was developed.

Binary neutron star merger. Computer simulations in general relativistic hydrodynamics show the merger of two neutron stars and the resulting gravitational wave signal. Such simulations have been performed for the first time for neutron stars with astrophysical spin.

Quantum Theory

1. Investigation of quantum vacuum effects in strong electromagnetic fields. Prediction of angular distribution of scattered photons off a laser pulse and polarization flip, offering a new experimental path way to discover vacuum birefringence for the first time. Development of a new theoretical formalism based on vacuum emission that gives substantial analyical control over strong field phenomena.



The combination of vacuum birefringence and light-by-light scattering has been proposed as a signature for nonlinear quantum vacuum properties, paving the way for a first experimental verification in an all-optical experiment.

2. Investigation of mass bounds for the Higgs bounds and stability properties of the standard model effective potential. Derivation of new consistency bounds for the mass spectrum of the standard model of particle physics accounting for the sensitivity to new high-scale physics. Development of new numerical algorithms for the renormalization group evolution of effective potentials.

3. Exploration of the concept of asymptotic safety in quantum field theory and quantum gravity. Construction of new asymptotically free gauged Higgs and Higgs-Yukawa models. Studies of the parametrization dependence of quantum gravity and construction of a global phase diagram. Analysis of the spin-base invariant formulation of fermions in curved spacetime.

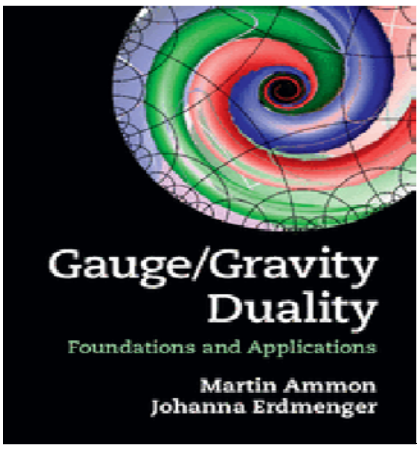
4. QCD phase diagram: We have continued the investigation of QCD and QCD-like theories both at finite density and finite temperature. We have calculated condensates and the baryon density to detect phase transitions at dense QCD-like matter at high densities.

5. Lattice QCD investigations of hadron physics phenomenology and the elementary Green's func-

tions of QCD in Landau gauge. The former studies are of direct interest for experiments on strong interaction physics. The latter calculations provide important benchmarks quantities for related physics communities working on QCD, the theoroy of the strong interaction, using functional methods (Dyson-Schwinger or Functional Renormalization Group equations). The corresponding lattice calculations are typically performed on supercomputers at the national centers for High-Performance computing (e.g., LRZ, HLRN, Jülich) or the local linux cluster “Omega” of the University of Jena.

6. Studies on the relativistic dynamics of highly-charged and finite quantum systems, based on Dirac's relativistic equation and the density matrix theory. Analysis of angular and polarization correlations of emitted electron and photons in collisions with ions, atoms and molecules. Comparison and support of ongoing experiments at synchrotrons, FEL and strong laser facilities.

7. Investigations of new dualities between quantum gravity theories and ordinary quantum field theories, known as gauge/gravity dualities. Within this framework, the phase diagram of strongly coupled field theories with chiral anomaly was investigated. In particular new spatially modulated phases were discovered within these field theories which are reminiscent of chiral nematic phases discussed in condensed matter physics. Moreover, the dynamics of strongly coupled superfluids after a sudden quantum quench is studied.



'An excellent introduction to the gauge/gravity duality and its main applications....', Juan Maldacena, Princeton

b) Cooperations (national)

Exchange and scientific overlap with L. Andersson (Max Planck Institute for Gravitational Physics, Potsdam)

Within Project G1 of GRK 1523 strong cooperation with J. Kunz-Drolshagen (University of Oldenburg)..

In the framework of the SFB/TR18, TPI cooperates closely with IOQ (group of Prof. Paulus) at FSU.

In the framework of the DFG research unit FOR 723, there exist an ongoing collaborations with ITP Heidelberg U. (groups of Profs. Pawlowski and Wetterich), ITP Frankfurt U. (group of Prof. Kopietz).

On Higgs mass bounds and vacuum stability, there is a larger collaboration also involving ITP Heidelberg (groups of Profs. Jaeckel and Plehn, Dr. Scherer).

Collaboration with IKP at TU Darmstadt (group of Prof. Braun) on relativistic fermion systems and in condensed matter systems and inhomogeneous phases in fermionic models.

Dr. Sternbeck is Associate Member of the SFB-TR55 (Regensburg-Wuppertal-Graz) and continues to work with colleagues on Lattice QCD investigations of hadron physics phenomenology. Thus there is a close collaboration between the TPI and the theory group of the University of Regensburg.

There is also a close collaboration with Prof. Müller-Preussker from the Humboldt-University on lattice QCD calculations of QCD's elementary Green's functions. The calculations were performed at the Norddeutsche Verbund für Hoch- und Höchstleistungsrechnen (HLRN).

With Dr. Göckeler and J. Simeth from the University of Regensburg and Dr. Perlt and Dr. Schiller from the University of Leipzig, Dr. Sternbeck is working on lattice perturbation theory.

A tight collaboration exists for many years with the Atomic Physics Division at GSI Darmstadt on excitation, ionization and decay processes in strong Coulomb fields (group of prof. T. Stöhlker).

The study of multi-electron photoionization processes at noble gases is in the focus of a collaboration with the groups of prof. S. Schippers at the Justus Liebig University of Giessen.

Multi-photon ionization and subsequent Auger processes are currently investigated together with the group of Dr. Michael Meyer from XFEL Hamburg, Germany.

Angle- and polarization studies are performed together with the Emmy-Noether group of Dr. Stanislav Tashenov from Heidelberg University.

7.9. Research Training Group (RTG) GRK 1523/2 "Quantum and Gravitational Fields"

a) Research

Quantum Field Theory:
The Theory of Quantum Fields is of great importance for gaining deeper insights into the fundamental laws of nature and has an increasing impact on novel applications. Quantum fields successfully describe the fundamental interactions in elementary particle physics and are of utmost importance for theories beyond the standard model. At the same time the theory of quantum fields plays an increasingly important role in laser, atom, and molecular physics, and is an indispensable tool to study phase transitions in many-body systems.

Gravity:
On large scales the universal gravitational force described by the gravitational field dominates. Through the burgeoning field of gravitational wave astronomy with its far reaching implications for astrophysics and cosmology, a deeper knowledge, and in particular realistic solutions of the Einstein field equations are urgently needed.

Mathematical Methods:
Research in Field Theory profits considerably from mathematical methods and the fruitful interplay of physics and mathematics. For example, the methods of modern differential geometry are needed for investigating symmetries and solutions of nonlinear field equations - in particular of Einstein's equations, and the emerging integrable structures. Structural insights and rigorous results about interesting states in quantum (field) theories are obtained with powerful methods of functional analysis. Moreover, for efficient and controlled simulations of quantum field theories optimized numerical and stochastic methods become increasingly important.

b) Cooperations

national:
With research groups in University Oldenburg (J. Kunz-Drolshaben), MPI Potsdam (L. Anderson), Tübingen (of K. Kokkotas und C. Lubich), MPI in Garching (E. Müller), MPI in Potsdam (B. Schutz and G. Huisken), University Frankfurt (P. Kopietz and M. Wagner), Technical University Darmstadt (L. von Smekal, J. Braun), University Giessen (C. Fischer), University Jena (G. Paulus), University Heidelberg (C. Wetterich, J. Pawlowski, J. Jaeckel, M. Scherer and V. Plehn), ITP Freiburg (Dr. Gneiting), MPI-FK Stuttgart (W. Metzner), DESY Hamburg (A. Ringwald), MPI in Munich (J. Erdmenger).

international:
With A. Castro (Amsterdam, Netherland), N. Iqbal (UC Santa Barbara, USA), M. Gutperle (UC Los Angeles, USA), A. O'Bannon (U of Oxford, UK), W. Tichy (U Florida, USA), A. Nagar (Bures-sur Yvette, France), T. Damour (Bures-sur-Yvette, France), G. Dunne (U Connecticut, USA), C. Schubert (U Morelio, Mexico), A. Eichhorn (Waterloo, Canada), F. Saueressig (U Nijmegen, Netherland), A. Codello (U Odense, Denmark), G.P. Vacca (U Bologna, Italy), J. Skullerud (U Maynooth, Ireland), O.

Cruciel (Wien, Austria), R. Alkofer (Graz, Austria), K. Langfeld (Plymouth, UK), I. Shapiro (Juis de Fora, Brazil), E. Mottola (Los Alamos, USA), D. Litim (Sussex, UK), M. Plyushchay (Santiago, Chile), M. Schaden (Rutgers University, USA), E. Strobel (ICRANeT, Italy), G. Torgrimsson (Chalmers U.), Dr. A. Kizilersü, A. G. Williams (both University of Adelaide, Australia), G. D'Odorico (University of Nijmegen, the Netherlands), T. Morris (University of Southampton, UK), M. Safari (University of Bologna, Italy).

c) Structure and financing of GRK

Members of the RTG „Quantum and Gravitational Fields“ are at the same time members of the

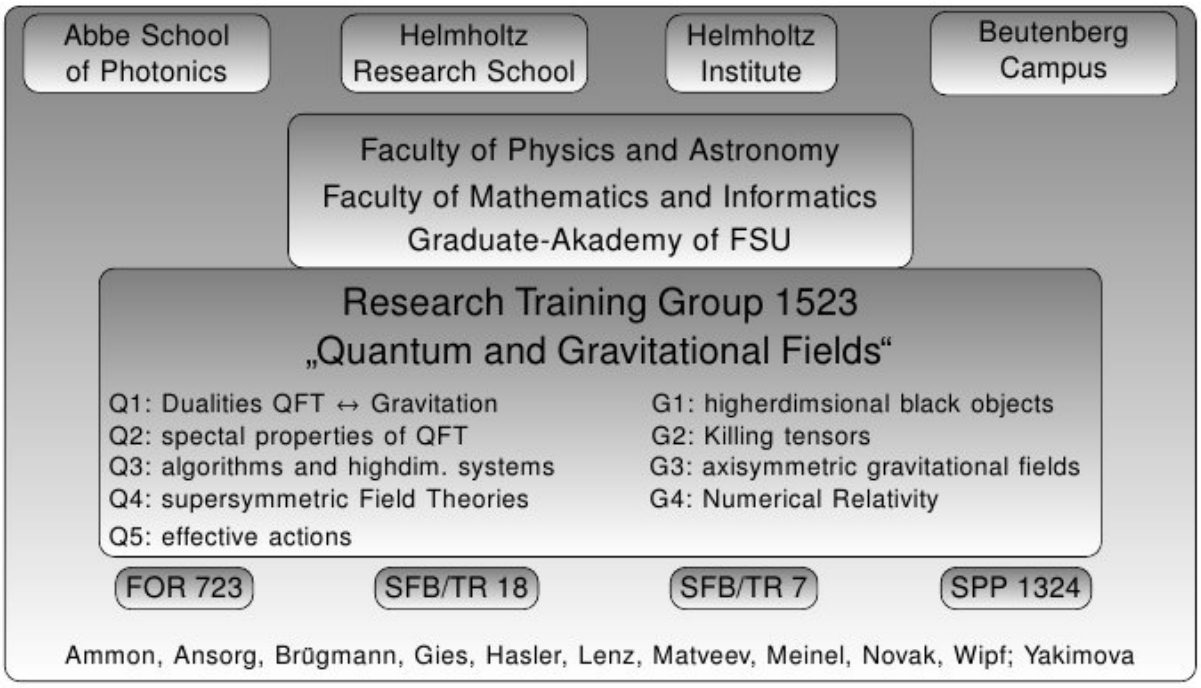
- Institute for Theoretical Physics (Theoretisch-Physikalisches Institut TPI)
- Institute for Mathematics (Mathematisches Institut MI)

Speaker is Prof. Dr. Andreas Wipf (TPI).

The RTG exists since October 2009 and the first funding period ended in September 2013. After a very successful evaluation the group is now in its second funding period which ends in March 2018.

The RTG consists of 15 PhD students and one postdoc which are funded directly by the DFG. Another 15 PhD students and seven postdocs, which are funded by the university or other sources, are associated members of the RTG. Principal investigators are the Professors M. Ammon (TPI), M. Ansorg (TPI), B. Brügmann (TPI), H. Gies (TPI), D. Hasler (MI), D. Lenz (MI), V. Matveev (MI), R. Meinel (TPI), E. Novak (MI) und A. Wipf (TPI). In addition, Professor O. Yakimova (MI) is associated to the RTG.

The RTG 1523 is divided into two research areas: Quantum Field Theory and Gravitation. It consists of 9 projects dealing with research problems in fundamental theoretical physics and mathematical physics.



Structure of the Research Training Group “Quantum and Gravitational Fields”

Content and objectives of the program:

The first focus of the college deals with the quantum field theoretical description of fermionic many-body systems and their coupling to bosonsic fields

Project Q1 of the RTG deals with quantum critical phenomena in strongly coupled quantum systems. They are studied with the help of dualities between quantum field theories and gravity. For example,

with the well-established AdS/CFT correspondence physically relevant phases and states are classified. Thereby non-equilibrium quantities such as relaxation times of observables and transport coefficients are calculated. A key feature of this project is the cross-fertilization of quantum field theory and gravity. In the second project Q2 analytical methods are applied to investigate spectral and dynamical properties of quantum matter in interaction with quantum fields. Of particular interest are the properties of the ground state and of excited states, for example in non-relativistic quantum electrodynamics. In addition, decoherence properties of quantum fields at finite temperature are characterized and the existence of phase transitions in long-range spin models are proved. An extension of the analysis based on renormalization is under way. In several projects of the RTG stochastic methods are used. Thus randomized algorithms for approximating high-dimensional integrals are examined, further developed and optimized in project Q3. The important conductivity of local and global algorithms is estimated and compared for spin models and nonlinear sigma models. In project Q4 stochastic algorithms are used in the simulation of quantum field theories with fermions and in particular supersymmetric lattice theories. Supersymmetry is part of many attempts to construct a unified theory beyond the Standard Model of particle physics. In the project nonperturbative effects such as symmetries of the ground state (or ground states), the emergence of condensates, the mass spectra, phase transitions or the breaking of supersymmetry are investigated. Here sophisticated analytical and numerical methods such as the functional renormalization group or state of the art simulation algorithms for lattice theories with dynamical fermions play an important role. Many studies of classical or quantum systems aim at the calculation of the effective action for macroscopic degrees of freedom. The project Q5 is dedicated to the functional renormalization group. In the past it has been successfully applied (and further developed in Jena) in order to answer several important questions, examples include the non-perturbative study of the Higgs mass bounds, the calculation of condensates and symmetry-breaking phase transitions. It also is used to investigate the quantum-induced energy-momentum tensor in curved spacetimes.

The second focus of the RTG is on gravitational fields in the vicinity of compact astrophysical objects.

In project G1 so-called black objects, such as black holes or black strings in higher dimensions, are constructed and investigated for their physical and geometric properties. Such solutions of the gravitational field equations in higher dimensions with an event horizon are of great importance in the string-inspired correspondence between quantum field theories and gravity. Especially sought are solutions with de Sitter or anti-de Sitter asymptotics. The solutions will be constructed with the pseudo-spectral methods developed in Jena. When one solves Einstein's field equations and describes geodesic motions in the gravitational field symmetries and conserved quantities play a major role. These are closely connected with the existence of Killing tensors. The theory of Killing tensors and their relationship with curvature invariants are studied in the project G2. Here the question will be investigated when a stationary and axially symmetric vacuum solution admits Killing tensors. One can interpret the Killing equations as field equations for the Killing-connection and may construct curvature invariants with field theoretic methods. This also leads to he Ernst equation, which has been carefully studied by the gravity group in Jena. Hence there is a close relation of project G2 to other projects in the RTG dealing with gravitational fields. In the project G3 stationary and axially symmetric solutions of the Einstein-Maxwell equations will be constructed. As a concrete application a rigidly rotating disk of dust with constant specific charge will be investigated. Here a parametric transition to black holes is possible. The emerging system of coupled integrable Ernst equations will be treated with soliton theoretic methods. Thereby methods developed in Jena for the treatment of boundary value problems of the Ernst equation are used. In parallel, a hyperbolic version of the Ernst equation should be investigated. It describes the propagation of (nonlinear) gravitational waves. Project G4 deals with the numerical treatment of black holes and neutron stars - as single objects or bound in binary systems. In the numerical calculation of gravitational two-body systems, there exist several renowned contributions of the relativity group in Jena. The goal is the detection and analysis of gravitational waves in the final stages of binary systems and the creation of a complete catalog of wave

templates in the phase space of compact objects. With different approaches initial data for eccentric neutron star binaries will be calculated. These will be used to compute the time-evolution of these systems. Here the influence of strong magnetic fields of neutron stars is of particular interest.

Activities during the reporting period

In addition to the contact interaction between the PhD-students and principal investigators, the students profit from attending schools and conferences and the chance to come in contact with renowned guest scientists invited by the RTG. The following events have been organized by the RTG or co-organized by principal investigators of the RTG:

- Weekly seminar organized by the PhD-students
- 21st Heraeus Summer School for graduate students on ,,Foundations and New Methods in Theoretical Physics", from August 31st to September 11th 2015 in Wolfersdorf
- Workshop „New directions in Mathematical Physics and beyond“, January 14th 2015 in Jena
- Networking Workshop of the RTGs Models of Gravity (RTG 1620) and Quantum and Gravitational Fields (RTG 1523), March 2nd to March 5th 2015, ZARM, University of Bremen
- Monitoring-Workshop of the RTGs of Graz and Jena, September 28th and 29th 2015 in Jena
- Workshop “Strongly Interacting Field Theories (SIFT) 2015”, from November 5th to November 7th 2015 in Jena

In the year 2015, the Research Training Group supported about 100 trips of PhD-students and postdocs to conferences, workshops, annual meetings, summer schools and research visits, including some longer-term visits of institutions abroad.

7.10. Abbe Center of Photonics (ACP)

The Abbe Center of Photonics (ACP) is an interfaculty center within the Friedrich Schiller University Jena with its office allocated at the Faculty of Physics and Astronomy. Its members are dedicated to the optics and photonics research and education. By the end of 2015, ACP is comprised of 46 principal scientists, among them 35 full professors, four junior professors and seven group leaders. 25 of ACP’s members are affiliated with the Faculty of Physics and Astronomy, the others with the Faculties of Chemistry and Earth Sciences, Biology and Pharmacy, and Medicine, respectively. The center and its members commit themselves to Jena’s tradition of excellent research and teaching in the field of optics and photonics and thus form the core of the key research area “Light” regarding the University’s institutional strategy “Light – Life – Liberty”. ACP's main mission is to promote and to coordinate interdisciplinary research jointly performed by scientists from different subject areas and to contribute sustainably both in fundamental and applied optical sciences. While encompassing a broad variety of research fields, ACP concentrates on expertise development in its three strategic domains **ultra optics, strong field physics and biophotonics**. Besides ACP’s research efforts, the education of young research scientists, represented by its integrated **Abbe School of Photonics (ASP)**, exhibits its fourth profile cornerstone and cross-connects all research areas (see Figure 1).

Since its foundation in 2010, ACP was supported by a concept for structural measures funded by the Carl Zeiss foundation. In sync with its integrated **Abbe School of Photonics (ASP)**, ACP sustains strategic cooperations with more than 20 industrial partners. By now, ACP’s members have experienced a remarkable synergetic effect by creating novel ideas together. Jointly they developed a strategic roadmap called “ACP^{2020} – Agenda for Excellent Photonics”. Since the beginning of 2015, its implementation is financially supported by the Thuringian state government until at least 2019. Within this program, a new junior research group was established at ACP and the staffing of the leader position was collocated with a highly competitive selection procedure at the standard of a regular appointment procedure. As a result and starting from July 2015,the position was staffed with Dr. Isabelle Staude, formerly Karlsruhe Institute of Technology and Australian National University, an early-career

experimental scientist with a strong background in nanostructured active and passive photonic materials. The junior research group is part of a roadmap which defines ACP's vision of establishing itself by the year 2020 as one of the leading European centers for research and education in optics and photonics, as well as in the development and transfer of optical technologies. This agenda will be a stimulus of a strong level of commitment for all ACP scientists in the years to come.

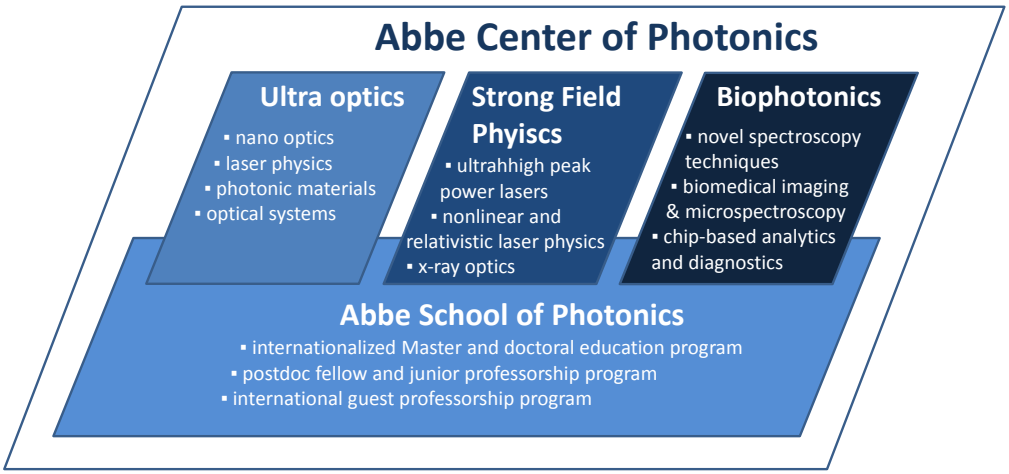


Figure 1. ACP's structure, research and education foci.

2015 was quiet an eventful year for ACP. For the sake of brevity, only a selection of highlights will be mentioned here. Very early this year, the first actions within the international staff exchange program NANOPHI ("Europe-Asia-Pacific Exchange program in Nanophotonics") were carried out. The purpose of the program is the exchange of researchers and lecturers as well as the buildup of an international research network in the field of nanophotonics, implying e.g. nano-based optoelectronics and high-resolution micro- and nanoscopy. In this project, partnered by ACP, an overall of eight universities from Europe (Università degli Studi di Brescia, Université Paris Diderot, Aston University, King's College London, Sofia University St. Kliment Ohridski), Australia (Australian National University) and New Zealand (Massey University) are involved. The project is being funded with EUR 1.5 million for four years within the scope of the European Commission's mobility program Erasmus Mundus. Now and still until 2018, Jena's doctoral students, postdocs, research scientists and lecturers in the field of nanophotonics can apply for an individual research stay at the Oceanian partners. Concerning incoming mobility, ACP will host at next the Australian scientists Mrs. Katie Chong and Mr. James Titchener within the framework of NANOPHI in early 2016.

Figure 2. Impressions from ACP's annual meeting in March 2015.

During 2015, ACP's members gathered two times to plan and discuss scientific activities and collaborative research projects. Firstly, on March 18, the regular annual meeting was hold at the Fraunhofer IOF. Beside the ACP members, also the Vice-Rector for Research and dean of the Faculty for Biology and Pharmacy were among the attendants (see Figure 2). The meeting was called in by the board of

directors who reported on the center's activities and achievements during the last year. Particular focus was placed on discussing the agenda "ACP^{2020} – Agenda for Excellent Photonics", funded with up to EUR 3.9 million within Thuringia's ProExcellence strategy 2014 – 2019.

The second annual strategic meeting took place in the form of a workshop at the 2-day retreat in Suhl. The strengthening of existing and the establishing of new links inside the ACP community were one focus. The participants discussed novel approaches to pertinent research and educational questions with special regard to the scientific landscape and perspective of Jena. Particular emphasis was put on developing strategies for future projects in structured funding schemes of the German Research Foundation. The optimization of the optics and photonics academic education in Jena was another key point of the meeting, for which fruitful proposals.

On both occasions, ACP scientists continued to work along the lines of their agenda via an internal competitive research scheme called "ACP Explore". In this scheme, small to medium research projects with a high level of innovation and risk, strategic importance as well as a clear potential to promote scientific networking, are funded with up to EUR 100,000 each. Thus, each ACP Explore project is co-operated by at least two ACP principal scientists with different topical backgrounds. Only in 2015, already six ACP Explore projects were launched:

- “Enlightning new states of matter” by Alexander Szameit and Holger Gies,
- “Intelligent laser scalpel for the diagnosis and therapy of tumors” by Jürgen Popp and Stefan Nolte,
- “Time-resolved spectroscopy of molecular dynamics with pulses at different wavelengths” by Stefanie Gräfe, Benjamin Dietzek and Christian Spielmann,
- “Integration of Molybdenum Disulfide Monolayers with Photonic Nanostructures” by Isabelle Staude and Andrey Turchanin,
- “Quantum mechanical calculation of near-field Raman spectra considering field gradients at plasmonically active metal nanoparticles” by Volker Deckert, Ulf Peschel and Stefanie Gräfe, and
- “Single molecule trap for ultrasensitive detection of soluble markers and drugs against autoimmune diseases” by Michael Börsch and Jens Limpert.

A regular external evaluation of the ACP and its activities was carried out on May 26 by the second meeting of the ACP advisory board (see
On June 1, Thomas Pertsch regularly resigned his position as the executive director of the Abbe Center of Photonics after one year. According to the statute of the ACP, Andreas Tünnermann was elected as the new executive director for one year, with Stefanie Gräfe from the Faculty of Chemistry and Earth Sciences being the deputy director. Along with this election, all ACP directors confirmed that the center will continue to take its management decisions and responsibilities as a joint task with the respective duties and obligations shared by the whole board.

Figure 3). The advisory board had been appointed in 2013 by the former rector Prof. Klaus Dicke. The board's primary role is to assist the ACP directors in the development of a management strategy and vision for the future, ensure that the proposed goals and achievements are consistent with the strategic plan, and serve as a vehicle for strengthening linkages between academia, industry, government and community. The board was chaired by its speaker, Prof. Günther Tränkle (Director of the Ferdinand-Braun-Institute, Berlin). The other members of the board are Prof. Thorsten Heinzel (Vice-President for Research at the Friedrich Schiller University), Dr. Michael Kempe (Head of Corporate Research and Technology at the Carl Zeiss AG), Mr. Dennys Klein (Head of division at the Thuringian Ministry for Economy, Science and Digital Society), Prof. Vahid Sandoghdar (Director of the Max Planck Institute for the Science of Light, Erlangen), and Prof. Helmut Zacharias (Professor at the University of Münster). At the meeting, the center's scientific profile and future role was comprehensively investigated. Special focus was placed on the ACP's vision and future goals. Emphasis was also put on the new ACP research building at the Beutenberg campus, its future usage and the consecutive demands for infrastructure and laboratory equipment. The advisory board formulated detailed

statements and suggestions, which were forwarded to the president of the Friedrich Schiller University.

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Figure 3. Impressions from the meeting of the ACP advisory board in May 2015.

Already in 2013, ACP became part of a project funded by the Alexander von Humboldt Foundation for international alumni work. The ACP and the University of Jena were among the altogether sixteen winners of two rounds of the competition "Research Alumni Strategies" funded by the Federal Ministry of Education and Research (BMBF). In 2015, five members from the Friedrich Schiller University were invited to participate in the "3rd Research Alumni Conference", an international research networking event by the in Berlin in September. The idea behind was to win outstanding researchers as ambassadors for the German research landscape and German research institutions. The conference aimed to provide an overview of current trends in international scientific mobility, of the German research landscape as well as of funding programs available to international researchers. Likewise in Berlin and in December, the involvement of ACP lead to three invited slots to attend the prestigious the Falling Walls Conference 2015. Falling Walls is an international platform for leaders from the worlds of science, business, politics, the arts and society. It was initiated on the occasion of the 20th anniversary of the fall of the Berlin wall and fosters discussion on research and innovation and promotes the latest scientific findings among a broad audience from all parts of society. The participants nominated by ACP were Dr. Daniil Kartashov (IOQ), Dr. Nadine Ritter (coordinator of the alumni work at the University) and Dr. Christian Helgert (ACP).

Figure 4. Left-hand side: Jena's participants at the 3rd Research Alumni Conference 2015: Dr. Dorit Schmidt, Dr. Zhenglong Zhang, Mr. Sina Saravi, Dr. Nadine Ritter and Dr. Olexandr Nikolaychuk (from left to right) . Right-hand side: Federal Minister Johanna Wanka and others at the Falling Walls Conference 2015. For both events, ACP received a limited edition of tickets from the Alexander von Humboldt Foundation.

The most publicly visible steps in 2015 were certainly achieved with regard to the new research building "Abbe Center of Photonics", see Figure 5. This multifunctional research and teaching building will offer 2,600 m² space for functionalized optical, biological and chemical labs, seminar rooms, offices and an auditorium. Now, the date of the handing-over to the scientists is fixed: from March 2016 on, the new research site will give an integrative stage for interdisciplinary exchange within ACP's main research areas by hosting laboratories for joint research performed by ACP's principal scientists. The research groups which will move into the building are those of Jens Limpert and Thomas Pertsch, furthermore parts of the groups of Ulrich Schubert, Jürgen Popp, Stefan Heinemann, Andreas Tünnermann, Ulf Peschel and Stefan Nolte will operate the new offices and laboratories. Furthermore, the new building will allow for the enhanced integration of ACP's photonics educational programs into its research program, e.g. the optics training laboratory for the 1st semester in the M.Sc. Photonics course program. The construction works were funded by the State of Thuringia and the German federal government with more than EUR 25 million.


Figure 5. Left-hand side: A delegation of the Federal Minister for Energy and Economic Affairs Sigmar Gabriel passed the new Abbe Center of Photonics building during his visit at the Fraunhofer IOF on the Beutenberg Campus in Jena (Copyright by OTZ/Tino Zippel). Right-hand side: The Western facade of the almost finished building by October 2015.

7.11. Research School of Advanced Photon Science of the Helmholtz Institute Jena

Among the most important tasks of the Helmholtz Institute Jena (HI Jena) is the education and support of young scientists. The Research School of Advanced Photon Science (RS-APS) provides structured PhD education adapted to the research profile and organizational structure of the HI Jena. Emphasis is given to research fields that are relevant for the international FAIR project in Darmstadt and the European XFEL facility in Hamburg, both being currently in the construction phase.

In 2015 about 35 PhD students were participating in the program of the research school. The significant increase in participant numbers compared to previous years is due to the very successful attraction of third-party funding for new Phd positions. The Phd students were supervised by 14 principal investigators belonging directly to the Helmholtz Institute Jena or to institutes of the cooperating University Jena. Besides their doctoral work the students have the possibility to participate in the academic program which is offered directly by the Helmholtz Institute Jena and moreover they have access to the broad spectrum of courses provided by the cooperating graduate programs. More specifically, RS-APS is member of the graduate academy of the Jena University and additionally, the school is in close cooperation with both the Abbe School of Photonics, which resides at the Department for Physics and Astronomy (PAF), and the DFG graduate college “Quantum and Gravitational Fields”. Moreover since 2013 the RS-APS is member of the Helmholtz Graduate School for Hadron and Ion Research (HGS-HIRe) which promotes structured PhD education for research associated with FAIR and GSI.

The regular on-site seminars of the Research School provide the students either a platform for presenting their recent results or meeting distinguished researchers in the field. Additionally in 2015 almost half of the students of the HI Jena participated in dedicated soft skill block courses offered by HGS-HIRe focusing on the strengthening the core competencies of young researchers. Furthermore students of the Helmholtz Institute attended so-called Power Weeks by HGS-HIRe. A Power Week is focused on a particular science topic. In contrast to a lecture week it is not interdisciplinary and therefore allows discussions on a much deeper level. In addition transferable skill courses offered on site by the graduate academy Jena have been visited, e.g. qualification in academic teaching.

One major event in 2015 was the second joint HGS-HIRe and RS-APS Lecture Week which took place in Haus Ebertsberg from September 8th to 13th. The whole week 20 students from RS-APS and HGS-HIRe dealt intensively with “(Laser) Spectroscopy of Stored and Trapped Ions”. The PhD students have been supervised by the lecturers Yuri Litvinov (GSI), Wilfried Nörtershäuser (TU Darmstadt), Jan Rothhardt (HI Jena) and Andrey Surzhykov (HI Jena).

The Research School of the HI Jena is not only supporting its students financially through scholarships but also every student has its own annual travel budget which he can spend individually. In 2015 more than half of the doctoral candidates took use of this money for visiting international workshops and conferences to present their research results.

Figure 1: Participants of the lecture week at Haus Ebersberg

8. Visible Results of the Research and Teaching Avtivities

8. 1. Honorary Doctorate

2015 was proclaimed as *International Year of Light.* On this occasion the Faculty of Physics and Astronomy decided to set a highlight with the award of an honorary doctorate to an outstanding personality in the field of optics and laser physics. Such an excellent personality is Prof. Dr. Anne L'Huillier from the University of Lund, Sweden. Her discovery of high-harmonic generation had a deep impact on the present scientific programs at our faculty. The research programs of more than five research groups take advantage of Professor L'Huillier's discovery. Furthermore, it was the first time that a woman was awarded with the honorary doctorate of the Faculty of Physics and Astronomy. The dean respectfully calls her "the Marie Curie of the attosecond laser physics".

Anne L'Huillier has an extraordinarily distinguished scientific record. She authored an co-authored some 190 publications that have been cited 16.000 times. Her h-index exceeds 60, meaning that 1/3 of her papers were cited more than 60 times. There are at least three extremely important papers: The discovery of high-harmonic generation, the discovery of non-sequential double ionization and the discovery that high harmonics can magically form attosecond pulses.

Prof. L'Huillier received a series of honors and prizes. In 2011 she became a member of the Legion of Honor, the highest French Order of Merit. Two years ago she received the Carl Zeiss Award. In the same year, she received her first and so far only honorary doctorate from Université Pierre et Marie Curie in Paris. Anne L'Huillier is a member of the Nobel Prize committee

During the awarding ceremony of the honorary doctorate: The Dean of the Faculty of Physics and Astronomy, Prof. G.G. Paulus (left), Prof. Anne L'Huillier (in the middle) and the President of the Friedrich Schiller University, Prof. W. Rosenthal (right).

8.2. Abbe School of Photonics guest professor and visiting scholar program

The ASP guest program was continued as a truly international brand. Besides its research focus, it emphasizes the involvement of world-class international scientists as guest professors in ASP's education program. Renowned scientists from all over the world are invited to join the local optics and photonics community for several weeks in challenging research collaborations and teaching activities in the Master's degree and doctoral programs. In 2015, two guest professors were our guests:

Prof. Asger MORTENSEN (Denmark Technical University), he gave a series of lectures:

- Nanoplasmonics: From classical electrodynamics to possible quantum mechanical phenomena
- Nanophotonic approaches to enhanced light-matter interactions: Slow-light effects
- Nanophotonic approaches to enhanced light-matter interactions: Field-enhancement effects
- Nanoplasmonics probed by fast electrons
- Semi-classical approach to nonlocal plasmonic response: Hydrodynamics
- Semi-classical approach to nonlocal plasmonic response: Extended approaches
- Graphene plasmonics (& beyond)
- Quantum plasmonics in metallic nanostructures

PD Dr. Sandro WIMBERGER (Dipartimento di Fisica e Science della Terra, Università di Parma, Italy), he gave one lecture:

- Stable Structure Formation and Non-equilibrium Transport in Dissipative Optical Lattices

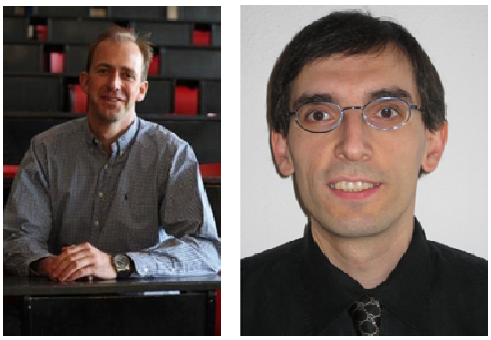


Figure. ASP guest professors in 2015: Asger Mortensen (left) and Sandro Wimberger.

During his long stay, Prof. Mortensen gained considerable insight into the research and teaching activities at ACP and ASP. Hence he offered his valuable feedback on our curriculum based on his very personal perspectives. Excerpts from the impressions of our guest Asger Mortensen are as follows: "My 2-month stay in Jena at the Abbe School of Photonics has been highly rewarding and a truly exciting experience for me. Being invited to spend a sabbatical in the 'Lichtstadt' during the International Year of Light has been a great honor for me! The historic academic atmosphere, the stimulating scientific environment, and the impressive industry activity create a unique setting for leading research and innovation in the field of optics & photonics. The ASP guest professor program has been a wonderful platform for me to engage in both young-researcher training and in research collaborations. Lecturing for dedicated research students, postdocs, and faculty has been a real privilege for me. The weekly lectures have also served to catalyse enlightening discussions from which projects and collaborations are now emerging, thus hopefully creating impact that reach far beyond my return to DTU. Indeed, I hope that my term in Jena will be the seed for long-term research collaborations and future student and researcher exchange. Also on a personal level, my stay has been highly rewarding and I have enjoyed the warm and kind hospitality of Prof. Thomas Pertsch, his nano-optics research group, and the entire ASP organization. I am leaving Jena with my luggage full of long-lasting memories and I already anticipate my return for at least shorter visits - hopefully also to see your activities flourish in the new Abbe Center of Photonics building!"

8. 3. Awards

8. 3. 1. Awards for the best doctoral thesis and Master's thesis

Since 1991 the Rohde & Schwarz Company, Munich, is endowing an annual prize for the best thesis (1,500 €) and the best diploma or Master's thesis (1,000 €) of the faculty of Physics and Astronomy. The company founders Dr. Lothar Rohde and Dr. Hermann Schwarz endowed this prize to honour the university where they in 1931 did their doctorate in the Physical Technical Institute. The Prize should honour outstanding scientific paper whereby the award winners were selected by the faculty alone. Rohde & Schwarz demonstrates with the endowed prize its interest in highly qualified engineers and physicists.

In 2015 the prize for the best Master's thesis went to **M.Sc. Paul Pflugradt** from the Institute of Solid State Theory and Optics for his Master's thesis entitled "Silicene on metallic surfaces". Silicenes are theoretically predicted as "miracle material" for nanoelectronics. The problem is the preparation of silicene layers by chemists or physicists. In his master's thesis Paul Pflugradt therefore has screened the most favored metal substrates and their surface orientations. Two of them he checked in detail by density functional theory. For a silver(111)-substrate he constructed a silicene phase diagram. The calculated atomic geometries and electronic structures resulting for silicene adsorbates explain the experimental findings very well.

In 2015 the prizes endowed by the Rohde & Schwarz company were awarded to M.Sc. Paul Pflugradt (left) for his Master's thesis and to Dr. Falk Eilenberger (right) for his doctoral thesis. The prizes were presented by Dr. Hendrik Bartko from Rohde & Schwarz (always left) and the dean of the faculty, Prof. Dr. Gerhard Paulus, (always right).
Photos: Jan Bernard

The prize for the best doctoral thesis went to **Dr. Falk Eilenberger** from the Institute of Applied Physics for his thesis entitled "Spatiotemporal, Nonlinear Optics and the Quest for the Observation of Discrete Light Bullets". In his work Dr. Eilenberger focuses on the experimental proof of the existence of so-called "Light Bullets". This are spatiotemporal localized light fields in which diffraction, dispersion and non-linearity are in balance. Such critical states of equilibrium of linear and nonlinear properties are responsible for the behaviour of some nonlinear systems like wether phenomena, effects in the human nervous system, traffic or the dynamic of oceans. Their understanding is essential for science and techniques. But all these systems are experimentally difficult to access. Therefore the nonlinear optics as model system plays an important role as an explorative experimental "playground".

Further prizes were awarded by the Friedrich Schiller University respectively its society of friends and supporters. Each faculty can award one prize for the best doctoral thesis the so-called *Promotionspreis* and one prize for the best degree thesis (diploma, examina or Master's thesis), the *Examenspreis*.

The Promotionspreis for the Faculty of Physics and Astronomy went in 2015 to **Dr. Stefanie Kroker** from the Institute of Applied Physics. In her thesis "Siliziumbasierte resonante Wellenleitergitter für rauscharme interferometrische Resonatorkomponenten" she developed components with highest requirements for the application in interferometers to measure gravitational waves.

On the occasion of the annual matriculation ceremony the Examenspreis 2015 was awarded to **M.Sc. Philipp Wustelt** from the Institute of Optics and Quantum Electronics. In his Master's thesis he investigated the ionization of atomic ions in intense laser fields.

The award of the prize for the best doctoral thesis to Dr. Stefanie Kroker on the occasion of the Schiller day.

M.Sc. Philipp Wustelt (fourth from right) was awarded with the Examenspreis for his Master's thesis.

(Photos: Jan-Peter Kasper)

Dr.-Ing. Siegfried Werth Prize

The Dr.-Ing. Siegfried Werth Foundation, established in memory of the pioneer of optical coordinate measurement and founder of the company of Werth Messtechnik GmbH in Giessen, has made it its aim to sponsor junior scientists in the field of optoelectronic coordinate measurement. On an initiative of Dr.-Ing. habil. Ralf Christoph, today's managing director of the company and an alumnus of our Faculty, the Foundation has since 2010 been donating an annual price for the best doctoral, Diplom or Master's thesis in the field of optical measurement, to be awarded by the Faculty of Physics and Astronomy.

In 2015, the prize of the Dr.-Ing Siegfried Werth Foundation was awarded to **Dr. Michael Zürch** of the Institute of Optics and Quantum Electronics, for his doctoral thesis on "Coherent High Resolution Imaging of Artificial and Biological Specimens Using Compact Ultrafast Extreme Ultraviolet Sources" published in Springer Theses (Recognizing Outstanding Ph.D. Research).

Arno Fink , Chairman of the Board of Trustees of the Dr.-Ing. Siegfried Werth Foundation (right), during presentation of the prize to Dr. Michael Zürch (centre).
Photo: Jan Bernert

8.3.2. Prize for Exceptional Commitment to the Benefit of the Faculty of Physics and Astronomy

This prize was first awarded in 2013 on the ceremonial occasion of handing out the graduation certificates. It is endowed by the financial services company MLP AG with the aim of promoting charitable commitment to the benefit of the Faculty. The prize money of 250 € can be split between several persons.

In 2015, this prize went to the team of the student council of the faculty. The students council is a reliable link between the students and the Dean's office of the faculty. Upcoming problems were discussed with the dean regularly. Together we seek for solutions. Furthermore, the students council is very active in lecture evaluation, organization of orientation days for new students and diverse events for all our students. (see chapter 11.3) On behalf of the entire team the chairman, Michel Pannier, and the very active members Nils Becker and Sebastian Ulbricht accepted the MLP prize.

Jens Trinter (right), director of the Jena branch of MLP, awarded the Prize for Exceptional Commitment to the Benefit of the Faculty of Physics and Astronomy to the student council. Nils Becker, Sebastian Ulbricht and Michel Pannier (from left right) accepted the prize on behalf of the whole team.

Photo: Jan Bernert

8. 3. 3. Teaching awards

The student body of the Faculty of Physics and Astronomy annually evaluates all courses held at the Faculty and awards a teaching award (without prize money) in the form of a challenge cup. In the context of the achievement-oriented distribution of funds within the Faculty, the Faculty Council has come out in favour of including teaching into the achievement criteria and therefore decided to endow the student body's teaching award with a prize money out of the Faculty's budget. In addition, the Council has earmarked prize money for another award conferred by the Dean to faculty members of merit in teaching who are regularly disregarded by the student body.

On basis of the evaluation the student body teaching award in winter semester 2014/15 went to **Dr. Ronny Nawrodt** for his lectures and practical training in electronics and measurement techniques.

The prize was awarded during the traditional student-professors - meeting on June 24th. (Photo left: Stefanie Kroker)

In summer semester 2015 the award was given to **Jun.-Prof. Dr. Martin Ammon**, whose lectures in quantum field theory, as well as his seminars achieved marvelous ratings. (see photo left below)

Additional acknowledgement for exceptionally good teaching was given to **Dr. Stefan Völker**. Because he couldn't take part in the traditional meeting "The Dean informs you" on December 3rd he was later awarded in the Dean's office. (see photo right below)

Photo: Jan Bernert

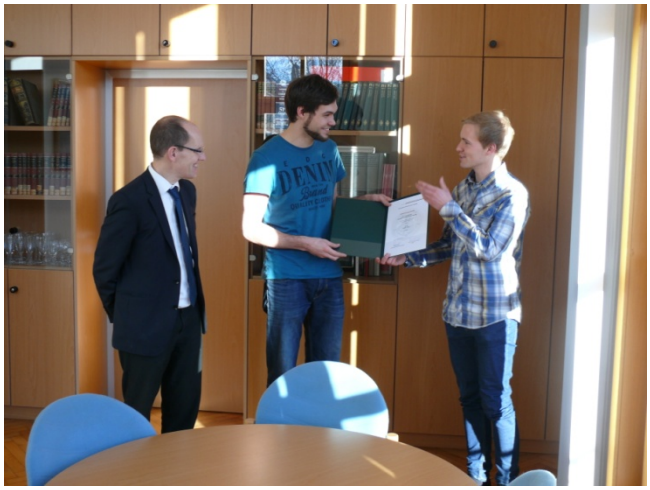


Photo: Angela Unkroth

The Dean's teaching award went to the Master students **Sebastan Ulbricht** und **Michel Pannier** for the organisation and performance of a refresher course in mathematics before the mathematical pre-course for study beginners in physics. Such a refresher course was introduced in 2015 first time because of the bad mathematical knowledge of more and more study beginners.

The Dean of students, Prof. Lotze, presents the Dean's teaching award to Sebastian Ulbricht (left) and Michel Pannier (right). Photo: Jan Bernert

8. 3. 4. Performance bonuses

The University has made it possible to pay bonuses to employees who perform exceptionally well. Proposed by the institutes and the Faculty Board, the following employees of the Faculty of Physics and Astronomy were paid performance bonuses in 2015:

- **Bodo Martin**, charged with the technical management of the Institute of Applied Physics, is responsible for all infrastructural measures concerning the buildings and most of the equipment. He is the institute's safety, laser protection and stocktaking officer and attends to its extensive computer systems. The smooth function of the IAP's infrastructure is, to a decisive extent, due to his exceptional commitment, even after regular working hours.

- **Dr. Frank Schrempel** has built and used one of the world-wide first helium-ion microscopes in the last years. He guides a lot of stuff members scientifically. Furthermore he is engaged with much agility and care in teaching. He supervises young researchers in the institute and works in outreach programs to attract new people interested in natural sciences and technical studies.

- **Dr. Ronny Nawrodt** from the Institute of Solid-State Physics (IFK) was proposed for performance bonuses because of his excellent and engaged teaching which was honoured also with the teaching award of the student council. When we had a problem with a lecture in the summer term, he stood in and helped the faculty by this way.

- The Scientific Workshops rewarded **Andreas Rose** and **Marcus Müller** with performance bonuses in 2015. *Andreas Rose* supervises the workshop of the electrotechnology since March 2011. To fulfil this task he qualified to an Industrial Master Electrotechnology at the side of his job. Under his supervision the workshop of electrotechnology developed in the right direction. *Marcus Müller* is employed as industry mechanics in the workshop of precision engineering 2. He became familiar with the CNC milling very fast and encompassing and he competent and fast does all the programming work arising.

- **Sarah Wusch** started her job in the Office of the Dean of Studies as maternity-leave replacement in 2011. Her task was the support service for bachelor, master and teacher students of physics. Due to her careful and foresighted work procedure, her detailed knowledge of all study and examination regulations she became an indispensable partner of the Dean of Study. The increasing number of foreign students requires communication in English language more often. She has taken up that challenge too.

- **Dr. Joachim Hein** is an internationally reputed excellent laser physicist in the institute of optics and quantum electronics (IOQ). For many years as non-professorial co-researcher, he has a leading role in many cooperative projects (ZIK ultra optics, onCOOPtics). Especially in the starting phase of the POLARIS project he was one of the driving forces. Without his extreme high engagement and his extraordinary expertise in the field of diode-pumped solid-state lasers the actual top position of the POLARIS would be unthinkable. Last but not least, he is intensively involved in the advanced practical courses, where he does an excellent job.

  Marco Hellwing has been working at the IOQ since 1990. With great commitment and outstanding success, he has solved many problems in the development of high-power lasers. In the last t 10 years he was involved especially in the development of the amplifier architecture of the POLARIS laser system. His skills to build laser amplifiers, to involve some diagnostic instruments and to resolve technical problems often exceed the level of a technical co-worker. Furthermore he is responsible for the daily operation of the POLARIS. Due to his engaged and competent work he contributed to the top position of the POLARIS, which is the worldwide most powerful fully diode-pumped laser system usable for experiments. For this he was also willing to work overtime.

8. 4. Astrophysical Institute and University Observatory

10 most important publications (in alphabetical order)

Dinçel B., Neuhäuser R., Yerli S.K., Ankay A., Tetzlaff N., Torres G., Mugrauer M.: Discovery of an OB runaway star inside SNR S147, Mon. Not. R. Astron. Soc. 448 (2015), 3196–3205

Hambaryan V., Wagner D., Schmidt J.G., Hohle M.M., Neuhäuser R.: 3XMM J185246.6+003317 as transient neutron star, Astron. Nachr. 336 (2015), 545–565

Mugrauer M., Ginski C.: High-contrast imaging search for stellar and substellar companions of exoplanet host stars, Mon. Not. R. Astron. Soc. 450 (2015), 3127–3136

Neuhäuser R., Hohle M.M., Ginski C., Schmidt J.G., Hambaryan V.V., Schmidt T.O.B.: The companion candidate near Fomalhaut – a background neutron star?, Mon. Not. R. Astron. Soc. 448 (2015), 376–389

Neuhäuser R., Neuhäuser D.L.: Solar activity around AD 775 from aurorae and radiocarbon, Astron. Nachr. 336 (2015), 225–248

Neuhäuser R., Neuhäuser D.L.: Variations of 14C around AD 775 and AD 1795 – due to solar activity, Astron. Nachr. 336 (2015), 930–954

Pawellek N., Krivov A.V.: The dust grain size–stellar luminosity trend in debris discs, Mon. Not. R. Astron. Soc. 454 (2015), 3207–3221

Reinert C., Mutschke H., Krivov A.V., Löhne T., Mohr P.: Absorption of crystalline water ice in the far infrared at different temperatures, Astron. Astrophys. 573 (2015), A29

Schüppler C., Löhne T., Krivov A.V., Ertel S., Marshall J.P., Wolf S., Wyatt M.C., Augereau J.-C., Metchev S.A.: Collisional modelling of the AU Microscopii debris disc, Astron. Astrophys. 581 (2015), A97

Zeidler S., Mutschke H., Posch T.: Temperature-dependent infrared optical constants of Olivine and Enstatite, Astrophys. J. 798 (2015), 125

Invited talks and tutorials at international conferences

Alexander Krivov

Invited review talk: Debris Disks as Components of Planetary Systems, 3rd Chinese-German Workshop on Star and Planet Formation, Nanjing, China (23rd–26th March)

Invited plenary talk: Debris disks – The Heritage of Herschel, Annual Meeting of the Astronomische Gesellschaft, Kiel (14th–18th September)

Major extra-budgetary projects

DFG:

KR 2164 / 10-1
Interpretation of Herschel´s “cold” debris disks
Total: 126,000 € (plus 25,200 € program lump sum), for 2 full-time employees
Receipts 2015: 26,320 €

KR 2164 / 13-1
FOR 2285, Project P1: Collisional modeling of resolved debris disks
Total: 132,750 € (plus 26,600 € program lump sum), for 1.5 full-time employees
Receipts 2015: 0 €

KR 2164 / 14-1
FOR 2285, Project PZ: Coordination
Total: 145,157 € (plus 29,000 € program lump sum)
Receipts 2015: 0 €

KR 2164 / 15-1
FOR 2285, Project P3: Origin of warm and hot dust and planetary system architecture
Total: 214,920 € (plus 43,000 € program lump sum), for 3 full-time employees
Receipts 2015: 0 €

LO 1715 / 1-1
Statistical study of extrasolar Kuiper belts with Herschel/DUNES
Total: 128,500 € (plus 25,700 € program lump sum), for 2 full-time employees
Receipts 2015: 880 €

LO 1715 /2-1
FOR 2285, Project P2: Sculpturing of debris disks by planets and companions
Total: 109,650 € (plus 21,900 € program lump sum), for 1.5 full-time employees
Receipts 2015: 0 €

MU 1164 /7-2, SPP 1385
Measurements of high-temperature optical constants of solar-nebula minerals
Total: 76,850 € (plus 15,400 € program lump sum), for 1 full-time employee
Receipts 2015: 91 €

MU 1164 /8-1, SPP 1573
Laboratory measurements of the far-infrared to millimeter dust opacity at low temperatures
Total: 104,004 € (plus 20,800 € program lump sum), for 1.5 full-time employees
Receipts 2015: 26,640 €

MU 1164 /8-2
SPP 1573
Laboratory measurements of the far-infrared to millimeter dust opacity at low temperatures
Total: 127,700 € (plus 22,500 € program lump sum), for 1.5 full-time employees
Receipts 2015: 35,400 €

MU 1164 /9-1
FOR 2285, Project P5: Dust opacity measurements for debris disks
Total: 163,080 € (plus 54,400 € program lump sum), for 2 full-time employees
109,242 € Investment (loan)
Receipts 2015: 12,000 €

NE 515 / 34-2, SPP 1385
Young transiting planets
Total: 64,700 € (plus 12,900 € program lump sum), for 1 full-time employee
Receipts 2015: 4,296 €

NE 515 / 35-2, SPP 1385
Direct detection of Jovian planets around young solar analogs and their atmospheres
Total: 30,650 € (plus 6,100 € program lump sum), for 0.5 full-time employees
Receipts 2015: 206 €

MPI für Astronomie Heidelberg:

Total: 25% tariff part E9, 4+, TV-L
Receipts 2015: 13,118 €

8. 5. Institute of Applied Optics

10 most important publications

Ndagano, B.; Bruening, R.; McLaren, M.; Duparré, M.; and Forbes, A.: “Fiber propagation of vector modes” Opt. Express 23, 17330 - 17336 (2015)

Weigel, D.; Kiessling, A.; Kowarschik, R.: "Aberration correction in coherence imaging microscopy using an image inverting interferometer", Optics Express 23, 20505-20520 (2015)

Bruening, R.; Ngcobo, S.; Duparré, M.; and Forbes, A.: “Direct fiber excitation with a digitally controlled solid state laser source” Opt. Lett. 40, 435 – 438 (2015)

Lutzke P., Heist S., Kuehmstedt P., Kowarschik R. Notni G.: „Monte Carlo simulation of three-diemnsional measueremnst of translucent objects” Opt. Eng. 54, DOI: 10.1117/1.OE.54.8.084111 (2015)

Schulze, C.; Bruening, R.; Schroeter, S.; and Duparré, M.: “Mode coupling in few-mode fibers induced by mechanical stress” J. Lightwave Technol. 33, 4488 - 4496 (2015)

Bruening, R.; Zhang, Y.; McLaren, M.; Duparré, M; and Forbes, A.: “Overlap relation between free-space Laguerre Gaussian modes and step-index fiber modes” J. Opt. Soc. Am. A 32, 1678 - 1682 (2015)

Weigel, D.; Babovsky, H.; Kiessling, A.; Kowarschik, R.: “Widefield microscopy with infinite depth of field and enhanced lateral resolution based on an image inverting interferometer", Optics Communications 342, 102-108 (2015)

Third-party projects (title, duration, source, amount in 2015)

Industry:

2015: 59,500 €

TMWFK:
2015: 29,400 €

8. 6. Institute of Applied Physics

10 most important publications

T. Eichelkraut, A. Szameit, PHOTONICS Random sudoku light, Nature 526 (7575), 643-644 (2015).

A. Szameit, Photonics: Chaos from symmetry, Nature Physics 11 (11), 895-896 (2015).

S. Hädrich, M. Krebs, A. Hoffmann, A. Klenke, J. Rothhardt, J. Limpert, A. Tünnermann, Exploring new avenues in high repetition rate table-top coherent extreme ultraviolet sources, Light: Science & Application 4, e320 (2015).

D. Lehr, J. Reinhold, I. Thiele, H. Hartung, K. Dietrich, C. Menzel, T. Pertsch, E.-B. Kley, A. Tünnermann, Enhancing Second Harmonic Generation in Gold Nanoring Resonators Filled with Lithium Niobate, Nano Letters 15 (2), 1025–1030 (2015).

M. Lebugle, M. Gräfe, R. Heilmann, A. Perez-Leija, S. Nolte, A. Szameit, Experimental observation of N00N state Bloch oscillations., Nature Communications 6, 8273 (2015).

M. Tillmann, S.-H. Tan, S. E. Stoeckl, B. C. Sanders, H. de Guise, R. Heilmann, S. Nolte, A. Szameit, P. Walther, Generalized Multiphoton Quantum Interference, Physical Review X 5 (4), 041015 (2015).

F. Setzpfandt, A. S. Solntsev, J. Titchener, C. W. Wu, C. Xiong, R. Schiek, T. Pertsch, D. N. Neshev, A. A. Sukhorukov, Tunable generation of entangled photons in a nonlinear directional coupler, Laser & Photonics Reviews 1-6 (2015).

T. Gottschall, T. Meyer, M. Baumgartl, C. Jauregui, M. Schmitt, J. Popp, J. Limpert, A. Tünnermann, Fiber-based light sources for biomedical applications of coherent anti-Stokes Raman scattering microscopy, Laser & Photonics Reviews 9 (5), 435-451 (2015).

T. Meany, M. Gräfe, R. Heilmann, A. Perez-Leija, S. Gross, M. J. Steel, M. J. Withford, A. Szameit, Laser written circuits for quantum photonics, Laser & Photonics Reviews 9 (4), 363-384 (2015).

J. M. Zeuner, M. C. Rechtsman, Y. Plotnik, Y. Lumer, S. Nolte, M. S. Rudner, M. Segev, A. Szameit, Observation of a Topological Transition in the Bulk of a Non-Hermitian System, Physical Review Letters 115 (4), 040402 (2015).

Invited talks und tutorials

J. Limpert

J. Limpert, Coherent Addition of Ultrafast Fiber Laser Pulses, OSA Conference on Laser and Electrooptics (CLEO) Europe, Munich, Germany, 21. - 25. June 2015.

J. Limpert, Coherent combination of ultrafast laser pulses: A route to Joule-class high repetition rate femtosecond lasers, SPIE Photonics West, San Francisco, USA, 7. - 12. Feb 2015.

J. Limpert, Coherent combination of ultrafast lasers, Ultrafast optics, Beijing, China, 19. Aug 2015.
J. Limpert, High repetition rate high performance ultrafast lasers for scientific applications, ISUILS International Symposium on Ultrafast Intense Laser Science, Kauai, Hawaii, USA, 9. - 13. Dec 2015.

J. Limpert, Fiber Laser Pumped MHz Repetition Rate Few-Cycle OPCPA System , LaserLab Europe OPCPA Training Course, Bordeaux, France, 20. Jan 2015.

J. Limpert, Coherent Combination of Ultrafast Fiber Laser Pulses, Toward Joule-Class High Repetition Rate Femtosecond Lasers, Colloquium Bilkent University , Ankara, Turkey, 29. Apr 2015.

J. Limpert, Performance Scaling of Ultrafast Fiber Lasers, Laser Seminar ETH Zurich, Zurich, Switzerland, 31. Aug 2015.

J. Limpert, High photon flux and repetition rate table-top coherent EUV sources based on ultrashort pulse fiber lasers, Molecular Physics Seminar DESY Hamburg (CFEL), Hamburg, Germany, 19. Nov 2015.

S. Nolte

S. Nolte, Ultrashort pulse laser processing of glass – from cutting to welding, SPIE Photonics West, Laser-based Micro- and Nanoprocessing IX, San Francisco, USA, 7. - 12. Feb 2015.

S. Nolte, Ultrashort pulse laser processing of transparent materials – potential and applications, 3rd UKP-Workshop: Ultrafast laser Technology, Aachen, Germany, 22. - 23. Apr 2015.

S. Nolte, Ultrashort Pulse Laser Processing of Transparent Materials, Laser World of Photonics 2015, Application Panel "Advanced Applications of Ultrashort Pulsed Laser Systems", Munich, Germany, 22. - 25. June 2015.

S. Nolte, Ultrakurzpulslaser – vom Labor zum produktiven Werkzeug in der Mikrobearbeitung, OptoNet Workshop "Präzisionsbearbeitung mit ultrakurzen Laserimpulsen - von der Idee zur Automation", Jena, Germany, 10. - 10. June 2015.
S. Nolte, Ultrashort pulse lasers for precise processing: overview on a German research initiative, Conference on Lasers and Electro Optics (CLEO), San José, USA, 10. - 15. May 2015.

S. Nolte, Processing of transparent materials by ultrashort laser pulses – fundamentals and applications, Korea Institute of Machinery & Materials (KIMM), Daejeon, Korea, 28. Aug 2015.

S. Nolte, Mikrobearbeitung mit Ultrakurzpulslasern – vom Labor zum Werkzeug in der industriellen Fertigung, CORTRONIK GmbH, Rostock-Warnemünde, Germany, 15. Oct 2015.

S. Nolte, Ultrashort pulse laser processing of transparent materials, Leibniz Universität Hannover, Institut für Quantenoptik, Dahnsdorf, Germany, 8. Sept 2015.

S. Nolte, K. Bergner, F. Dreisow, R.G. Krämer, D. Richter, S. Richter, C. Voigtländer, F. Zimmermann, Ultrashort pulse laser processing of transparent materials – potential and applications, Conference on Laser Ablation – COLA, Cairns, Australia, 31. Aug - 4. Sept 2015.

S. Nolte, K. Bergner, R. Krämer, D. Richter, S. Richter, C. Voigtländer, F. Zimmermann, Volume processing of transparent materials by ultrashort laser pulses: potential and applications, CLEO Pacific Rim, Busan, Korea, 24. - 28. Aug 2015.

A. Szameit

A. Szameit, Topological Anderson Insulators for Light, Workshop on Waves and Imaging in Random Media, Paris, France, 9. - 10. Nov 2015.

A. Szameit, Quantum optical analogies in coupled waveguide lattices, PICQUE Roma Scientific School: Integrated Quantum Photonics Applications: from Simulation to Sensing, Rome, Italy, 6. - 10. July 2015.

A. Szameit, Photonic Topological Insulators, 1st International Symposium on Green Photonics at Nazarbayev University, Astana, Kazakhstan, 29. - 30. Oct 2015.

A. Szameit, Laser-written integrated photonic quantum circuits, PICQUE Workshop in Integrated Quantum Photonics, Oxford, UK, 7. - 9. Jan 2015.

A. Szameit, Integrated laser-written quantum photonics, Complex Nanophotonics Science Camp, Cumberland Lodge, UK, 18. - 21. Aug 2015.

A. Szameit, Integrated optical circuits for classical and quantum light, Leopold-Franzens-Universität, Innsbruck, Austria, 14. Apr 2015.

A. Szameit, Integrated Quantum Photonics: Towards the Optical Computer Chip, University of Toronto, Toronto, Canada, 2015.

A. Szameit, Photonics Topological Inslators and Topological Anderson Insulators, Westfälische Wilhelms-Universität, Münster, Germany, 22. Oct 2015.

A. Szameit, Photonic Topological Insulators and Topological Anderson Insulators, Université de Strasbourg, Strasbourg, France, 2015.

A. Szameit, Integrated optical circuits for classical and quantum light, Aston University, Birmingham, UK, 6. Oct 2015.

A. Szameit, New Frontiers in integrated photonics: supersymmetry and unphysical phenomena, Friedrich-Schiller-Universität , Jena, Germany, 20. Jan 2015.
A. Szameit, S. Stützer, J. M. Zeuner, M. C. Rechtsman, Y. Plotnik, Y. Lumer, M. A. Bandres, M. Segev, P. Titum, N. H. Lindner, G. Refael, Photonic Topological Insulators and Topological Anderson Insulators, Photonica conference, Belgrade, Serbia, 24. - 28. Aug 2015.

A. Szameit, S. Stützer, J. M. Zeuner, P. Titum, G. Refael, Y. Plotnik, Y. Lumer, M. A. Bandres, N. Lindner, M. Segev, M. C. Rechtsman, Topological Photonics, The Aston Year of Light workshop, Birningham, UK, 6. - 7. Oct 2015.

A. Szameit, S. Stützer, J. Zeuner, M. Rechtsman, Y. Plotnik, K. Lumer, M. Segev, Realization of a Topological Anderson Insulator, CUDOS Workshop No. 14, Lovedale, Australia, 16. - 19. Feb 2015.

A. Szameit, S. Stützer, Y. Plotnik, J. M. Zeuner, M. C. Rechtsman, Y. Lumer, M. A. Bandres, M. Sergev, Realizing Photonic Topological Insulators and Topological Anderson Insulators, Workshop on Topological effects and synthetic gauge/magnetic fields for atoms and photons, Zagreb, Croatia, 29. Sept - 1. Oct 2015.

C. Jauregui

C. Jauregui, Performance scaling of fiber laser systems: current challenges, Dresden Fraunhofer IWS, Dresden, Germany, 12. Oct 2015.

C. Jauregui, H.-J. Otto, J. Limpert, A. Tünnermann, Fiber laser systems: high performance against the odds, OPTOEL , Salamanca, Spain, 13. - 15. July 2015.

C. Jauregui, H.-J. Otto, N. Modsching, J. Limpert, A. Tünnermann, Recent progress in the understanding of mode instabilities, SPIE Photonics West, San Francisco, USA, 7. - 12. Feb 2015.

F. Setzpfand

F. Setzpfandt, F. Eilenberger, S. Minardi, A. Tünnermann, T. Pertsch, Complex nonlinear dynamics in waveguide arrays: spatio-temporal solitons and nonlocal nonlinearities, Nonlinear Photonics: Theory, Materials, Applications, St. Petersburg, Russia, 29. June - 2. July 2015.

F. Setzpfandt, R. Geiss, S. Diziain, S. Saravi, T. Pertsch, Resonant Lithium Niobate Nanostructures for Nonlinear Frequency Conversion, Progress In Electromagnetics Research Symposium (PIERS), Prague, Czech Republic, 6. - 9. July 2015.

J. Rothhardt

J. Rothhardt, High photon flux XUV and soft X-ray sources , COST Workshop - XVU Metrology, Jena, Germany, 20. Mar 2015.

J. Rothhardt, S. Hädrich, M. Krebs, J. Limpert, A.Tünnermann, High photon flux XUV and soft X-ray sources enabled by high harmonic generation of high power fiber lasers, icOPEN 2015, Singapore, Singapore, 14. - 16. Apr 2015.

M.C. Rechtsmann

M. C. Rechtsman Y. Plotnik, J. M. Zeuner, Y. Lumer, D. Podolsky, M. Segev, A. Szameit, Aspects of topological insulators, APS Mar Meeting conference, San Antonio, USA, 2. - 6. Mrz 2015.

M. C. Rechtsman, J. M. Zeuner, Y. Plotnik, Y. Lumer, M. Segev, A. Szameit, Topological physics in photonic devices, SPIE Photonics West, San Francisco, USA, 7. - 12. Feb 2015.

M. Gräfe

M. Gräfe, R. Heilmann, A. Perez-Leija, M. Lebugle, M. Lebugle, D. Guzman Silva, M. Heinrich, S. Nolte, A. Szameit, Integrated laser-written quantum photonics, SPIE Active Photonic Materials, San Diego, USA, 9. - 13. Aug 2015.

M. Gräfe, R. Heilmann, A. Perez-Leija, M. Lebugle, R. Keil, S. Nolte, D.N. Christodoulides, A. Szameit, Quantum Random Walks in Photonic Lattices, Quantum Simulations, Benasque, Spain, 22. - 27. Feb 2015.

M. Heinrich

M. Heinrich, M.-A. Miri, S. Stützer, S. Nolte, A. Szameit, D. N. Christodoulides, Supersymmetric photonics: Mode conversion, scattering and transformation optics, Nonlinear Optics, Kauai, Hawaii, USA, 26. - 31. July 2015.

M. Heinrich, M.-A. Miri, S. Stützer, S. Nolte, A. Szameit, S. Nolte, D. N. Christodoulides, Supersymmetric photonics: From mode converters to a new class of transformation optics, Metamaterials 2015, Oxford, UK, 7. - 12. Sept 2015.

M. Heinrich, M.-A. Miri, S. Stützer, S. Nolte, D.N. Christodoulides, A. Szameit, Supersymmetric scattering and transformation optics, CLEO/Europe-EQEC, Munich, Germany, 21. - 25. June 2015.

M. Heinrich, R. Heilmann, J. Zeuner, T. Eichelkraut, S. Stützer, S. Weimann, S. Nolte, A. Szameit, Complex wave dynamics in non-Hermitian photonic lattices, Emergent Paradigms in Nonlinear Complexity Conference, Santa Fe, USA, 10. June 2015.

M. Segev

M. Segev, M. C. Rechtsman, S. Stützer, Y. Plotnik, Y. Lumer, M. A. Bandres, J. M. Zeuner, A. Szameit, Photonic topological insulators and topological Anderson Insulators, International Conference on Metamaterials, Photonic Crystals and Plasmonics (META), New York, USA, 7. - 10. Aug 2015.

M. Segev, M. C. Rechtsman, Y. Plotnik, Y. Lumer, M. A. Bandres, J. M. Zeuner, A. Szameit, Photonic topological insulators, Progress In Electromagnetics Research Symposium (PIERS), Prague, Czech Republic, 6. - 9. July 2015.

S. Breitkopf

S. Breitkopf, Hochleistungslaser, Year of Light Science Slam, LIDO, Berlin, Germany, 12. Oct 2015.

S. Breitkopf, T. Eidam, A. Klenke, M. Kienel, M. Müller, J. Limpert, A. Tünnermann, Potential of Fiber-based Laser Technology for Accelerators, International Particle Accelerator Conference, Richmond, USA, 4. - 8. May 2015.

S. Kroker

S. Kroker, E.-B. Kley, A. Tünnermann, Micro-structured surfaces for high-precision metrology, Stanford University, Palo Alto, CA, USA, 14. Oct 2015.

S. Kroker, E.-B. Kley, A. Tünnermann, Micro- and nanooptical elements based on effective media , University of Science and Technology of China, National Synchrotron Radiation Laboratory, Hefei, Province of Anhui, China, 28. Oct 2015.

S. Kroker, E.-B. Kley, A. Tünnermann, Bringing mirrors to rest - grating concepts for ultra-precisen metrology, SPIE Photonics West, San Francisco, USA, 7. - 12. Feb 2015.

S. Kroker, E.-B. Kley, A. Tünnermann, Tailoring the angular transmission bahavior of high-contrast gratings, SPIE Photonics West, San Francisco, USA, 7. - 12. Feb 2015.

A. Perez-Leija, M. Gräfe, R. Heilmann, A. Szameit, On-chip laser written photonic circuits for quantum applications, Progress In Electromagnetics Research Symposium (PIERS), Prague, Czech Republic, 6. - 9. July 2015.

C. Helgert, S. Nolte, T. Pertsch, Internationalized and research-oriented photonics education - Abbe School of Photonics, SPIE Education and Training in Optics and Photonics (ETOP), Bordeaux, France, 29. - 29. June 2015.

H. Gross, A. Brömel, M. Beier, R. Steinkopf, J. Hartung, Y. Zhong, M. Olesko, D. Ochse, Overview on surface representations for freeform surfaces, SPIE “Optical Systems Design”, Jena, Germany, 7. - 10. Sept 2015.

I. Staude, M. Decker, K. E. Chong, D. N. Neshev, I. Brener, Yu. S. Kivshar, Functional photonic nanostructures based on resonant dielectric nanoparticles, SPIE Micro+Nano Materials, Devices, and Applications, Sydney, Australia, 6. - 9. Dec 2015.

S. Demmler, High repetition rate OPCPA system for strong-field applications, Abbe School of Photonics, FSU, Jena, Germany, 10. July 2015.

S. Hädrich, J. Rothhardt, M. Krebs, S. Demmler, J. Limpert, A. Tünnermann, High photon flux and repetition rate table-top EUV sources based on ultrashort pulse fiber lasers, IEEE Photonics Conference, Reston, USA, 4. - 8. Oct 2015.

S. Stützer, M. C. Rechtsman, Y. Plotnik, Y. Lumer, J. M. Zeuner, S. Nolte, M. Segev, A. Szameit, Realization of a Topological Anderson Insulator, Progress In Electromagnetics Research Symposium (PIERS), Prague, Czech Republic, 6. - 9. July 2015.

T. Pertsch, B. Walther, S. Fasold, M. Falkner, C. Menzel, I. Staude, B. Kley, A. Tünnermann, M. Decker, C. Rockstuhl, Diffractive optical elements made from photonic metamaterials, SPIE Optical Systems Design , Jena, Germany, 7. - 10. Sept 2015.

Third-party funded projects >30T € (expenses 2015)

DFG - German Research Society (expenses in 2015: 776,000 €)

- Graduiertenkolleg "Geführtes Licht, dicht gepackt: neue Konzepte, Komponenten und Anwendungen"
- Optische Beschichtung mittels ALD - Beschichtung nanostrukturierter Substrate und Adsorption von Flüssigkristallen an dünnen Schichten (Emmy Noether-Programm)
- Lineare und nichtlineare Lichtausbreitung in Wellenleiterarrays bei komplexen Anregungsprofilen
- Optisch erzeugte Sub-100-nm-Strukturen für biomedizinische und technische Zwecke
- Emulation der Graphenstruktur mittels Photonik
- Ultrakurzpuls–induzierte Erzeugung periodischer Nanostrukturen im Volumen transparenter Festkörper
- Investigation on near-plane varied-line-spacing gratings made by electron beam lithography and near field holography
- Metamaterialien in flüssiger Phase
- Nonlinear optics plasmonic nanoantennas from Lithium Niobate
- Aktive Mikrooptik: Adaptierbare plenoptische Kameras: Design, Herstellung, Integration
- SFB Transregio „Gravitationswellenastronomie“

EU - European Union (expenses in 2015: 664,000 €)

- ERC Advanced Grant MIMAS - Multi-dimensional interferometric amplification of ultrashort laser pulses
- ERC Consolidator Grant ACOPS - Program „Ideas“,; Advanced coherent ultrafast laser pulse stacking
- Marie Curie Initial Training Network PICQUE - Photonic Integrated Compound Quantum Encoding
- ADOPSYS - Advanced Optical System Design
- QuILMI - Quantum Integrated Light Matter Interface

BMBF/BMWI – Federal ministries (expenses in 2015: 3,902,000 €)

- ZIK Ultra Optics 2015 – Forschergruppe Fertigungstechnologien für hoch entwickelte Mikro- und Nano-Optiken
- ZIK Ultra Optics 2015 – Nachwuchsgruppe Design und Realisierung komplexer mikro- u. nanostrukturierter photonischer Systeme basierend auf Diamant- u. Kohlenstoffoptiken
- Verbund-ZIK Hitecom - Spektroskopische Untersuchungen zur Vergasung von Kokspartikeln unter Hochdruck- und Hochtemperaturbedingungen
- Wachstumskern fo+ - Untersuchung ultrapräziser Freiformsysteme
- Zwangzig20 - Allianz 3Dsensation: FastDetect - Methoden zur ultraschnellen dreidimensionalen Detektion zeitveränderlicher Lichtfelder
- Zwangzig20 - Allianz 3Dsensation: Untersuchungen zur Visualisierung von 3D-Objekten im freien Raum mittels Laser
- Zwangzig20 - Allianz 3Dsensation: 3D-NanoVisual - Dreidimensionale Visualisierungssysteme auf der Basis photonischer Nanomaterialien
- Zwangzig20 - Allianz 3Dsensation: OMNIdetect - Redundanzfreie omnimodale 3D-Detektionstechnologie
- T4nPV - Tailored for next PV, UKP-Laserstrukturierung von dünnen Schichten für PV-Anwendungen
- NEXUS - Kompakte Ultrakurzpulslaser basierend auf kohärenter Kombination
- MEDUSA - Mehrdimesionale Ultrakurzpulssynthese für Faserlaser der TW-Klasse
- NanoInt - Verbundprojekt Integrierte Nanooptik
- ALSI - Advanced Laser-writing for Stellar Interferometry
- SITARA - Selbstadaptierende intelligente Multiaperturkamera-Module

- SolarNano - Nanostructured plasmonic reflectors for efficient thin film solar cells
- TEHFA - Erforschung thermo-optischer Wellenleitereffekte in monolithischen Hochleistungslaserfasern, Moden und hochleistungsstabile Komponenten für Faserlaser
- Verbund APPA R&D: Licht-Materie-Wechselwirkung mit hochgeladenen Ionen
- HoruS - Hochrobuste ultrakurzpulsgeschriebene Fasersensorarrays
- MonOCrom - Moderne optische Technologien zur Crosstalk-Minimierung in Silizium-Photomultipliern
- Ultrakurzpulslaser-Bearbeitung von Gläsern mit biologisch aktiven Oberflächen; Ultrakurzpulslaser-Bearbeitung von Glassubstraten
- FieldTracing - Einführung von Field Tracing Verfahren für anisotrope und nichtlineare Medien
- Design optischer Komponenten zur flexiblen Lichtformung mit Anwendungen für Weißlicht LEDs; inverser Ansatz für das Design von Komponenten zur Lichtformung
- Integriert-optische Module durch neue Bondtechnologien

State of Thuringia (expenses in 2015: 197,000 €)

- ProExz., ACP Explore - Intelligentes Laserskalpell für die Diagnose und Therapie von Tumoren
- ProExz., ACP Explore - Einzelmolekülfalle (ABEL trap) zum ultrasensitiven Nachweis löslicher Marker und Wirkstoffe gegen Autoimmunerkrankungen
- ProExz., ACP-Explore - Enlightening New States of Matter
- ProExz., ACP-Explore - Integration of Molybdenum Disulfide Monolayers with Photonic Nanostructures
- ProExz., ACP2020 – Agenda für exzellente Photonik (Nachwuchsgruppe)

Foundations/Others (expenses in 2015: 580,000 €)

- Stiftungsprofessur Theorie optischer Systeme (endowed professorship)
- GIF Grantee - Luminous fluid flow in 2d structures: experiment and theory
- 8x Carl-Zeiss-Scholarships
- 1x TRUMPF-Scholarship
- DAAD exchange programs (Australia, Taiwan, Serbia)

Contract research (expenses in 2015: 2.819,000 €)

- Additives Laserschmelzen mit ultrakurzen Laserpulsen
- Advanced Technologies für Adaptive Systems – Fast Closed Loop Control of Laser Wavefronts for High Power Space Applications
- Anorganisch-organische Hybridschichten für die Optik
- Auslegung eines neuartigen Gitterspektrometers
- Axiale Fassungsstrukturen für optische Elemente mit großem Aspektverhältnis
- Design, growth, sructure and optical properties of interface-engineered multilayer coatings for EUV lithography
- Design, Verschaltung und Charakterisierung von photosensorischen Elementen
- Einfluss der Abscheidebedingungen auf die optischen und mechanischen Eigenschaften amorpher Funktionsschichten
- Einfluss der Plasmakomponenten und -energetik auf die Zusammensetzung und Struktur plasmagestützter präparierter dielektrischer Schichten
- Entspiegelung von SiON-Schichten
- Entwicklung einer Hochleistungsfaserlaserkomponente
- Entwicklung keramischer Gasdurchführungen für Atmosphären- und Vakuumanwendungen
- Entwicklung und Analyse einer athermalen Werkstoffkombination für formstabile Metalloptiken
- Entwicklung und Charakterisierung eines Array-Projektors für die 3D-Messtechnik
- Entwicklung und Fertigung eines 6 Zoll Zonenplattensegmentes zur Kollimierung von Röntgenstrahlen
- Entwicklung und Untersuchung eines Aktuators mitsamt Fertigungsprozess für direkt in Schichttechnologien integrierbare elektrostatische Aktorik zur Verstellung von Mikrolinsen in einem abgeschlossenen und volumenminimierten Optiksystem

- Entwicklung von Berechnungsmodellen und -methoden zur Auslegung hochenergetischer Lasersysteme
- Entwicklung von Methoden für das 3D-Messen mit strukturierter Beleuchtung in Bewegung
- Entwicklung von Methoden zur Hochgeschwindigkeits-3D-Vermessung transluzenter Objekte mittels Specklemusterprojektion
- Entwicklung von THz-Tomographiesystemen
- Evaluation eines neuartigen Ansatzes zur dreidimensionalen Objektaufnahme basierend auf hybriden optischen Systemen
- Evaluierung der Leistungsbeständigkeit und Leistungsfähigkeit von Scanner-Systemen
- Evaluierung von Finiten Differenzen Methoden für die Simulation von diffraktiven optischen Elementen mir Rsoft FullWave
- Extreme Light Infrastructure Attosecond Light Pulse Source
- Femtofügen von Glas
- Funktionale Oberflächen mit spezifischen optischen, haptischen und Benetzungseigenschaften
- Herstellung von ultraleichten Metalloptiken auf der Basis additiver Fertigungsverfahren
- Inkjet-printing of OLEDS for Microfluidic Lab-on-a-chip Devices
- Komplexe Strahlformung für hocheffiziente Laserkavitäten
- Magnetorheological Finishing (MRF) als Formkorrekturverfahren für metallische Freiformspiegel
- Nanotechnologie - Charakterisierung von Metamaterialien für optische Anwendungen
- Neuartige Laserquellen für schmalbandige faserbasierte Verstärkung im nahen IR
- Optimization method of Glass selection
- Realisierung von FBGs mit Hilfe ultrakurzer Laserpulse für Strahlungstests
- Stability and performance improvement of miniaturized, laser beam soldered laser assemblies
- Steuerung komplexer Flüssigkeiten in geätzten Nanokanälen
- Streulichtcharakterisierung Optischer Oberflächen und Materialien
- Streulichtmechanismen an optischen Oberflächen
- Steigerung des Wirkungsgrades von Nano-SIS Solarzellen sowie Entwicklung und Anpassung von TCO-Materialien für nano-SIS Bauelemente
- Streulichtoptimierung lithographisch hergestellter Spektrometergitter
- Strukturelle und optische Eigenschaften von Multischichten für 6,x nm Wellenlänge
- Ultrakurze X-Wellen für hochpräzise laserbasierte Materialbearbeitung
- Unterstützung bei der Entwicklung kohärent kombinierter Ultrakurzpuls-Laser
- Untersuchungen zur Hochgeschwindigkeits-3D-Messung und Optimierung der Datenauswertung durch Nutzung von 2D und 3D-Informationen
- Zerstörschwellenmessung an dielektrischen Schichten

Awards

Sven Döring
Green Photonics exceptional price Thuringia (STIFT), best Dissertation
“Analysis of the Hole Shape Evolution in Ultrashort Pulse Laser Drilling”

Falk Eilenberger
Award of the Faculty of Physics and Astronomy of the Friedrich-Schiller-University Jena endowed by the company Rohde & Schwarz, Munich, for the best dissertation
“Spatiotemporal, Nonlinear Optics and the Quest for the Observation of Discrete Light Bullets”

Christian Gaida
2nd Place Best Student Presentation, Photonics West, „Fiber Lasers: Technology, Systems, and Applications”
“Entwicklung von Thulium-dotierten Faserlasern bei 2 Mikrometer Wellenlänge mit hoher Ausgangsleistung”

Martin Heilemann
Green Photonics exceptional price Thuringia (STIFT), best Master’s thesis

“Siliziumoberflächenmodifikation durch Laserstrukturierung zur Herstellung hochempfindlicher Photodetektoren”

Marco Kienel
1st Place Best Student Presentation, Photonics West, „Fiber Lasers: Technology, Systems, and Applications”
“Experimental demonstration of multi-dimensional amplification of ultrashort pulses”

Arno Klenke
3rd Place Best Student Presentation, Photonics West, „Fiber Lasers: Technology, Systems, and Applications”
“5.7 mJ fiber-CPA system delivering 22 GW of peak power”

Stefanie Kroker
Award of the Friedrich-Schiller-University Jena for the best dissertation
“Siliziumbasierte resonante Wellenleitergitter für rauscharme interferometrische Resonatorkomponenten”

Martin Steglich, Ernst-Bernhard Kley
2nd Place AMA Innovation Price 2015
“Ge-on-Si-Photodiode mit Black-Silicon-Lichtfalle”

Fabian Stutzki
2nd Place Photonics21 Student Innovation Award „Runner-Up“
“Yb- und Tm-basierte Ultrakurzpuls-Faserlaser, auf Grundlage unseres Faserkonzeptes „Large-Pitch Faser“ (LPF) ”

Andreas Tünnermann
ERC Advanced Grant
“Multi-dimensional interferometric amplification of ultrashort laser pulses”

Felix Zimmermann
Best Student Presentation, Photonics West, "Frontiers in Ultrafast optics: biomedical, scientific and industrial applications XV"
“Realisierung eines mit Ultrakurzpulsen induzierten Nanogitters in Glas zur Erzeugung einer künstlichen Doppelbrechung”

Patents

Publications

A. Klenke, J. Limpert, H.-J. Otto, A. Tünnermann
Optische Anordnung mit Strahlaufteilung (PCT/EP2015/052204, DE 10 2014 001 252 A1)

Assignations

A. Breitbarth, P. Kühmstedt, G. Notni, P. Schreiber, M. Sieler
Projektionssystem mit statischen Mustererzeugungselementen und mehreren optischen Kanälen zur optischen 3D-Vermessung (DE 102012206472B4)

C. Jauregui Misas, J. Limpert, D. Nodop, A. Tünnermann
Effiziente Frequenzkonversion (EP 2656141B1)

D. Nodop, Dirk, A. Steinmetz, J. Limpert, A. Tünnermann
Lasersystem with nonlinear compression (US 8948219B2)

F. Jansen, C. Jauregui Misas, J. Limpert, F. Stutzki, A. Tünnermann
Structured double-sheath fiber (US 9065245B2)

J. Limpert, A. Tünnermann, E. Seise, D. Schimpf, T. Eidam
Device for amplifying transporting electromagnetic radiation (US 8982453B2)

J. Limpert, T. Eidam, C. Jauregui Misas, F. Röser, A. Tünnermann
Single-mode propagation in microstructured optical fibers (US 9170368B2)

N. Kaiser, H. Ludwig, P. Munzert, U. Schulz
Verfahren zur Herstellung einer Entspiegelungsschicht auf einem Substrat und Substrat mit einer Entspiegelungsschicht (DE 102013103075B4)

8. 7. Institute of Solid State Physics

10 most important publications published in 2015

Charge Transfer and Hybridization at an Organic Semiconductor / Conductive Oxide Interface
M. Gruenewald, L. K. Schirra, P. Winget, M. Kozlik, P.F. Ndione, A.K. Sigdel, D.S. Ginley, J.J. Berry, J. Shim, H. Kim, B. Kippelen, R. Forker, J.-L. Bredas, T. Fritz, and O.L.A. Monti
J. Phys. Chem. C **119** (9), 4865–4873 (2015).

Commensurism at electronically weakly interacting phthalocyanine/PTCDA heterointerfaces
M. Gruenewald, C. Sauer, J. Peuker, M. Meissner, F. Sojka, A. Schöll, F. Reinert, R. Forker, and T. Fritz
Phys. Rev. B. **91**, 155432 (2015).

Anomalous plastic deformation and sputtering of ion irradiated silicon nanowires
A. Johannes, S. Noack, W. Wesch, A. Lugstein, M. Glaser, C. Ronning
Nano Letters **15**, 3800 (2015)

Ultrafast dynamics of lasing semiconductor nanowires
R. Röder, T.P.H. Sidiropoulos, C. Tessarek, S. Christiansen, R.F. Oulton, C. Ronning
Nano Letters **15**, 4638 (2015)

Compound semiconductor alloys: From atomic-scale structure to bandgap bowing
C.S. Schnohr
Appl. Phys. Rev. **2**, 031304 (2015)

Measurement of the mechanical loss of prototype GaP/AlGaP crystalline coatings for future gravitational wave detectors
A. Cumming, K. Craig, I. Martin, R. Bassiri, L. Cunningham, M. Fejer, J. Harris, K. Haughian, D. Heinert, B. Lantz, A. Lin, A. Markosyan, R. Nawrodt, R. Route, S. Rowan
Class. Quantum Grav. **32**, 035002 (2015)

Superconductivity, role of pnictogen, and Fe substitution in 112-$LaPd_xPn_2$ (Pn = Sb, Bi)
R. Retzlaff, A. Buckow, P. Komissinskiy, S. Ray, S. Schmidt, H. Mühlig, F. Schmidl, P. Seidel, J. Kurian, L. Alff
Phys. Rev. B **91**, 104519 (2015)

A laboratory study of ion-induced erosion of ice-covered carbon grains,
T. Sabri, G. A. Baratta, C. Jäger, M. E. Palumbo, T. Henning, G. Strazzulla, and E. Wendler
Astron. Astrophys. **575**, A76 (2015)

Dissociative photoionization of polycyclic aromatic hydrocarbon molecules carrying an ethynyl group
G. Rouillé, S. A. Krasnokutski, D. Fulvio, C. Jäger, Th. Henning, G. A. Garcia, X.-F. Tang, and L. Nahon
Astrophys. J. **810**, 114 (2015)

Defect-induced magnetism in SiC: Interplay between ferromagnetism and paramagnetism
Y.T. Wang, Y. Liu, E. Wendler, R. Hübner, W. Anwand, G. Wang, X.L. Chen, W. Tong, Z.R. Yang, F. Munnik, G. Bukalis, X.L. Chen, S. Gemming, M. Helm, S.Q. Zhou
Phys. Rev. B **92**, 174409 (2015)

Invited Talks at Conferences and Colloquia

T. Fritz:

Incommensurate Growth and Static Distortion Waves in Organic-Inorganic Epitaxy
The 15th International Conference on the Formation of Semiconductor Interfaces (ICFSI-15)
Hiroshima (Japan), 19.11.2015

Incommensurate Growth and Static Distortion Waves in Organic-Inorganic Epitaxy
Electronic Structure and Processes at Molecular-Based Interfaces (ESPMI viii)
Biosphere 2 (USA), 14.10.2015.

Epitaxial Organic Thin Films of Large Aromatic Hydrocarbons - Structure and Physical Properties
Department of Chemistry, University of Arizona, Tucson (USA), 02.10.2015.

Incommensurate Growth and Static Distortion Waves in Organic-Inorganic Epitaxy
1st workshop on functional molecules
Izu-Kogen (Japan), 03.09.2015.

Organic-Inorganic Epitaxy: Lattice Epitaxy vs. Incommensurate Growth
Department of Physics, Osaka University, Osaka (Japan), 27.08.2015.

Incommensurate Growth and Static Distortion Waves in Organic-Inorganic Epitaxy
Department of Chemistry, Osaka University, Osaka (Japan), 06.08.2015.

C. Ronning:

Ion-Nanostructure Interactions
The 19th International Conference on Surface Modification of Materials by Ion Beams (SMMIB-19), Chiang Mai, Thailand, 23. Nov. 2015

Semiconductor nanowire photonics
Ireland Photonics 2015, Cork, 03.09.2015

Ion beam doping of semiconductor nanowires
Seminar at TU Eindhoven, Netherlands, 01.09.2015

Semiconductor nanowire photonics
Seminar of the Department of Electrical Engineering at U Wisconsin, Madison, USA, 24.08.2015

Semiconductor nanowire photonics
Physikalisches Kolloquium, TU Ilmenau, 21.04.2015

P. Seidel:

Josephsoneffekte in eisenbasierten Supraleitern
Christian-Albrechts-Universität zu Kiel, 23.07.2015

SQUID-Sensorik für Teilchenbeschleuniger
Workshop "Zukunftsperspektiven supraleitender Anwendungen", Dresden, 31.08.2015

E. Wendler:

Primary Processes of Damage Formation in Ion Implanted Semiconductors
Leibniz-Institut für Oberflächenmodifizierung (IOM), Leipzig, 10.12.2015

R. Nawrodt:

Experimental Aspects of Gravitational Wave Detection
Astronomy from 4 perspectives, Jena, September 04, 2015

Materials for future gravitational wave detectors
Stanford University, USA, May 15, 2015

Materials for suspensions and test masses in a cryogenic detector
GWADW 2015, Girdwood/Alaska, USA, Mai 19, 2015

C. Jäger:

Current expectations concerning the interstellar PAH population
International Symposium on Polycyclic Aromatic Compounds, Session: Interstellar PAHs,
Bordeaux, 13-17 September 2015

Dust formation and processing in the ISM
International Workshop on Silicates in Space, Heidelberg, Kirchhoff-Institut für Physik
28. September – 01. October 2015

The Characteristics of Dust in Molecular Clouds
International Conference ''From Clouds to Protoplanetary Disks: The Astrochemical Link, Berlin, Germany,
5 – 8 October 2015

Laboratory experiments on the formation and processing of dust in astrophysical environments
Planet and Star-Formation Workshop of the Max Planck Institute for Astronomy, Ellwangen, Germany,
26 – 28 October 2015

G. Rouillé:

Optical absorption spectroscopy on cold, isolated molecules
Seminar zur Oberflächenforschung, Institut für Physikalische und Theoretische Chemie, Bonn, 16 January 2015

Polycyclic aromatic hydrocarbon molecules carrying an ethynyl group: Photostability in H I regions
Planet and Star-Formation Workshop of the Max Planck Institute for Astronomy, Ellwangen, Germany, 26 – 28 October 2015

S. Krasnokutski:

Reaction between H2 molecules and C atoms at ultra-low temperatures
Planet and Star-Formation Workshop of the Max Planck Institute for Astronomy, Ellwangen, Germany, 26 – 28 October 2015

R. Forker:

Organic Epitaxial Interfaces
7th School on Organic Electronics, Lake Como School of Advanced Studies, 14-18.09.2015

Third party funding

DFG projects

Dotierte aromatische Dünnfilme mit supraleitenden Eigenschaften
(FO 770/2-1)
Time span: 09/14 – 08/17

Formation and shaping of magnetic nanoclusters in oxides, using ion implantation
Time span: 03/11 – 02/15

Research Unit FOR1616: Dynamics and Interactions of Semiconductor Nanowires for Optoelectronics
Time span: 03/12 – 06/15
Time span: 08/15 – 08/18

Teilprojekt P4: Light-matter interaction in optically doped nanowire LEDs and nano lasers
Time span: 03/12 – 11/15
Time span: 08/15 – 08/18

Josephson effects at iron pnicides - phase-sensivitve experiments
Time span: 10/13 – 09/16

Experimental and theoretical studies of charge transport in heterostructures based on two-band superconductors and/or ferromagnetic metals
Time span: 11/13 – 06/15

Experimental studies of the low-temperature condensation of cosmic dust in the interstellar medium
(HE 1935/26-1) (1. Tranche of the SPP 1378) (financial management by the MPIA)
Time span: 02/12 – 01/15

Experimental studies of the low-temperature condensation of cosmic dust in the interstellar medium
(JA 2107/2-2) (2. Tranche of the SPP 1378)
Time span: 10/14 – 09/17

Kohlenwasserstoff-Chemie bei ultratiefen Temperaturen in flüssigen Helium-Tröpfchen
(HU 474/22-3)
Time span: 05/12 – 05/15

Optical properties and photostability of ice-silicate-carbon mixtures in stellar UV fields
(JA 2107/3-1) TP8 of the Research Group 'Debris disks in planetary systems'
Time span: 12/15 – 12/18

Experimental studies on the diamond formation in astrophysical environments
(JA 2107/4-1)
Time span: 11/15 – 10/18

BMBF-, BMU- and BMWi-projects

Verbundvorhaben: Grenzflächen und Defekte – Rechnerunterstützte Optimierung des Wirkungsgrades von CIGS Dünnschichtsolarzellen in der industriellen Umsetzung
Teilvorhaben: Ermittlung von Struktur-Eigenschaftsbeziehungen und ihre Beeinflussung durch Variation der Prozessparameter
Time span: 08/12 – 02/16

Neuartige Verbundmaterialien u. Fertigungstechnologien für Kryostate zur see- u. luftgestützten Rohstoff- und Umwelterkundung (MAKSEL)
Time span: 09/14 – 12/17

Phase dynamics of intrinsic Josephson junctions and superconducting quantum interference devices
(Heisenberg-Landau Programm)
Time span: 01/15 – 12/15

ET R&D – Networking and R&D for the Einstein Telescope (3rd common ASPERA call)
Time span: 03/13 – 02/16

Verbundprojekt 05P2015 - R&D Beschleuniger (CCC): Entwicklung, Sensoroptimierungen und Tests von Kryogenen Stromkomparatoren zum Einsatz an neuartigen Ionenquellen, Beschleunigeranlagen und Speicherringen
Time span 07/15 - 06/18

Other projects

Nanoscale Interfaces for Organic Electronics (DAAD PaJaKo Project Japan, ID 56264880)
Time span: 01/13 – 12/15

Virtuelles Institut „MEMRIOX" (HZDR Dresden-Rossendorf)
Memory Effects in Resistive Ion-beam Modified Oxides
Time span: 10/11 – 09/16

Switchable and tunable infrared devices by controlled manipulation of the insulator-to-metal transition in Vanadium dioxide (DAAD/PPP USA)
Time span: 01/14 – 12/15

Schwingungsdynamik in komplexen Verbindungshalbleitern (ProChance, FSU Jena)
Time span: 03/13 – 03/16

FP7-PEOPLE-IRSES Scientist Exchange Program „ELiTES"
Time span: 03/12 – 02/16

8. 8. Institute of Solid State Theory and Optics

10 most important publications

1. F. Bechstedt, Many-body approach to electronic excitations (Springer, Berlin, 2015)
2. M. Wimmer, M.-A. Miri, D. Christodoulides, and U. Peschel, "Observation of Bloch oscillations in complex PT-symmetric photonic lattices," Scientific Reports 5, Article number: 17760 (2015) doi:10.1038/srep1776
3. R. Buschlinger, M. Lorke, and U. Peschel, "Light-matter interaction and lasing in semiconductor nanowires: A combined finite-difference time-domain and semiconductor Bloch equation approach," Phys. Rev. B 91, 045203 (2015) DOI: http://dx.doi.org/10.1103/PhysRevB.91.045203
4. M. Wimmer, A. Regensburger, M-A. Miri, C. Bersch, D. N. Christodoulides, and U. Peschel, "Observation of optical solitons in PT-symmetric lattices," Nature Communications 7782 (2015) doi:10.1038/ncomms8782.
5. S. Rigamonti, S. Botti, V. Veniard, C. Draxl, L. Reining, and F. Sottile, "Estimating Excitonic Effects in the Absorption Spectra of Solids: Problems and Insight from a Guided Iteration Scheme," Phys. Rev. Lett. 114, 146402 (2015) | 10.1103/PhysRevLett.114.146402
6. Rafael Sarmiento-Pérez, Tiago F. T. Cerqueira,Sabine Körbel, Silvana Botti, and Miguel A. L. Marques "Prediction of Stable Nitride Perovskites,"Chem. Mater., 2015, 27 (17), pp 5957–5963 (2015) | DOI: 10.1021/acs.chemmater.5b02026
7. Tiago F. T. Cerqueira , Sun Lin , Maximilian Amsler , Stefan Goedecker , Silvana Botti , and Miguel A. L. Marques, "Identification of novel Cu, Ag, and Au ternary oxides from global structural prediction,"Chem. Mater., 2015, 27 (13), pp 4562–4573 (2015) | 10.1021/acs.chemmater.5b00716
8. Tiago F. T. Cerqueira, Rafael Sarmiento-Pérez, Maximilian Amsler, F. Nogueira, Silvana Botti, and Miguel A. L. Marques, "Materials Design On-the-Fly,"J. Chem. Theory Comput., 2015, 11 (8), pp 3955–3960 (2015) | 10.1021/acs.jctc.5b00212
9. S. Körbel, D. Kammerlander, R. Sarmiento-Pérez, C. Attaccalite, M. A. L. Marques, and S. Botti, "Optical properties of Cu-chalcogenide photovoltaic absorbers from self-consistent GW and the Bethe-Salpeter equation," Phys. Rev. B 91, 075134 (2015) | 10.1103/PhysRevB.91.075134
10. X. Ma, I.Yu. Chestnov, M.V. Charukhchyan, A.P. Alodjants, and O.A. Egorov, "Oscillatory dynamics of nonequilibrium dissipative exciton-polariton condensates in weak-contrast lattices," Phys. Rev. B 91, 214301 (2015)

Invited talks and tutorials at international conferences

O.A. Egorov

O.A. Egorov, "Strong coupling between excitons and plasmons in a metallic slot waveguide," International conference, Days on Diffraction 2015, St. Petersburg, Russia.

O.A. Egorov, "Macroscopic oscillations of dissipative exciton-polariton condensates in weak-contrast lattices," International Workshop, Nonlinear Photonics: Theory, Materials, Applications, St. Petersburg, Russia.

O.A. Egorov, "Nonequilibrium dynamics of polariton condensates in periodic lattices," 5th Korean-German-French Workshop on nanophotonics, Würzburg, Germany.

U. Peschel

"Photonic Mesh Lattices: From PT Solitons to Optical Superfluidity," The third international workshop Frontiers in Photonics, TEDA/Nankai, Tianjin, China.

Martin Wimmer

"Photonic Mesh Lattices: From PT Solitons to Optical Superfluidity," CLEO Europe 2015, Munique.

F. Bechstedt

F. Bechstedt, "From 2D to 1D: Honeycomb crystals and their nanoribbons", Fruehjahrstagung DPG, Berlin, Germany.

F. Bechstedt, "Quasiparticle and pair excitations: Influence of dynamical screening, free carriers and defects" CECAM Workshop "Perspectives of many-particle methods: Total energy, spectroscopy and timedependent dynnamics", Bremen, Germany.

F. Bechstedt, "Topological states at semiconductor interfaces" 15th Int. Conf. Formation of Semiconductor Interfaces, Hiroshima, Germany.

S. Botti

S. Botti, “Electronic excitations in PV materials” at the workshop “Theory of metal atoms, clusters and nanoparticles stabilized by organic matter,” Helsinki, Finland.

S. Botti, “Thin-film solar cells: which ab initio approaches?” at the CECAM Workshop “Electronic structure at the cutting edge with the Elk code,” Lausanne, Switzerland.

S. Körbel

"Optical properties of Cu-based photovoltaics absorbers from the Bethe-Salpeter equation: bulk and nanostructures" at the EUSpec Meeting in Aveiro, Portugal.

M. Furthmüller

"Density Functional Theory", Instituto Tecnológico de Aeronáutica (ITA), São José dos Campos, Brazil.

Third party funded projects (name, duration, funding agency, financial volume in 2014)

DFG:

Project, EG344/2-1, Personal research project Dr. O.A. Egorov (Eigene Stelle) “Nonlinear dynamics of polaritons in photonic semiconductor structures”
(duration: 05/14 – 05/16)
2015: 64.100 €

Interregio Forschergruppe FOR 1700 „Metallic nanowires“
(duration: 12/12 – 11/15)
2015: 40.000 €

Project P5 "Modeling the Dynamics and Interaction of Photonic Nanowire Lasers" of the Forschergruppe „Dynamics and Interactions of Semiconductor Nanowires for Optoelectronics"
(duration: 05/2012 – 04/2018)
2015: 61.400 €

Project PE 523/14-1 „Nonlinear Optics of Temporally Discrete Systems“
(duration: 09/2015 – 08/2018)
2018: 10.800€

SFB F25 „InfraRed Optical Nanostructures (IR-ON)“
(duration: 04/05 – 03/09 + 04/09 – 03/12 + 04/12 – 03/15)
2015: 19.000 €

DFG FOR 1700 „Metal-induced chains„
(duration 12/2012 – 11/2015)
2015: 55.526 €

EU
LIMACONA “Light-Matter Coupling in Composite Nanostructures” Collaboration network programme supported by Marie Curie International Research Staff Exchange
(duration 10/13 – 09/16)
2015: 8.900 €

Industry

LANXESS “Predictive models for real iron oxide pigments”
(duration 08/2012 - 09/2017)
2015: 51.000 €

French National Research Agency (ANR) Programme Blanc.

“Photovoltaics with Ab initio Novel Electronic-Structure Simulations”
(duration: 01/12 – 12/15)
2015: 112.000 €

8. 9. Otto-Schott-Institute of Materials Research

10 most important publications

1. “Controlled Suppresion of Wear on the Nanoscale by ltrasonic Vibrations”, P Pedraz, R Wannemacher, E Gnecco, ACS Nano 2015, 9, 8859–8868; impact factor: 12.881
2. “Fixation and Release of Intact E-4 Tetrahedra (E=P,As)”, F Spitzer M Sierka, M Latronicao, P Mastrorilli, AV Virovets, M Scheer, Angew. Chem, Int. Ed. 2015, 11, 3029-3041; impact factor: 11.261
3. "Nature of Active Sites in Ni2P hydrotreating catalysts as probed by iron substitution" HY Zhao, ST Oyama, HJ Freund, R Windarczyk, M Sierka, App. Cat. B – Env, 164 2015, 204-216; Impact Factor: 7.435
4. ”Order-Disorder Transformation in a Nanocrystalline SmCo7 alloy“, M Seyring, XY Song, ZX Zhang, M. Rettenmayr, Nanoscale. 2015, 7, 12126-12132; impact factor: 7.394
5. ”Structure Evolution fo Nanoparticulate Fe2O3, A Erlebach, HD Kurland, J Grabow, FA Müller, M Sierka, Nanoscale 7, 2015 2960-2969; impact factor: 7.394
6. “Carbon Nanotubes An Carbon Nanofibers Perpared on Tubular Porous Ceramic Substrates“, A Simon, S Kämnitz, H Richter, I Voigt, M Seyring, M. Rettenmayr, U Ritter, Carbon 2015, 90, 25-33; impact Factor: 6.196
7. ”Characterization of biomimetic calcium phosphate labeled with fluorescent dextran for quantification of osteoclastic activity“, SM Maria, C Prukner, Z Sheikh, FA Müller, SV Komarova, JE Barralet, Acta Biomater. 2015, 20, 140-146; impact factor: 6.025
8. “Characterization of Nanoparticles by Solvent Infrared Spectroscopy (SIRS)”, J Kiefer, J Grabow, HD Kurland, FA Müller, Anal. Chem. 2015, 87, 12313-12317; impact factor: 5.636
9. “Aqueous Black Colloids of Reticular Nanostructured Gold”, SE Stanca, W Fritzsche J Dellith, F Frohlich, A Undisz, V Deckert, C Krafft, J Popp, Scientific Reports 2015, 5, 7899; impact factor: 5.578
10. “Mechanisms and kinetics of the crystal thickening of poly(butadiene)-block-poly(ethylene oxide) during annealing within the melting range ”, S Hoelzer, TN Buettner, R Schulze, MML Arras, FH Schacher, KD Jandt, US Schubert, Europ. Polymer J. 2015, 68, 10-20; impact factor: 3.005

Invited talks and tutorials at international conferences

Prof. Dr. Markus Rettenmayr

11. Tagung ”Gefüge und Bruch”, Leoben AT, 8.-10. April 2015

6. Int. Conference on Coupled Problems, San Servolo It, 18.-20. Mai 2015

Prof. Dr. Klaus D. Jandt

Third Annual International Workshop on Light Sources in Dentistry, Dalhousie University, June 24-26, 2015, Halifax, Canada

Prof. Dr. Frank A. Müller

Laser induced gas phase condensation
NanotechItaly, “Smart Hybrid Devices” Workshop, November 2015, Bologna, Italy

Prof. Dr. Marek Sierka

Low-Dimensional Metal Oxides: Synergy Between Theory And Experiment, BIT's 4th Annual World Congress of Advanced Materials-2015 (WCAM-2015) in Chongqing, China

Theory And Experiments Go Hand in Hand: Nanoparticulate Metal Oxides, CECAM Workshop "Emergent structural and electronic phenomena at interfaces of nanoscale oxides", Lausanne, Schweiz

External funding

EU:

European Commission - 7th Framework Program
Smart nano-structured devices hierarchically assembled by bio-mineralization processes - SMILEY
Projektdauer: 12/2012 – 11/2015
2015: 136,000 €

DFG:

Phase stability of alloy-type lithium storage anode materials
Duration: 08/2010 – 07/2016
2015: 85,000 €

Thermodynamics and interdiffusion at interfaces with potential jumps
Duration: 11/2014 – 10/2016
2015: 45,000 €

Thermoelektrische Materialien im System Bi2Te3-In2Te3
Duration: 01.04.2015 - 31.03.2018
2015: 50,000 €

Erstarrung von metallischen Legierungen in sehr dünnen Kapillaren
Duration: 01.10.2015 - 30.09.2018
2015: 15,000 €

Influence of a pressure induced piezoelectric field on the recombination processes in photocatalytically active nanoparticles
Duration: 03/2014 – 02/2017
2015: 95,000 €

Self-healing capacity of damage tolerant calcium phosphate biocements
Duration: 11/2014 – 10/2017
2015: 65,000 €

Effiziente globale Strukturoptimierung in beschränkten Räumen: Entwicklung und Anwendung für das Design von fortgeschrittenen Materialien
Duration: 12/2014 – 11/2016
2015: 77,000 €

Erzeugung und Verständnis von Nanofasern
Duration: 07/2014 – 06/2016
2015: 58,600 €

BMBF

Wachstumskern PADES: Funktionalisierung von Partikeln für Hochleistungskeramiken
Duration: 01.10.2014 – 30.09.2017
2015: 204,000 €

Wachstumskern PADES: Kompositwerkstoffe mit hoher Additivbeladung
Duration: 01.10.2014 – 30.09.2017
2015: 129,240 €

Ostseenetzwerk für Biomaterialverbunde
Duration: 01.10.2014 – 31.08.2016
2015: 1,370 €

Zwanzig20-InfectControl 2020 transsektorale Forschungsplattform
Duration: 03/2015 – 02/2018
2015: 41,513 €

AkMiArray – Akustooptische Systeme für die hochauflösende Ultraschallmikroskopie und Materialprüfung
Duration: 09/2013 – 08/2016
2015: 36,300 € (until August 2015)

Biologische Elimination komplexer diganostischer Nanopartikel – NanoBEL
Duration: 05/2015 – 04/2008
2015: 6,400 €

Laser-based microstructuring and functionalization in thin glasses
Duration: 02/2015 – 01/2017
2015: 62,300 €

JCMC
Duration: 08/2014 – 07/2017
2015: 10,000 €

Carl Zeiss Foundation
Postdoctoral research funding (Robert Schulze)
Duration: 01/2014 - 04/2016
2015: 64,641 €

Direct Industry funding:

Entwicklung von Hartloten
Duration: 04/2014-03/2017
2015: 70,000 €

Analytical Energy Gradients for Density Functional Methods With Periodic Boundary Conditions
Duration: 01/2015 – 06/2016
2015: 76,000 €

DAAD
Design of ceramic-metal nanocomposites
Duration: 01/2014 – 12/2015
2015: 6,400 €

TKM/TMBWK:
Nanosorb – Wissensbasierte Design mikro- und nanostrukturierter Sorptionsgradienten auf anorganischen Werkstoffoberflächen
Duration of the project: 12/2013 – 11/2015
2015: 0 €

Prices and awards

MSc Robert Hanke, Chair of Metallic Materials,

Dipl.-Phys. Matthias M. L. Arras, Chair of Materials Science: DGM-Nachwuchspreis 2015, 16. September, Dresden, Germany

Dipl.-Biochem. Carolin Dewald, Chair of Materials Science, Otto Schott Institute of Materials Research and Jena School for Microbial Communication: DGBM-Preis 2015 for the best talk in the Young Scientists Forum on the DGBM Annual Meeting, 12-14 November 2015, Freiburg, Germany

Public visibility

Press releases:

- Reibungsphänomene unterm Mikroskop; idw - Informationsdienst Wissenschaft (29.10.2015)

- Winzige Partikel mit großen Möglichkeiten; Chemiker und Materialwissenschaftler der Universität Jena forschen im inovativen regionalen Wachstumkern „pades“ mit idw - Informationsdienst Wissenschaft: (12.02.2015)
- Innovativ gegen Infektionen; idw - Informationsdienst Wissenschaft: (16.03.2015)
- Materialwissenschaftler aus Jena arbeiten an der Verbesserung von Prothesen aus Keramik tlz - Thüringische Landeszeitung: (05.04.2015)
- Biomaterialien für eine sich wandelnde Gesellschaft; idw - Informationsdienst Wissenschaft: (17.04.2015)
- Euro BioMAT 2015 in Weimar: Biomaterials for a changing society; MSE Newsletter: (10.06.2015)

8. 10. Institute of Optics and Quantum Electronics

10 most important publications

Ultrabright X-ray laser scattering for dynamic warm dense matter physics
LB Fletcher, HJ Lee, T Döppner, E Galtier, B Nagler, P Heimann, C Fortmann, S LePape, T Ma, M Millot, A Pak, D Turnbull, DA Chapman, DO Gericke, J Vorberger, T White, G Gregori, M Wei, B Barbrel, RW Falcone, C-C Kao, H Nuhn, J Welch, **U Zastrau**, P Neumayer, JB Hastings, SH Glenzer
Nature Photonics 9 (2015), 274-79; DOI: 10.1038/NPHOTON.2015.41

Investigation of femtosecond collisional ionization rates in a solid-density aluminium plasma
SM Vinko, O Ciricosta, TR Preston, DS Rackstraw, CRD Brown, T Burian, J Chalupsky, BI Cho, H-K Chung, K Engelhorn, RW Falcone, R Fiokovinini, V Hajkova, PA Heimann, L Juha, HJ Lee, RW Lee, M Messerschmidt, B Nagler, W Schlotter, JJ Turner, L Vysin, **U Zastrau**, JS Wark
Nature Communications 6 (2015), 6397 1-7; DOI: 10.1038/ncomms7397

Generation of neutral and high-density electron-positron pair plasmas in the laboratory
G Sarri, K Poder, JM Cole, W Schumaker, A Di Piazza, B Reville, T Dzelzainis, D Doria, LA Gizzi, G Grittani, S Kar, CH Keitel, K Krushelnick, **S Kuschel,** SPD Mangles, Z Najmudin, N Shukla, LO Silva, D Symes, AGR Thomas, M Vargas, J Vieira, **M Zepf**
NATURE COMMUNICATIONS 6 (2015), 6747; DOI: 10.1038/ncomms7747

Subcycle-resolved probe retardation in strong-field pumped dielectrics
AP Pati, IS Wahyutama, **AN Pfeiffer**
NATURE COMMUNICATIONS 6 (2015), 7746; DOI: 10.1038/ncomms8746

A strong-field driver in the single-cycle regime based on self-compression in a kagome fibre
T Balciunas, C Fourcade-Dutin, G Fan, T Witting, AA Voronin, AM Zheltikov, F Gerome, **GG Paulus,** A Baltuska, F Benabid
Nature Communications 6 (2015), 6117; DOI: 10.1038/ncomms7117

The generation of amplified spontaneous emission in high-power CPA laser systems
S Keppler, A Sävert, J Körner, M Hornung, H Liebetrau, J Hein, MC Kaluza
Laser & Photonics Reviews (2015); DOI: 10.1002/lpor.201500186

Tunable Subluminal Propagation of Narrow-band X-Ray Pulses
KP Heeg, J Haber, D Schumacher, L Bocklage, HC Wille, **KS Schulze, R Loetzsch, I Uschmann, GG Paulus**, R Rüffer, R Röhlsberger, J Evers
Phys. Rev. Lett. 114 (2015), 203601, DOI: 10.1103/PhysRevLett.114.203601

Noncollinear Polarization Gating of Attosecond Pulse Trains in the Relativistic Regime
M Yeung**, J Bierbach, E Eckner**, S Rykovanov, **S Kuschel, A Sävert,** M Förster**, C Rödel, GG Paulus**, S Cousens, M Coughlan, B Dromey, **M Zepf**
Phys Rev Lett. 115(19) (2015); DOI: 10.1103/PhysRevLett.115.193903

Direct Observation of the Injection Dynamics of a Laser Wakefield Accelerator Using Few-Femtosecond Shadowgraphy
A Sävert, SPD Mangles**, M Schnell**, E Siminos, JM Cole**, M Leier, M Reuter, MB Schwab, M Möller**, K Poder, O Jäckel, **GG Paulus, C Spielmann**, S Skupin, Z Najmudin, **MC Kaluza**
Phys. Rev. Lett. 115 (2015), 055002; DOI: 10.1103/PhysRevLett.115.055002

Erratum: Test of Time Dilation Using Stored Li+ Ions as Clocks at Relativistic Speed
B Botermann, D Bing, C Geppert, G Gwinner, TW Hänsch, G Huber, S Karpuk, A Krieger, T Kühl, W Nörtershäuser, C Novotny, S Reinhardt, R Sánchez, D Schwalm, **T Stöhlker**, A Wolf, G Saathoff
Phys. Rev. Lett. 114 (2015), 239902; DOI: 10.1103/PhysRevLett.114.239902

Invited talks and tutorials at international conferences

Gerhard Paulus / chair nonlinear optics

Relativistic surface high-harmonic generation
Eingeladenes Kolloquium, University of Strathclyde, Glasgow, 28 – 29 January 2015

Extreme States of Matter: From Cold Ions to Hot Plasma
POF III RT1 Treffen an der Geschäftsstelle Berlin Helmholtz-Gemeinschaft, Berlin, 16 – 17 March 2015

Multiphoton multi-electron ionization of ions to high charge states
Conference on "Extremely High-Intensity Laser Physics", Heidelberg, 21 – 24 July 2015 (invited Speaker)

Momentum-resolved study of strong-field multiple ionisation
Super Intense Laser-Atom Physics (SILAP), Bordeaux/Frankreich, 08 – 11 September 2015 (invited talk)

International Workshop on Atomic Physics, Max-Planck-Institute for the Physics of Complex Systems, Dresden, 22 – 27 November 2015 (invited talk)

Attosecond Science I – From the simplest Molecule to Polycyclic Aromatic Hydrocarbons
International Symposium on Ultrafast Intense Laser Science (ISUILS14), Kauai, Hawaii/USA, 08 – 14 December 2015

Coherent control at its most fundamental Area/Ultrafast Intense Laser Chemistry
The International Chemical Congress of PACIFIC BASIN SOCIETIES 2015 (PACIFICCHEM2015), Honolulu, Hawaii/USA, 14 – 18 December 2015

Christian Spielmann/chair quantum electronics

Coherent XUV imaging
IQO Retreat of the University of Hannover, Dahnsdorf/Germany, September 2015 (invited presentation)

Laser-Plasma-Based Secondary Sources: Accelerating Particles and Light
Frontiers in Optics Conference, San Jose/USA, 17 – 23 October 2015 (Tutorial)

C. Kern, M. Zürch, Z. Samsonova, D. Kartashov, and C. Spielmann
Laser induced damage of nanostructured materials
5th European Conference on Applications of Femtosecond Lasers in Materials Science, Mauterndorf/Austria, 16 March 2015 (invited talk)

C. Kern, M. Zürch, P. Hansinger, A. Dreischuh, and C. Spielmann
Extreme Nonlinear Optical Processes with Beams Carrying Orbital Angular Momentum
36th Progress in Electromagnetics Research Symposium (PIERS Conference), Prague/Czech Republic, 6 June 2015 (invited talk)

M. Zürch and C. Spielmann
CDI at high numerical aperture and phase contrast holography using a high harmonic source, COST MP2013 Meeting - 3D imaging with coherent and incoherent X-ray sources
Uppsala/Sweden, 18 September 2015 (invited talk)

M. Zürch, A. Guggenmos, C. M. Heyl, B. Landgraf, A. Hoffmann, C. Spaeth, R. Hollinger, S. Namba, U. Kleineberg and C. Spielmann
Narrow-band high harmonic emission at 100eV from an optimized generation geometry driven by an ultrafast 40mJ table-top laser
3rd International Conference on Correlation Effects in Radiation Fields, Rostock/Germany, 14 September 2015 (hot topic talk)

M. Zürch, J. Rothhardt, S. Hädrich, S. Demmler, M. Krebs, J. Limpert, A. Tünnermann, A. Guggenmos, U. Kleineberg, and C. Spielmann
Approaching the Abbe Limit in the Extreme Ultraviolet: Ultrafast Imaging Using a Compact High Average Power High Harmonic Source
Frontiers in Optics Conference, San Jose/USA, 22 October 2015 (talk, featured by AIP/OSA)

M. Zürch, S. Foertsch, M. Matzas, K. Pachmann, R. Kuth, and Ch. Spielmann
Cancer cell classification with coherent diffraction imaging using a table-top soft Xray Source
COST MP2013 Meeting - New X-ray sources for industrial metrology, Jena/Germany, 23 March 2015

M. Zürch. *Coherent ultrafast imaging in the extreme ultraviolet - from cancer cell classification to optical vortex generation for phase-structured illumination*
German Physical Society - Spring Meeting, Heidelberg, Germany, 24 March 2015 (invited talk)

D. Kartashov et al.
Standoff Sources of Coherent Radiation Initiated by Femtosecond Filaments
CLEO: Science and Innovations, San Jose/USA, May 2015 (invited talk)

Malte Kaluza/ chair for Relativistic Laser Physics

M. C. Kaluza et al.
Observing the Dynamics of a Laser-Driven Plasma-Electron Accelerator
LA3NET Conference on Laser Applications at Accelerators, Mallorca/Spain, March 2015 (invited)

M. C. Kaluza et al.
Observing the Dynamics of a Laser-Driven Plasma-Electron Accelerator
SPIE, Prague/ Czech Republic, April 2015 (invited)

M. C. Kaluza et al.
Laser-ion acceleration: Current status and future prospects
46. Jahrestagung der DGMP, Marburg/Germany, September 2015 (invited)

M. C. Kaluza et al.
Visualizing the Dynamics of a Plasma-Based Electron Accelerator
Colloquium at PSI Villigen/Switzerland, October 2015 (invited)

Alexander Sävert

A. Sävert et al.
Laser wakefield acceleration under the microscope
Workshop on Nonlinear Photonics: Theory, Materials, Applications, St. Petersburg/Russia, 2 July 2015 (invited)

A. Sävert et al.
Optical probing of a laser driven electron accelerator
EAAC 2015, Elba/Italy, 17 September 2015 (plenary)

S. Keppler et al.
Full ASE Characterization of high-Power Laser Systems - a comparative study for various materials
SPIE Optics and Optoelectronics, Prague/Czech Republic, 14 April 2015 (invited)

M. Hornung et al.
Laser- and Target-Diagnostics at the POLARIS Laser System
3rd meeting of the Networking Activity on Ultrafast Ultraintense Lasers (NAUUL), Salamanca/Spain, 30 November 2015 (invited)

Eckhart Förster/ work group x-ray physics

Introduction to the COST Meeting on Advanced X-ray spatial and temporal metrology
European Cooperation in the Field of Scientific and Technical Research, ACTION MP 1203, Jena/Germany, 23 – 24 March 2015

Ultrafast structural changes in crystals studied by pump-probe experiments
Workshop on Application of Laser Plasma Sources of X-rays and Extreme Ultraviolet (EUV) in Technology and Science – ALPS 2015, Warsaw/Poland, 6 – 9 July 2015

Ulf Zastrau

Electron trapping by strong Coulomb coupling in a relativistic laser plasma
Workshop on Modern Methods in Plasma Spectroscopy, ICTP, Trieste/Italy, 23 – 27 March 2015

X-ray spectroscopy to explore extreme states of dense matter
Institutsseminar für Strukturphysik, TU Dresden, Dresden, 16.12.2014

H. Bernhardt
High Precision X-ray Polarimetry a powerful tool for nuclear resonant X-ray scattering
5th International Workshop on Nuclear Resonance Scattering of Synchrotron Radiation: Status, Highlights, Methodology, and Trends, Hamburg/Germany, 23 September 2015

Thomas Stöhlker/ Chair Atomic Physics of HIghly Charged Ions

APPA@FAIR: From Basic Science to Applications
FAIR review of Science Case and Project Management Structure, GSI Darmstadt, 16 February 2015

Extreme States of Matter:From Cold Ions to Hot Plasmas
Workshop on Research Topic 1 "Extreme States of Matter: From Cold Ions to Hot Plasmas" of the POF Program "From Matter to Materials and Life", Berlin, 15 March 2015

The Physics of FAIR: Exploring Matter in Extreme Electromagnetic Fields
High Energy Density Science, Seminar, LLNL Livermore, 2 April 2015

APPA@FAIR: From Basic Science to Applications
SHIM, Swift Heavy Ion Conference, Darmstadt/Germany, 17 May 2015

Exploring Matter in Extreme Electromagnetic Fields
Physikalisches Kolloquium TU Darmstadt, 8 November 2015

Exploring Matter in Extreme Electromagnetic Fields
Seminar, Universität Lüneburg, 15 November 2015

APPA@FAIR: Instrumentation and Basic Requirements
HIC for FAIR Workshop, Hamburg, 15 July 2015

FAIR: Facility for Antiproton and Ion Research
Seminar, Lanzhou/China, 18 August 2015

Midterm Program for Research at GSI
KHuK Annual Meeting 2015, Physikzentrum Bad Honnef, 5 December 2015

Current Status of FAIR
SPARC Workshop 2015, Fodele Beach, Crete, 23 September 2015

Sven Bernitt

S. Bernitt
Electron beam ion traps at ultrabrilliant light sources
HI Jena, 1 July 2015

S. Bernitt
Spectroscopy with highly charged ions at ultrabrilliant light sources
Stefan-Meyer-Institut (ÖAW), Wien, 4 November 2015

Tobias Gassner

Lamb-Shift of Heavy Highly Charged Ions by X-Ray Spectroscopy
Fundamental Constants Meeting, Eltville, 5 February 2015

High Precision X-Ray Spectroscopy at Storage Rings
Advanced Seminar on Condensed Matter Physics, Universität Heidelberg, 19 November 2015

G. Weber
SPARC detectors and polarimetry: New results from PETRAIII
SPARC Workshop 2015, Crete/Greece 22 - 28 September 2015

Matt Zepf / chair laser particle accelerator

Ultrafast temporal response of materials to proton irradiation
Swift Heavy Ions in Matter (SHIM), Darmstadt/Germany, 18 – 19 May 2015

Experimental Investigation of QED at high intensities
Extremely High-Intensity Laser Physics (EXHILP), keynote talk, Heidelberg/Germany, 21 – 24 July 2015

Experimental Investigation of QED at high intensities
ELI Scientific Challenges, Prague/CZ, 19 – 20 October 2015

Adrian Pfeiffer

Sub-cycle resolved probe retardation in strong-field pumped dielectrics
Frühjahrstagung der DPG, Heidelberg, 24 – 26 March 2015

A. P. Pati, I. S. Wahyutama, and A. N. Pfeiffer
Sub-Cycle Resolved Probe Retardation in Strong-Field Pumped Dielectrics
Conference on Lasers and Electro-optics Europe (CLEO), Munich/Germany, 22 – 28 June 2015

Third -party projects

DFG

TRANSREGIO / TR18-04 „Relativistische Laser-Plasma-Dynamik“
Düsseldorf/Jena/München Teilprojekte A5, A7, A12, B7, B9
2013 -2016
2015: 432.860 €

Phase-dependent Strong-field Laser Physics
PA 730/4-2
2012 - 15
2015: 82.100 €

Investigation of relativistic plasmas produced by irradiating micrometer-sized solid-density hydrogen and argon droplets with ultraintense laser pulses
KA 2869/2-1
2012 – 15
2015: 61.400 €

Induzierte Terahertz-Strahlung und relativistische Optik - ein neues Charakterisierungsverfahren für laser-basierte Teilchenbeschleuniger
GO 1998/3-1
2013 - 2016
2015: 60.400 €

Erste Schritte in Richtung der Atomphysik von Stößen schneller Ionen mit langsamen Ionen
STO 346/4-1
2013 – 2016
2015: 56.200 €

Erforschung korrelierter Ionisationsdynamik
PA 730/5-1
2015 – 2018
2015: 35.800 €

QUTIF: Die HeH+ Isotopologie in intensiven asymmetrischen Lichtwellen
PA 730/6-1
2015 – 2018
2015: 24.000 €

BMBF

BMBF/DESY, FAIR-APPA: „Effiziente Röntgenoptik mit gebogenen Mosaikkristallen für die Röntgenspektroskopie“, 06JY7149
2012 – 2015
2015: 28.200 €

BMBF/ Zentren für Innovationskompetenz-Verbundprojekt "onCOOPtics - Hochintensitätslaser für die Radioonkologie, Teilvorhaben B: "Laser- und Targettechnologieentwicklung für therapierelevante Teilchenstrahlen" 03Z1H531
2012 - 2017
2015: 279.700 €

BMBF/DESY, „FEL-Spezifische Röntgendiagnostik zum Studium dichter Plasmen (XFEL)“, 05K13SJA
2013 – 2016
2015: 78.200 €

BMBF/DESY, Verbundprojekt 05K2013 „PolarX: Präzisions-Röntgen-Spektroskopie und -Polarimetrie. Teilprojekt 3: Röntgenpolarimetrie mit extrem hoher Reinheit“, 05 K 13SJ1
2013 – 2016
2015: 14.000 €

BMBF/DESY, Verbundprojekt 05K2013 „PolarX: Präzisions-Röntgen-Spektroskopie und Polarimetrie - Neue Röntgenstandards für Synchrotrone“ , 05K13SJ2
2013 – 2016
2015: 115.500 €

BMBF/Jülich, "XUV Kohärenztomografie zur zerstörungsfreien, dreidimensionalen Bildgebung von Nanostrukturen" XCT, VIP0515 03 V0690
2013 – 2016
2015: 609.900 €

BMBF/DESY, Verbund APPA R&D: „Licht-Materie Wechselwirkung mit hochgeladenen Ionen (FAIR-APPA)“, 05P15SJFAA
2015 – 2018
2015: 174.000 €

GSI - Helmholtz-Institut Jena
2015: 439.300 € (Uni-Konto)

State of Thuringia (TKM)

Angepasste Laser- und Konvertgläser – ALASKA(TMWAT)
2011 FGR 0122
2011 – 2014
2015: 41.600 €

Thüringen Pro Exzellenz 2014 – 2019: “ACP Explore Projekt/Time-Resolved Spectroscopy of Molecular Dynamics with Pulses at Different Wavelengths”, FSU-I-06-14 (gemeinsam mit Physikalischer Chemie)
2015 – 2016
2015: 35.000 €

German-Israeli Foundation for Scientific Research and Development (GIF)

Probing for Ultra-High Electric Fields in Relativistic Laser-Matter interactions Using Novel X-Ray Spectroscopy
I-1249-303.7/2014
2015 – 2017
2015: 16.400 €

VW-Foundation

Peter Paul Ewald-Fellowship: Exploring extreme states of matter by time-resolved X-ray spectroscopy
2012 – 15
2015: 35.200 €

Peter Paul Ewald-Fellowship: Exploring Relativistic Plasmas with free-Electron- Lasers
2014 – 2017
2015: 105.000 €

Patents
„Verfahren und Vorrichtung zur gleichzeitigen Bestimmung der axialen und lateralen Struktur von Objekten mittels Strahlung kurzer Wellenlänge“, Hausakte 15-24

„Vorrichtung zur Kühlung optischer Elemente“, DE 102015001673.3 (Februar 2015)

8. 11. Institute of Theoretical Physics

10 most important publications

T. Dietrich, N. Moldenhauer, N. Johnson-McDaniel, S. Bernuzzi, C. Markakis, B. Brügmann, W. Tichy;
Binary Neutron Stars with Generic Spin, Eccentricity, Mass ratio, and Compactness - Quasi-equilibrium Sequences and First Evolutions;
Phys. Rev. D92 124007 (2015).

T. Dietrich, S. Bernuzzi, M. Ujevic, and B. Bruegmann;
Numerical relativity simulations of neutron star merger remnants using conservative mesh refinement;
Phys. Rev. D91 124041 (2015).

M. Breithaupt, Y-C. Liu, R. Meinel and S. Palenta;
On the black hole limit of rotating discs of charged dust;
Class. Quant. Grav. 32, 135022 (2015).

M. Ammon, J. Erdmenger;
Gauge/Gravity dualities: fundations & applications;
Cambridge University Press.

I. Shapiro, P. de Morais Teixeira and A. Wipf;
On the functional renormalization group for the scalar field on curved background with non-minimal interaction;
Eur. Phys. J C75, 262 (2015).

F. Karbstein, H. Gies, M. Reuter and M. Zepf,
Vacuum birefringence in strong inhomogeneous electromagnetic fields,
Phys. Rev. D 92, 071301 (2015).

A. Eichhorn, H. Gies, J. Jaeckel, T. Plehn, M. M. Scherer and R. Sondenheimer,
The Higgs Mass and the Scale of New Physics,
JHEP 1504, 022 (2015).

H. Gies and S. Lippoldt,
Global surpluses of spin-base invariant fermions,
Phys. Lett. B 743, 415 (2015).

E. Eliav, S. Fritzsche and U. Kaldor;
Electronic structure of the superheavy elements;
Nucl. Phys. A 944, 518 (2015).

E. Jordan, G. Cerchiari, S. Fritzsche and A. Kellerbauer;
High-resolution laser spectroscopy on the negative lanthanum ion;
Phys. Rev. Lett. 115, 113001 (2015).

Invited talks and tutorials

M. Ammon
Recent progress in AdS/CFT & Higher Spin Gravity,
Talk at 3rd EFI winter conference on quantum gravity, Tux, Austria, 16.02.2015

Gravity meets condensed matter,
Talk at Networking Workshop RTGs 1523 and 1620, Bremen, 03.03. 2015

From gravity and black holes to condensed matter systems and back,
Colloquium, Department of Physics, University of Erlangen-Nürnberg, 08.06.2015

Phase diagram of field theories with axial anomaly from holography,
Talk at Yau Mathematical Sciences Center, Tsinghua University, Bejing, China, 21.07.2015 and
Talk at workshop "Holographic duality for condensed matter systems", KITPC, Bejing, China, 24.07.2015

Phase diagram of 4D field theories with chiral anomaly,
Talk at Workshop "Vienna Central European Seminar" (VCES 2015), University of Vienna, Austria, 27.11.2015

M. Ansorg
Conformal Mappings for Spectral Methods in Classical Field Theory,
Vernetzungsworkshop der GRKs ,,Models of Gravity" (1629) und ,,Quanten-und Gravitationsfelder'' (1523), Bremen, 03.03.2015

High-accuracy methods for black-hole perturbations: quasi-normal-modes filtering,

Jahrestagung der DMV, Hamburg, 23.09.2015
High-accuracy methods for black-hole perturbations: quasi-normal-modes filtering,

Universität Wien, Physikalische Fakultät, Gravitationsphysik-Seminar, 19.11.2015
High-accuracy methods for black-hole perturbations: quasi-normal-modes filtering,
Oberseminar, Mathematische Fakultät, Universität Regensburg, 11.12.2015

B. Brügmann
Black Holes and Neutron Stars in Numerical General Relativity,
DPG Spring Meeting, Berlin, 18.3.2015

Numerische Relativitätstheorie,
Einstein relativ einfach - 100 Jahre Allgemeine Relativitätstheorie, Bad Honnef, 23.7.2015

Numerische Relativität: Was Einstein noch nicht sehen konnte,
100 Jahre Allgemeine Relativitätstheorie, Zürich, 14.11.2015

T. Dietrich
Dynamical simulations of neutron star spacetimes with conservative mesh refinement,
DPG Spring Meeting, Berlin, 19.3.2015

S. Fritzsche
Atomic interactions of twisted particles and beams,
IPHT Kolloquium, 12. 05. 2015

Atomic excitations in relativistic heavy-ion collisions,
GSI Kolloquium, 07. 07. 2015

A computer-algebraic approach to quantum information: Classification and characterization of multi-qubit systems,
Invited Talk at Mathematical Modeling and Comp. Physics, Stara Lesna, Slowakia, 13.-17. 07. 2015

Production and decay of excited states in relativistic collisions,
Invited Talk at XXIX International Conference on Photonic, Electronic, and Atomic Collisions (ICPEAC), Toledo, Spain, 22.-28. 07 2015

Atomic interactions with twisted light and electrons,
Invited Talk at VIII Workshop on Atomic and Molecular Physics, Jurata, Poland, 12. 09. 2015

H. Gies
Pair Production at High Intensity,
ICEL 2015 Conference Bucharest, 11.2015

Quantum Vacuum and Building Blocks of Matter in Extreme Light,
QED vacuum birefringence workshop, DESY Hamburg, 11.2015

Critical Schwinger Pair Production,
EXHILP Conference, MPIK Heidelberg, 07.2015

Vacuum stability and the mass of the Higgs boson,
Theory Seminar, KFU Graz, 08.2015

Physics of the Quantum Vacuum,
Theory Colloquium, University of Cologne, 07.2015

Vacuum stability and the mass of the Higgs boson,
Theory Seminar, TU München, 05.2015

Low-dimensional Chiral Fermions,
Int. Conference, FERMIONS 2015, IWH Heidelberg, 04.2015

Fermions, Gravity & Chiral Symmetry,
Nordita International Workshop, Stockholm, 03.2015

Vacuum stability and the mass of the Higgs boson,
Theory Seminar, Leipzig University, 01.2015

D. Hilditch
Collapsing Gravitational Waves with Numerical Relativity,
Parma, Italy, 12.2015

Free-evolution formulations of General Relativity,
Daejeon, South Korea, July 2015

Progress in the numerical treatment of collapsing gravitational waves,
Toronto, Canada, 05.2015

Michael Kalisch
Pseudo-spectral solutions of non-uniform black strings in 6 dimensions,
Vernetzungsworkshop der GRKs ,,Models of Gravity'' (1629) und ,,Quanten-und Gravitationsfelder'' (1523),
Bremen, 04.03.2015

Highly Deformed Non-uniform Black Strings,
Talk at the fourteenth Marcel Grossmann Meeting, Rom, 14.07.2015

F. Karbstein
All-optical probes of quantum vacuum nonlinearity,
ICEL 2015 Conference Bucharest, 11.2015

QED vacuum birefringence beyond the constant field limit,
QED vacuum birefringence workshop, DESY Hamburg, 11.2015

All-optical probes of quantum vacuum nonlinearity,
Universität Erlangen, 10.2015

Measuring vacuum birefringence at HIBEF - a proposal based on novel theoretical insights,
Helmholtz-Zentrum Dresden-Rossendorf, 08.2015

All-optical probes of quantum vacuum nonlinearity,
EXHILP Conference, MPIK Heidelberg, 07.2015

All-optical probes of quantum vacuum nonlinearity,
Photon 2015, Budker Institute of Nuclear Physics, Novosibirsk, 06.2015

On the Search for inhomogeneous Phases in Fermionic Models,
Universität Frankfurt, 02.2015

S. Lippoldt
Global surpluses of spin-base invariant Fermions,
International Asymptotic Safety VTC Seminar, 02.2015

Fermions in gravity with local spin-base invariance,
RTG Network Workshop, Bremen, 03.2015

What fermions can tell us about quantum gravity,
``Relativity Lunch'', Imperial College, 04.2015

Generalized Parametrization Dependence in Quantum Gravity,
International Asymptotic Safety VTC Seminar, 10.2015

Gravity, Fermions and Spin Base Invariance,
International Workshop on Strongly-Interacting Field Theories, Jena, 11.2015

R. Meinel
Schwarze Löcher,
WE-Heraeus-Lehrerfortbildung, Potsdam, 11-14.3.2015

From rotating discs to black holes,
14th Marcel Grossmann Meeting on General Relativity, Rom, 12.-18.7.2015

Schwarze Löcher,
DPG-Fortbildungskurs für Physiklehrer, Bad Honnef, 20.-24.7.2015

Constructive proof of the no-hair theorem,
Jahrestagung der Deutschen Mathematiker-Vereinigung, Hamburg, 21.-25.9.2015

S. Palenta
The characteristic initial value problem of colliding plane gravitational waves,
5th Central European Relativity Seminar, Budapest, 26.-28.5.2015

Rodrigo Macedo
Axisymmetric fully spectral code for hyperbolic equations,
Vernetzungsworkshop der GRKs ,,Models of Gravity" (1629) und ,,Quanten-und Gravitationsfelder'' (1523),
Bremen, 04.03.2015

G. Schäfer
Where is the energy stored in the gravitational field?
Main Talk, DPG-Frühjahrstagung, Berlin, 16.– 20.03.2015

Spin effects in neutron stars and their orbital dynamics,
"The Many Faces of Neutron Stars", MIAPP Munich- Garching, 06.-18.09.2015

Motion of compact objects in general relativity,
The 2nd Conference of the Polish Society on Relativity: 100 Years of General Relativity,
Stefan Banach International Mathematical Center Warsaw and University, 22.–28.11.2015

100 Jahre Allgemeine Relativitätstheorie,
URANIA-Eichsfeld, Leinefelde-Worbis, 02.12.2015

R. Sondenheimer
Higgs mass bounds from renormalization flow,
International Schladming Winter School, 03.2015

A. Sternbeck
Taming hypercubic lattice artefacts via lattice perturbation theory,
Invited seminar, Humboldt-University /DESY Zeuthen, February 2015.

Hadron Structure from Lattice QCD,
International School of Nuclear Physics in Erice, Sicily, September 2015.

A. Wipf
G2-gauge theory at finite temperature and finite density,
4th Winter Workshop on “Non-Perturbative Quantum Field Theory”, Sophia-Antipolis, 1.-5.2.2015

G2-gauge theory,
Workshop on “Lattice Gauge Theory for the LHC and Beyond”, Kavli Institute for Theoretical Physics, Santa Barbra, 4.9.2015

The Functional Renormalization Group method – an introduction,
Saalburg Summer School, Wolfersdorf, 10.9.2015

L. Zambelli
Asymptotically free scaling solutions in non-Abelian Higgs models,
University of Warsaw, 12.2015

O. Zanusso
Probing the fundamental nature of fluctuating membranes with the Renormalization Group,
Nordita International Workshop, Stockholm, 03.2015

Third party funding

DFG-projects

GRK 1523: Quantum and gravitational fields
(Project term: 04/2009 – 03/2018)
2015: 574,340 €

SFB/TR18/2: Relativistic Laser-Plasma-Dynamics
Projekt B7 *From Compton Scattering to Strong Field Electrodynamics*
(Project term: 12/2005 - 06/2016)
2015: 44,342 €

Wi 777/11-1: *Supersymmetrische Yang-Mills Theorien im Kontinuum und auf dem Gitter*
(Project term: 2011 - 2016)
2015: *42,*278 €

FOR 723: Functional RG for strongly correlated fermions
Gi 328/6-2 Projekt 5 *Ultracold fermionic gases*
(Project term: 03/2010 - 12/2015)
2015: 61,240 €

Gi 328/7-1: *Chiral Fermions and Quantum Gravity*
(Project term: 09/2015 – 08/2017)
2015: 10,646 €

Successful defense of the SFB/Transregio 176 preproposal “Physics and Astrophysics of Neutron Stars”, May 2015; Defense of the main proposal in December 2015.

Other Projects

BMBF Project: 05P15SJFAA – APPA-Sparc:
Teilprojekt 4: Pair@Fair
(Project term: 07/2015-06/2018)
2015: 14,549 €

Land Thüringen, ProExzellenz 2014-219,
ACP Explore-Projekt: *Enlightning New States of Matter*
(Project term: 2015-2017)
2015: 19,579 €

BMBF Project: 05K2013 - PolarX: Präzisions-Röntgen-Spektroskopie und Polarimetrie. Teilprojekt 4: Polarisationskorrelation für die elastische Photonenstreuung"
(Förderkennzeichen 05K13VHA, Project term: 2013 – 2016)
2015: 51,770 €

BMBF Project: 05P2015 - ISOLDE: Präzise theoretische Vorhersagen zur offenschaliger Atome und Ionen für die Laserspektroskopie bei ISOLDE " (Förderkennzeichen 05P15SJCIA, Project term: 2015 – 2018)
2015: 4,985 €

Helmholtz-Institut Jena: Twin-Server: 14,200 €

Numerical simulations of G2-QCD at finite densities and tempertur at the Center for Scientific Computing in Frankfurt, approx. 30 million CPU-hours between 2011 and 2015

Numerical investigation of the QCD's Greens functions at the HLRN Verbund (www.hlrn.de) in collaboration with Prof. Müller-Preussker. Funding in 2015: 80000 NPL (approx. 800 000 CPUh)

The institute has spent approximately 43 400 Euros on improving and renewing its IT infrastructure. This included 25 000 Euros for servers, 14 000 Euros for workstations and laptops and 4 400 Euros on monitors. The expenditure were paid by the University, fund raising and funds from the Helmholtz Institute Jena.

8. 12. Research group - Teaching Methodology in Physics and Astronomy

Publications

Lotze, K.-H.: Themenheft 100 Jahre Allgemeine Relativitätstheorie, Astronomie+Raumfahrt im Unterricht, 52(2015)(6), Herausgeber

Salatowsky, S.; Lotze, K.-H. (Hrsg.): Himmelspektakel – Astronomie im Protestantismus der Frühen Neuzeit (Ausstellungskatalog), Gotha 2015

Lotze, K.-H.: Wie am Himmel so auf Erden – Galilei, Kepler und die Vereinheitlichung des physikalisch-astronomischen Weltbildes, Ausstellungskatalog Gotha (siehe oben), S. 73-85

Fischer, S.; Völker S.; Ruby, S.: „Optik – ein Kinderspiel“, Praxis der Naturwissenschaften, Physik in der Schule, Heft 5 2015

Völker, S.: „Wie lange lebt ein Stern? – Mit dem Hertzsprung-Russell-Diagramm der Sternentwicklung auf die Spur kommen (Teil II)“, RAAbits Physik (Dr. Josef Raabe Verlag), Beitrag II/H, Reihe 4, 2015

Völker, S.:„ Wie man im Klassenzimmer einen Stern auf die Waage legt – Die Bestimmung der Masse von 70 Ophiuchi“, ASTRONOMIE + RAUMFAHRT im Unterricht, Heft 6 2015

Völker, S.; Fischer, S.: „Freihandexperimente zur Schwerelosigkeit“, ASTRONOMIE + RAUMFAHRT im Unterricht, Heft 6 2015

Völker, S.; Sambale, A.: *Licht ist bunt*; Begleitheft für Grundschüler zur Ausstellung der Highlights der Physik in Jena 2015

Völker, S.; Sambale, A.: *Jenseits des sichtbaren Lichts*; Begleitheft für Grundschüler zur Ausstellung der Highlights der Physik in Jena 2015

Völker, S.; Sambale, A.: Begleitheft zur Ausstellung der Highlights der Physik in Jena 2015

Talks and Workshops:

Völker, Stefan: „Die Rolle der Beobachtung im Astronomieunterricht - Eine Schulbuchanalyse“ Vortrag im Rahmen der DPG Frühjahrstagung in Wuppertal 2015

Völker, Stefan: „Schülerprojekte mit astronomischen Originaldaten für den Einsatz im Astronomieunterricht der Oberstufe”, Vortrag im Rahmen des 2. astronomiedidaktischen Kolloquiums für Promovierende

Lotze, Karl-Heinz; Völker, Stefan: „Spezielle Relativitätstheorie mit Zirkel, Lineal und Geo-Gebra“, Lehrerfortbildung im Rahmen der 21. Tage das mathematisch-naturwissenschaftlichen Unterrichts in Erfurt 2015

Lotze, Karl-Heinz; Völker, Stefan: „Spezielle Relativitätstheorie mit Zirkel, Lineal und Geo-Gebra“, Lehrerfortbildung im Rahmen der Lehrerfortbildung „Einstein relativ einfach - 100 Jahre Allgemeine Relativitätstheorie“ in Bad Honnef 2015

Völker, Stefan; Fischer Silvana: Workshop im Rahmen des jun.iversity-Camps „Wenn Licht um Ecken und Kurven geht…“

Awards

Lotze, K.-H.: Hanno-und-Ruth-Roelin-Preis für Wissenschaftspublizistik des Max-Planck-Instituts in Heidelberg

Third-party funding

DPG 3,100 €

Meade 1,000 €

Wilhelm- und Else-Heraeus-Stiftung
Heraeus Summer Course "Kosmology" for teachers together with Heidelberg, Padua, Florenz,
duration: 2013 -2016
2015: 11,875 €

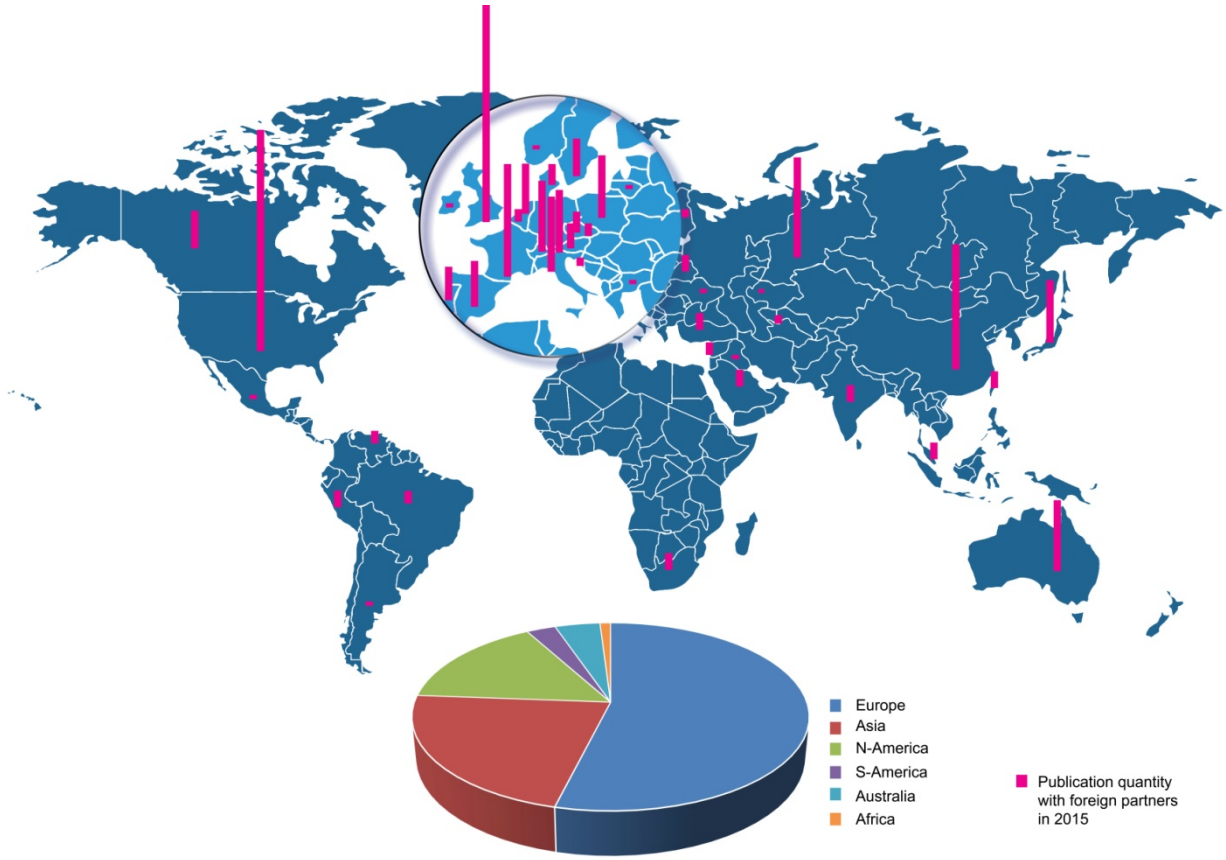
TMWWDG

Förderung von Genderkompetenz durch Lehr- und Weiterbildungsangebote an Thüringer Hochschulen; Erstellung MINT-Parcours an Thüringer Hochschulen
2015: 29,030 €

9. International Relationships

9. 1. Common Publications with International Partners

The cooperation with partners in foreign institutions in most of the cases leads to common publications in peer-reviewed journals. About 43 % of the publications of the Faculty of Physics and Astronomy are together with authors from foreign institutes. The authors are located in 43 countries. Most of the 188 common publications in 2015 were made with authors from the United States (53), the United Kingdom (52) and France (27). The figure below shows the distribution of the common publications with partners all over the world.



9. 2. Astrophysical Institute and University Observatory

a) Collaborations, shared research projects

The institute participates in numerous national and international collaborations many of which have been mentioned above. A short list of currently active ones follows:

- Direct detection and infrared spectroscopy of sub-stellar companions of young stars and their orbital movement and mass determination for analyzing their formation, Ralph Neuhäuser, Markus Mugrauer, Christian Adam together with N. Vogt, U Valparaiso, Chile, A. Seifahrt, U Chicago, USA, T. Mazeh, S. Zucker, U Tel Aviv, Israel,Ch. Ginski, U Leiden, NL, and others.
- Project YETI (Young Exoplanet Transit Initiative): photometric monitoring of young star clusters for analysis of very young transiting planets and other variability phenomena, Ralph Neuhäuser, Ronny Errmann, Markus Mugrauer et al. together with G. Maciejewski, A. Niedzielski, U Torun, Poland, W.P. Chen, National Central U, Taiwan, R. Redmer, N. Nettelmann, U. Kramm, U Rostock, D.P. Dimitrov, Inst. Astronomy, Bulgar. Aca. Sci., T. Pribulla, M. Vaňko, A. Budaj, Astron. Inst., Slov. Aca. Sci., G. Torres, D. Latham, CfA U Harvard, USA, St. Rätz, ESA ESTEC, and others.
- Search for additional companions of stars with transiting planets by means of the transit-time-variation method, Martin Seeliger, Manfred Kitze, Ralph Neuhäuser, Markus Mugrauer together with St. Rätz, ESA ESTEC, G. Maciejewski, U Torun, Poland, D.P. Dimitrov, Inst. Astronomy, Bulgar. Aca. Sci., and others.
- Investigation of young nearby neutron stars, particularly optical and X-ray observations to constrain the equation-of-state of neutron stars, Valeri Hambaryan, János Schmidt, Ralph Neuhäuser together with K. Kokkotas, K. Werner, V. Suleimanov, U Tübingen, F. Haberl, R. Diehl, MPE Garching, F. Walter, SUNYSB, USA, and others.
- Investigation of runaway stars inside of supernova remnants, Baha Dinçel, Anna Pannicke, Ralph Neuhäuser together with Dr. Ankay (Boğaziçi U Istanbul), Dr. Yerli (METU Ankara), Turkey, and G. Torres (Harvard).
- Investigation of fallback discs of neutron stars, together with Dr. Ekşi, TU Istanbul, Turkey.
- Interpretation of historic reports on astronomical observations to study solar activity and (super-)novae, Ralph Neuhäuser et al. in collaboration with M. Csikszentmihalyi, J. Chapman UC Berkeley, USA, P. Kunitzsch, LMU München, and others
- Cooperation with the former team of the Herschel Open Time Key Project DUNES ("Dust around Nearby Stars", PI: C. Eiroa, Spain), Alexander Krivov, Torsten Löhne, Harald Mutschke, together with the DUNES-consortium.
- Cooperation with the former team of the Herschel Open Time Key Project GASPS ("Gas in Protoplanetary Systems", PI: W.R.F. Dent, UK), Alexander Krivov, together with the GASPS-consortium.
- Investigation of spatially resolved debris discs, Nicolle Pawellek, Alexander Krivov, together with P. Abraham und A. Moor, Konkoly Observatory, Budapest, Hungary.
- A study of the AU Mic disk, Christian Schüppler together with T. Löhne, A. Krivov, S. Ertel (ESO/Chile), J.P. Marshall (UNSW Sydney), S. Wolf (U. Kiel), M.C. Wyatt (Cambridge U.), J.-C. Augereau (IPAG Grenoble), and S.A. Metchev (U. Western Ontario).
- Probing stellar atmospheres of the alpha Cen A and B, Alexander Krivov with R. Liseau (Onsala, Sweden) and others.
- Amorphous-silicate samples for X-ray absorption measurements, Harald Mutschke, Pierre Mohr, Gabriele Born together with E. Costantini, C. de Vries (SRON Utrecht, NL), S. Zeegers (U Leiden, NL).

b) Guests in 2015 (for several days):

Carlos Eiroa, UAM Madrid, Spain
Fernando Cruz, INAOE, Mexico
Kazim Yavuz Ekşi, Istanbul Technical University, Turkey
Emil Kundra, Ast. Inst. Tatranska Lomnica, Slovakia
Nikolaus Vogt, University Valparaiso, Chile
Pawel Zielinski, University Torun, Poland

9. 3. Institute of Applied Optics

a) Cooperation & joint projects

Image Processing Systems Institute (IPSI) of the Russian Academy of Sciences, Samara, Russia & Korolyov Samara State Aerospace University, Samara, Russia

- Selective excitation and quantitative detection of transversal modes of higher order in Few-Mode-Fibers by means of monolithic phase plates

National Laser Centre South Africa CISR, Pretoria

- Application of static and dynamic DOEs for the characterization of “classical” and “exotic” laser beams, of waveguides and fibers and for non-interferometric measurement of wave fronts

CREOL, Orlando, USA

- Comparison of different mode analyzing methods for sophisticated active and passive waveguides as well as for laser beams

Optical Research Center (ORC) of Tampere University, Tampere, Finland

- Modal description of new types of (tapered) waveguides
- Modal characterization of novel semiconductor disc lasers (cw and pulsed)

University Minsk, Belorussia

- Development and characterization of new photopolymers for holographic storage

Pedagogical University Mozyr, Belorussia

- Spatial solitons in photorefractive crystals

University Dublin

- Focusing and defocusing of laser beams in polymers

b) Guest scientists

Dr. Melnikova, State University Minsk, Belorussia
Prof. Dr. Alexej Tolstik, State University Minsk, Belorussia
Tatiana Kornienko, State University Minsk, Belorussia
Volha Kabanava, State University Minsk, Belorussia
Iryna Rushnova, State University Minsk, Belorussia

9. 4. Institute of Applied Physics

a) Cooperations

- Soreq NRC, Applied Physics Division, Yavne, Israel (Yoav Sintov)
- Aston University, Birmingham, UK (Sergei Turitsyn)
- AT Technologies (ADOPSYS Partner), Veldhoven, The Netherlands (Mikhail Loktev)
- Nonlinear Physics Center , Australian National University , Canberra , Australia (Dragomir Neshev)
- China Changchun Institute of Optics Fine Mechanics and Physics Chinese Academy of Science (CIOMP), Changchun, China (Yia Ping)
- CNRS (ADOPSYS Partner), , France (Dr. François Goudail)
- Department of Physics, Colorado School of Mines, Golden, USA (Jeff Squier)
- Datalogic (ADOPSYS Partner), Bologna, Italy (Federico Canini)
- Optics Research Group, Delft University of Technology (ADOPSYS Partner), Delft, The Netherlands (P. Urbach)
- Ecolé Polytechnique , Palaiseau, France
- Eidgenössische Technische Hochschule Zürich (ETH Zürich), Zürich, Switzerland
- ICFO-Institute of Photonic Sciences, Castelldefels, Spain (Lluis Torner)
- Imperial College London , London, GB

- Énergie, Matériaux et Télécommunications Research Center, Institut national de la recherche scientifique (INRS), Varennes, Canada (Roberto Morandotti)
- KLA-Tencor (ADOPSYS Partner), Milpitas, California, USA (Maarten van der Burgt)
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, USA (Wim Leemans)
- Lawrence Livermore National Laboratory (LLNL), Livermore, USA (Constantin Häfner)
- innoFSPEC, Leibniz-Institut für Astrophysik Potsdam, Potsdam, Germany (Martin Roth)
- Laboratory of Nanophotonics & Metamaterials, Lomonosov Moscow State University, Moscow, Russia (Andrey Fedyanin)
- LPI (ADOPSYS Partner), Madrid, Spain (Ruben Mohedano)
- Centre of Ultrahigh bandwidth Devices for Optical Systems (CUDOS), MQPhotonics Research Centre, Department of Physics and Astronomy, Macquarie University, Sydney, Australia (Michael Withford, Alex Fuerbach)
- Optical Sciences Center, National Central University, Jhongli , Taiwan (Wei-Kun Chang)
- OSRAM (ADOPSYS Partner), Munich, Germany (S. Malkmus)
- Sandia National Laboratories, Albuquerque, New Mexico (USA) (Igal Brener)
- Engineering Center OPTICA, State University of Information, Mechanics, and Optics (ITMO), St. Peters-burg, Russia (I. Livshits)
- Stellenbosch University, Stellenbosch, South Africa (Heinrich Schwörer)
- Technical University of Denmark, Lyngby, Denmark (Asger Mortensen)
- Technion, Haifa, Israel (Mordechai Segev)
- Tokio University, Tokio, Japan
- Institut für Energieverfahrenstechnik und Chemieingenieurwesen, TU Bergakademie Freiberg, Freiberg, Germany (Stefan Guhl)
- Optical Engineering Group (OEG), Universidad Politecnico de Madrid (UPM), Madrid, Spain (P. Benitez)
- Ultrafast Phenomena at surfaces, Universität Kaiserslautern, Kaiserslautern, Germany (Martin Aeschlimann)
- Laboratoire Ondes et Matière d'aquitaine (LOMA), Université Bordeaux, Bordeaux, France (Lionel Canioni)
- Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICMMO), Laboratoire de Physico-Chimie de L'Etat Solide (LPCES), Université de Paris Sud 11, Orsay, France (Matthieu Lancry)
- Centre d'optique, photonique et laser (COPL), Université Laval, Québec, Canada (Réal Vallée)
- Institute of Physics, University of Belgrade, Belgrade, Serbia (Goran Isic)
- College of Optics and Photonics, CREOL & FPCE, University of Central Florida, Orlando, USA (Kathleen Richardson)
- College of Optics and Photonics, CREOL & FPCE, University of Central Florida, Orlando, USA (Martin Richardson)
- Department of Physics and Mathematics, University of Eastern Finland (UEF) , Joensuu, Finland (J. Turunen)
- University of Oxford, Oxford, GB
- National synchrotron radiation Laboratory, University of Science and Technology of China, Hefei, China (Ying Liu)
- ARC Centre for Ultrahigh-Bandwidth Devic, University of Sydney, Sydney, Australia (Benjamin Eggleton)
- Department of Electrical and Computer Engineering, University of Toronto, Toronto, Canada (Peter Herman)
- Brussels Photonics Team, Vrije Universiteit Brussel (ADOPSYS Partner), Brussel, Belgium (H. Thienpont)
- Weizmann-Institut für Wissenschaften, Rechovot, Israel (Yaron Silberberg)

b) Guests

- Brynseraede, Yvan, University of Leuven Leuven, Leuven
- Cho, Sung-Hak, Korea Institute of Machinery & Materials (TIMM) Daejeon, Korea
- Chou, Chun-Han, National Taiwan University of Science and Technology Taipe, Taiwan
- Decker, Manuel, Australian National University Canberra, Australia
- Goran, Isic, University of Belgrade Belgrade, Serbia
- Guo, Rui, Australian National University Canberra, Australia
- toh, Kazuyoshi, Osaka University Osaka, Japan
- Leemans, Wim, LBNL Lawrence Berkeley National Lab Berkeley, USA
- Liu, Ying, National synchrotron radiation Laboratory, University of Science and Technology of China He-fei, China
- Mortensen, Asger, Technical University of Denmark Lyngby, Denmark
- Muratsugu, Atsushi, Osaka University Osaka, Japan
- Ping, Yia, China Changchun Institute of Optics Fine Mechanics and Physics Chinese Academy of Science (CIOMP) Changchun, China
- Ralevic, Uros, University of Belgrade Belgrade, Serbia
- Rolles, Daniel, Deutsches Elektronensynchrotron DESY / J.R. Macdonald Laboratory Hamburg, Germany
- Shamir, Yariv, Applied Physics Division, Soreq NRC Yavne, Israel
- Shcherbakov, Maxim, Moscow State University Moscow, Russia
- Song, Qiyuan, Riken Advanced Photonics Center, Keio University Tokyo, Japan
- Stanke, Ladislav, Joint Laboratory o Optics of Palacky University and Institute of Physics of the Academy of Sciences of the Czech Republic Prague, Czech Republic
- Sukhorukov, Andrey, Australian National University Canberra, Australia
- Szatkowski, Mateusz, Wroclaw University of Technology Wroclaw, Poland
- Tatsuno, Kimio, KRI Inc. Toronto, Japan
- Tetsuya, Yagi, Osaka University Osaka, Japan
- Vasic, Borislav, University of Belgrade Belgrade, Serbia
- Verhoeven, Antonie Daniël, University of Eastern Finland Joensuu, Finnland
- Wook Kim, Dae, University of Arizona Tucson , USA
- Xia, Chunqiu, Changchun Institute of Optics and Fine Mechanics Changchun, China

c) Visits

- Aston University, Birmingham, UK (Nils Becker)
- Australian National University , Canberra, Australia (Isabelle Staude)
- Ginzton Laboratory, Stanford University (Prof. Martin M. Fejer), Stanford, USA (Stefanie Kroker)
- Institut de Chimi Moleculaire et des Materiaux d'Orsay, Orsay, France (Felix Zimmermann)
- Institut d'Optique, St. Etienne, France (Herbert Gross)
- Institut national de la recherche scientifique (INRS), Montreal, Canada (Evgeny Shestaev)
- Institut national de la recherche scientifique (INRS), Montreal, Canada (Christoph Stihler)
- Korea Institute of Machinery & Materials (KIMM), Deajeon, Korea (Stefan Nolte)
- National Central University, Jhongli, Taiwan (Reinhard Geiß)
- National Central University, Jhongli, Taiwan (Jakob Stanicki)
- National synchrotron radiation Laboratory, University of Science and Technology of China, Hefei, China (Stefanie Kroker)
- Université Laval, Centre d'optique, photonique et laser (COPL), Quebec, Canada (Evgeny Shestaev)
- Université Laval, Centre d'optique, photonique et laser (COPL), Quebec, Canada (Christoph Stihler)
- University of Belgrade, Belgrade, Serbia (Matthias Falkner)
- University of Belgrade, Belgrade, Serbia (Stefan Fasold)
- University of Belgrade, Belgrade, Serbia (Jan Sperrhake)

- University of Toronto, Toronto, Canada (Stefan Nolte)
- University of Toronto, Toronto, Canada (Evgeny Shestaev)
- University of Toronto, Toronto, Canada (Christoph Stihler)

9. 5. Institute of Solid State Physics

a) Collaborations

The Surface Science group of **Prof. Dr. T. Fritz** strengthened their international cooperations in 2015. The ongoing collaboration with the group of Prof. Dr. T. Munakata (University of Osaka) was continued and even intensified not only by numerous exchange visits (founded via a PaJaKo project of the DAAD) between Germany and Japan but also by awarding a prestigious Visiting Professorship at Osaka University to Prof. Fritz.. In the USA we cooperate with the groups of Prof. Dr. O. Monti and Prof. Dr. N.R. Armstrong (University of Arizona). Within Europe we have intensive collaborations with the theory groups of Prof. Dr. E. Zojer (Graz University of Technology) and Prof. Dr. G.-P. Brivio (Universita di Milano-Bicocca). In Germany our collaborations include the group of Prof. Dr. C. Kumpf (Forschungszentrum Jülich GmbH), Prof. Dr. J. Kröger (TU Ilmenau), and the University Würzburg (Profs. F. Reinert and A. Schöll).

The group of **Prof. C. Ronning** collaborated in 2015 with various international groups. Special situations have been established with the groups of Prof. Dr. F. Capasso (U Harvard), Prof. M. Kats (U Wisconsin), Prof. S. Ramanathan (U Purdue), Prof. A. Lugstein (TU Vienna), Prof. A. Fontcuberta i Moral (EPF Lausanne), and Prof. K. Bharuth-Ram (iThemba Labs, South Africa), which have been founded either by the DAAD or DFG. Further collaborations have been conducted with the groups at the University of Lund (Sweden, Prof. L. Samuelson), Australian National University Canberra (Australia, Prof. M. Ridgway), University of Southern California (USA, Prof. J.G. Lu), University of Florence (Italy, Dr. F. di Benedetto), University of the Basque Country (Spain, Prof. A. Rubio), Institute of Light and Matter (France, Dr. S. Botti), ERSF Grenoble (France, Dr. G. Martinez-Criado & Dr. F. d'Acapito) and Imperial College (UK, Dr. R. Oulton & Prof. O. Hess).
The Low Temperature Physics group of **Prof. Dr. Paul Seidel** is collaborating in the field of superconducting materials and its application with the CERN and the universities of Bratislava, Poznan, Twente, Donetsk, Kharkov, Osaka, Tokyo and Nagoya. Scientific results have been obtained in close collaboration with international partners, such as the universities of Glasgow, Padova, Lyon, Tokyo, Pisa, Salerno, Roma, Moscow and others.

The Ion Beam Physics group of **Prof. Dr. Elke Wendler** cooperated in 2015 with Prof. Dr. Fadei F. Komarov (BGU Minsk), Prof. Dr. Maria Katsikini (U Thessaloniki), Dr. Katharina Lorenz (IST, U Lissabon), Prof. Dr. Johan B. Malberbe (U Pretoria) and Dr. Alexander Azarov (U Oslo).
The ***Laboratory Astrophysics and Cluster Physics Group*** collaborated in 2015 with Prof. Stephen Price at the Chemistry Department of the University College London, Prof. Elisabetha Palumbo, Laboratory Astrophysics Group at INAF–Osservatorio Astrofisico di Catania, Dr. Lisseth Gavilan from Institut d'Astrophysique Spatiale (CNRS, Paris), Dr. Akos Kereszturi, Research Centre for Astronomy and Earth Sciences Budapest, Prof. Paul Scheier University of Innsbruck, and Prof. Eva Kovacevic at GREMI, Université d'Orléans.

b) Joint research projects

Nanoscale Interfaces for Organic Electronics (DAAD PaJaKo Project Japan, ID 56264880)
Time span: 01/13 – 12/15
With Prof. Dr. T. Munakata (Osaka University)

Formation and shaping of magnetic nanoclusters in oxides, using ion implantation
Time span: 03/11 – 02/15
With Prof. K. Bharuth-Ram (iThemba Labs, Cape Town, South Africa)

Switchable and tunable infrared devices by controlled manipulation of the insulator-to-metal transition in Vanadium dioxide (DAAD/PPP USA)
Time span: 01/14 – 12/15
With Prof. F. Capasso & Prof. S. Ramanathan (U Harvard, USA)

Marie-Curie ITN network "Nanowiring" (EU Project)
Time span: 11/10 – 10/14
With 9 partners within the EU

Virtuelles Institut „MEMRIOX" (HZDR Dresden-Rossendorf)
Memory Effects in Resistive Ion-beam Modified Oxides
Time span: 10/11 – 09/16
With Prof. D. Basov (U of California @ San Diego, USA)

Formation of semiconductor nanocrystals in silicon-based dielectrica (DAAD/Osteuropapartnerschaften)
Time-span: 01/13 – 12/16
With Prof. Dr. Fadei F. Komarov (BGU Minsk, Belarus)

Heisenberg-Landau Program: *Phase dynamics of intrinsic Josephson junctions and superconducting quantum interference devices*
With Dr. Yu. Shukrinov, JINR Dubna

EU-Projekt ELiTES: *International Exchange Scheme*, Marie Curie Actions:
With FSU Jena (Dr. R. Nawrodt, coordinating workpackage 2 „Mirror thermal noise and cryogenics"
Institute for Cosmic Ray Research, The University of Tokyo (Prof. K. Kuroda)
Tokyo Institute of Technology (Prof. K. Somiya)
European Gravitational Observatory EGO (Dr. M. Punturo)
Rome University „La Sapienza" (Prof. F. Ricci)
University of Glasgow (Prof. S. Rowan)
FOM/NIKHEF, Amsterdam (Prof. J. van den Brand)
Max-Planck-Gesellschaft zur Förderung der Wissenschaft (AEI Hannover, Dr. H. Lück)
University of Sannio at Benevento (Prof. I. Pinto)
The University of the West of Scotland (Dr. S. Reid)
Time span: 03/12 – 02/17

EU/BMBF-Projekt: *ET R&D – Networking and R&D for the Einstein Telescope* (ERA-NET FT7 + ASPERA):
With FSU Jena (Dr. R. Nawrodt, coordinating working group 3 „Optical properties of silicon at cryogenic temperatures)
NIKHEF, Amsterdam (Prof. K. Kuroda)
Leibniz Universität Hannover (Dr. H. Lück)
Moscow State University (Prof. V. Rudenko – Sternberg Institute, Prof. S. Vyatchanin - Physics Department), Institute of Nuclear Research, Russian Academy of Science (Prof. L. Bezrukov)
University of Warsaw (Prof. T. Bulik), University of Zielona Gora, University of Bialystok, Warsaw University of Technology, Polish Academy of Science
University of Birmingham (Prof. A. Freise)
University of Glasgow (Dr. I. Martin)
University of Cardiff (Prof. B. S. Sathyaprakash)
University of the West of Scotland (Dr. S. Reid)
Time span: 03/13 – 02/16

c) Guests

Prof. Dr. Takashi Yamada	Osaka (Japan)
Prof. Dr. Toshiaki Munakata	Osaka (Japan)
Prof. Dr. Satoshi Kera	Okazaki (Japan)
MSc. Yui Ioka	Chiba (Japan)
Prof. Dr. Krish Bharuth-Ram	TU Durban (South Africa)
Dr. Sebastian Lehmann	U Lund (Sweden)
Prof. Dr. J. Grace Lu	U Southern California (USA)
Dr. T.P.H. Sidiropoulos	Imperial College London (England)
Prof. Dr. G. Cagnoli	LMA / Lyon (France)
Dr. K. Haughian	IGR / Glasgow (Scotland)

Dr. Mikhail Belogolovskii	Donetsk Physical and Technical Institute, National Academy of Sciences of Ukraine (Ukraine)
Dr. Olena Zhytlukhina	Donetsk Physical and Technical Institute, National Academy of Sciences of Ukraine (Ukraine)
Dr. Yury M. Shukrinov	Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research Dubna, Moscow Region (Russia)
Dr. Kulikov, Kirill	Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research Dubna, Moscow Region (Russia)
Rahmonov, Ilhom	Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research Dubna, Moscow Region (Russia)
Dr. Arnold Gucsik	Konkoly Thege Miklos Astronomical Institute, Astrophysical and Geo-chemical Laboratory, Budapest, Hungary and Department of Geology, University of Johannesburg
Prof. Dr. Jan Cami	University of Western Ontario, Department of Physics and Astronomy, Ontario, Canada
Dr. Svitlana Zhukovska	Max-Planck-Institut für Astrophysik Garching
Dr. A. Yu. Azarov	U Oslo

9. 6. Institute of Solid State Theory and Optics

a) Collaborating Institutions

- Ioffe-Institute, St. Petersburg, Russia
- The Australian National University, Canberra, Australia
- University of Central Florida, USA
- University of Parma, Italy
- University of Trento, Italy
- INRS, Montreal, Canada
- Ioffe-Institute, St. Petersburg, Russia
- The Australian National University, Canberra, Australia
- University of Central Florida, USA
- University of Parma, Italy
- University of Trento, Italy
- INRS, Montreal, Canada
- University of Basel, Switzerland
- University of West Virginia, Morgantown, USA
- Institut Lumière Matière, University of Lyon 1, France
- University of Grenoble, France
- Ecole Polytechnique, Palaiseau (Paris), France
- University of Luxembourg
- University of Coimbra, Portugal
- Luxembourg Institute of Science and Technology (LIST), Luxembourg
- Eindhoven University of Technology, The Netherlands
- Université de Lorraine
- Instituto Tecnologico de Aeronautica, San Jose dos Campos
- Ecole Polytechnique Palaiseau
- Universita di Roma "Tor Vergata"
- TU Eindhoven
- KAUST Thuwal
- University Prague
- University Wien

b) Joint Scientific Projects

Spezialforschungsbereich F25 Österreich: InfraRed Optical Nanostructures (IR-ON)

c) Guests

Dr. I. Chestnov
Department of Physics and Applied Mathematics, Vladimir State University, Vladimir, Russia
15.08.2015-18.10.2015, (LIMACONA)

Dr. A. Yulin
The International Research Centre for Nanophotonics and Metamaterials, ITMO University, St. Petersburg, Russia
28.09.2015-12.11.2015, (LIMACONA)

Dr. M. Bilogolovskyy
Donetsk, Institute for Physics and Engineering (DONIPE), Donetsk/Kiev, Ukraine
31.08.2015-05.09.2015, 11.09.2015-19.09.2015, (LIMACONA)

Dr. Olena Zhytlukhina
Donetsk, Institute for Physics and Engineering (DONIPE), Donetsk/Kiev, Ukraine
31.08.2015-05.09.2015, 11.09.2015-19.09.2015 (LIMACONA)

Sandro Wimberger
University of Parma, Italy
16.02.2015-21.02.2015

9. 7. Otto Schott Institute of Materials Research

a) Cooperations (joint projects or publications)

Chair of Metallic Materials

- Université de Lorraine, Nancy
- Harbin Institute of Technology
- Southeast University Nanjing
- Beijing University of Technology
- Montanuniversität Leoben

Chair of Materials Science

- Beijing University of Chemical Technology, Beijing, China
- Boğaziçi University, Istanbul, Turkey
- Carolina Center for Interdisciplinary Applied Mathematics, Department of Mathematics, University of North Carolina at Chapel Hill, Chapel Hill, United States
- Department of Marine Science, University of Georgia, Athens, Unites States
- Department of Marine Science, University of Southern Mississippi, Hattiesburg, United States
- Department of Marine Sciences, University of North Carolina at Chapel Hill, Chapel Hill, United States
- Department of Pharmaceutical Chemistry, Prince of Songkla University, Hat Yai, Songkhla, Thailand
- Faculty of Chemical and Process Engineering, Warsaw University of Technology, Warsaw, Poland
- Georgia Institute of Technology, School of Earth and Atmospheric Sciences, Atlanta, USA
- Institute for Clinical Dentistry, University of Oslo, Oslo, Norway
- Institute of Interdisciplinary Studies, Belgrade, Serbia
- Jilin University, Changchun, China
- Lamont-Doherty Earth Observatory, Columbia University, Palisades, United States
- Marine Science Institute, University of California Santa Barbara, Santa Barbara, United States
- Rudolfs Cimdins Riga Centre for Biomaterials Innovations and Development, Riga Technical University, Latvia

- School of Dentistry, University of Manchester, United Kingdom
- St. Cyril and Methodius University, Skopje, Macedonia
- Tribology Centre, Danish Technological Institute, Aarhus, Denmark
- University of Colorado Boulder, Boulder, Colorado, United States
- University of Lyon, Lyon, France
- University of Manchester, Manchester, United Kingdom
- University of Minho, Portugal
- University of Strasbourg, Strasbourg, France
- Wuhan University, Wuhan, Hubei Province, China

Colloids, Surfaces and Interfaces

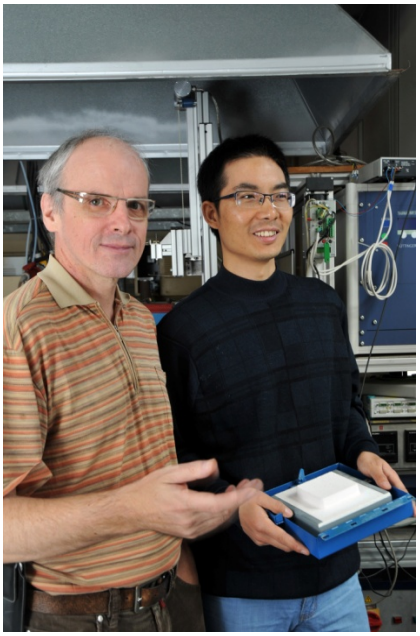
- CSIC-ICMM, Madrid, Spain
- McGill University, Montreal, Canada
- ISTEC-CNR, Faenza, Italy
- University of Turku, Finland
- University La Laguna, Tenerife, Spain
- South China University of Technology, Guangzhou, China
- S.N. Bose National Centre for Basic Sciences, Kolkata, India

Computational Materials Science

- University of California, Irvine, USA

b) Guests

- Prof. Xinzhong Li, Harbin University of Technology
- Prof. Mingfang Zhu, Southeast University Nanjing
- Dr. Irina Nizovtseva, Jekaterinburg University
- Prof. Chuanjun Li, Shanghai University
- Prof. Dr. Wang Xin, Jilin University, China
- Dr. Robin W. Mills, University of Bristol, United Kingdom
- Prof. Dr. David Watts, University of Manchester, United Kingdom
- Prof. Dr. Janis Locs, Riga Technical University, Latvia
- Prof. Dr. Bora Garipcan, Boğaziçi University, Istanbul, Turkey
- Prof. Dr. Henk Busscher, Faculty of Medical Sciences, Department of Biomedical Engineering; Groningen, The Netherlands
- Prof. Dr. Yijin Ren, Faculty of Medical Sciences, Orthodontics, Groningen, The Netherlands
- M.Med. Tanatchaporn Sangfai, Department of Pharmaceutical Chemistry, Prince of Songkla University, Hat Yai, Songkhla, Thailand
- So Han Florence Yip, University of Rochester, Rochester, United States



Prof. Chuanjin Li (right) with his host Prof. Rettenmayr in the laboratory

9. 8. Institute of Optics and Quantum Electronics

a) Cooperations

B. Dromey, Queen's University Belfast

Z. Najmudin, Imperial College, London

S. Glenzer, LCLS+ Stanford University

F. Quere, CEA Saclay

M. Jentschel, ILL Grenoble

C. William McCurdy, Stephen R. Leone and Daniel M. Neumark (UC Berkeley)

C. Detlefs, R. Rüffer, J. Härtwig (European Synchrotron Radiation Facility) – High purity X-ray polarimetry

Dr. E. Kroupp and E. Stambulchik (Weizmann Institute of Science) – Investigation of highly charged ions in high electromagnetic fields

N. Woolsey, Dr. A. Robinson (Rutherford Appleton Laboratory/Oxford University) – Hot electron production in laser solid interactions

Dr. Paul Gibbon, Laura Di Lucchio (Forschungszentrum Jülich) – PIC Simulationen von few-cycle Lp interactions

Prof. A. L'Huiller, Lund University, Sweden

Prof. P. Polynkin University of Arizona, USA

Prof. M. Shneider, Princeton University, USA

Prof. F. Legare, INRS Varenne, Canada

Prof. S. Namba, University of Hiroshima, Japan

Prof. B. Balakin, University of Nizhny Novgorod, Russia

Dr. Valer Tosa, National Institute for R&D Isotopic and Molecular Technologies, Cluj-Napoca, Romania

Prof. A. Baltuska, Vienna Unviersity of Technology, Austria

b) Visitors

Prof. Jens Biegert	ICFO – The Institute of Photonic Sciences, Castelldefels Barcelona/Spain
Prof. See Leang Chin	Center for Optics, Photonics and Laser (COPL), Laval University, Quebec City/Canada
Dr. Brendan Dromey	Queen´s University Belfast, UK
Prof. Thomas Feurer	Institut für Angewandte Physik (IAP), Bern/Switzerland
Dr. Christoph Heyl	Department of Physics, Lund/Sweden
Prof. Wim Leemans	Lawrence Berkeley National Laboratory, US
Dr. Laura Di Lucchio	Forschungszentrum Jülich GmbH, Institute for Advanced Simulation, Jülich
Dr. Nicholas Matlis	Lawrence Berkeley National Laboratory, US / DESY Hamburg
Dr. Fabien Quéré	CEA Saclay, France
Dr. Oldrich Renner	Academy of Sciences of the Czech Republic
Dr. Alex P. L. Robinson	Central Laser Facility, UK
Dr. Gianluca Sarri	Queen´s University Belfast, UK
Prof. Arnd Specka	École Polytechnique-CNRS/IN2P3, France
Dr. Mark Yeung	Queen´s University Belfast, UK

9. 9. Institute of Theroretical Physics

a) Cooperations on common research projects

Prof. M. Ansorg

Cooperation with Loic Villain, Université François Rabelais, Tours, France, and Dorota Gondek-Rosinska, Uniwersytet Zielonogórski Budynek, Poland, on differentially rotating neutron stars

Prof. M. Ammon

Cooperation with Dr. Nabil Iqbal (Amsterdam) and Prof. Matthias Kaminski (University of Alabama)

Prof. B. Brügmann

Collaboration with Prof. W. Tichy, Florida Atlantic University (USA) on black holes and Dr. Alessandro Nagar, IHES, Bures-sur-Yvette (France) on gravitational waves

Prof. S. Fritzsche

Collaboration and regular exchange exists with the groups of professors Michel Godefroid (Brüssels, Belgium), Raimund Feifel (Goeteborg, Sweden), Jacek Bieron (Krakow, Poland), Chenzhong Dong (Lanzhou, China), Gerda Neyens (Leuwen, Belgien), Alexei Grum-Grzhimailo (Moscow, Russia), Vladimir Yerkhin and Vladimir Shabaev (St. Petersburg, Russia).

Prof. H. Gies

Collaboration with Prof. Gerald Dunne, University of Connecticut (USA) and Prof. C. Schubert (Morelia, Mexico) an effective actions in quantum field theory. Collaboration with Prof. Reinhard Alkofer, Graz U. (Austria), Dr. E. Strobel (ICRANeT, Italy) and Dr. G. Torgrimsson (Chalmers U.) on quantum electrodynamics far from equilibrium. Collaboration with Dr. Astrid Eichhorn, Perimeter Institute (Waterloo, Canada) and Imperial College London (UK) on Higgs boson mass bounds and vacuum stability. Collaboration with Dr. Lukas Janssen, SFU Burnaby/Vancouver (Canada) on relativistic fermion systems in condensed matter systems. Collaboration with Dr. Rashid Shaisultanov, Nazarbayev U. Astana (Kazachstan) on strong-field quantum electrodynamics. Collaboration with Dr. Frank Saueressig (RU Nijmegen, Netherlands) on asymptotically safe quantum gravity.

Prof. R. Meinel

Collaboration with Prof. P. Chruściel, University of Vienna, in the area of Ernst equation.

Prof. G. Schäfer (retd.)

Collaboration with Prof. P. Jaranowski. University of Bialystok, Bialystok, Poland, and Prof. T. Damour, IHES, Bures-sur-Yvette, France, on the problem of motion in general relativity.

Prof. A. Wipf

Collaboration with Prof. Ilya Shapiro (Luiz de Fora, Brazil) on quantum induced effects in curved spacetimes. On simulations of strongly coupled lattice system there exists and ongoing collaboration with Prof. Kurt Langeld (University Plymouth). Collaboration with Manuel Asorey (University of Zaragoza, Spain) on the quantization of non-Abelian two-dimensional Gauge Theories with massless fermions.

Dr. F. Karbstein

Collaboration with Dr. Rashid Shaisultanov, Nazarbayev University, Republic of Kazakhstan, on strong field QED. Collaboration with Prof. Matt Zepf, HI-Jena and Queen's University Belfast, UK, on an proposal to verify vacuum birefringence with high-intensity lasers.

Dr. A. Sternbeck

Collaboration with Prof. Schaden (Rutgers University, NJ, USA) on Dyson-Schwinger equations for lattice QCD in Landau gauge.

Collaboration with Dr. Kizilersü, Prof. Williams (University of Adelaide), Dr. Skullerud (Maynooth, Irland), Dr. Silva and Dr. Oliveira (University of Coimbra, Portugal) on a lattice study of the Quark-Gluon-Vertex in Landau gauge.

Dr. O. Zanusso

Project with Prof. F. Saueressig (Radboud University Nijmegen, The Netherlands) on quantum gravity, quantum geometry and asymptotic safety. Collaboration with Dr. A. Codello (CP3-Origins, Denmark) and Dr. G. D'Odorico (University of Nijmegen, the Netherlands) on the relation between conformal field theory and the renormalization group. Collaboration with Prof. T. Morris (University of Southampton, UK) and Dr. M. Safari (University of Bologna, Italy) on the background field approach in field theory.

Dr. L. Zambelli
Collaboration with Dr. G. P. Vacca, Bologna U., Italy, on the role played by multimeson Yukawa interactions at criticality.

***b) Guests from abroad** (including GRK 1523)*

Dr. David Schaich, Syracuse University
Dr. Markus Pak, University of Graz
Prof. Uwe-Jens Wiese, Universität Bern
Dr. Jonathan Kress, University of New South Wales
Dr. Christian Wiesendanger, University of Zurich
Dr. Sho Osaki, KEK, Japan
Dr. Jose Luis Jaramillo, Université de Bretagne Occidentale, Brest
Dr. Matthieu Tissier, Université Pierre et Marie Curie, Paris
Dr. Michael Ferlaino, University of Swansea
Prof. Wolfgang Tichy, Florida Atlantic University
Prof. Jean Bellissard, Georgia Institute of Technology Atlanta
Dr. Georgios Lukes-Gerakopoulos, Charles University Prague
Dr. Astrid Eichhorn, Imperial College London
Prof. Ilya Shapiro, Federal University of Juiz de Fora
Dr. Dario Benedetti, Université Paris
Prof. N. Emil J. Bjerrum-Bohr, University of Copenhagen
Dr. Alessandro Codello, University of Southern Denmark
Prof. Andrzej Görlich, University of Copenhagen
Dr. Razvan Gurau, CPHT Palaiseau
Prof. Herbert W. Hamber, University of California
Dr. Daniel Litim, University of Sussex
Prof. Roberto Percacci, SISSA, Trieste
Dr. Giulio D'Odorico, Radboud University
Dr. Gian Paolo Vacca, INFN, Bologna

<u>longer-term guests:</u>

Dr. Javadi Motaghi, Universitiy of Regensburg (Nov/Dec 2015, 2 weeks)
Dr. Markus Pak, University of Graz (Dec 2015, 2 weeks)
Prof. Piotr Jaranowski, Univ. Bialystok (Feb 2015, 2 weeks)

9. 10. Research Group - Teaching Methodoly in Physics and Astronomy

Cooperations

Within the Heraeus Summer School "Kosmology from 4 perspectives" we work together with the University in Padua (Italy).

10. Academic Organization and Bodies

10. 1. Scientific Advisory Board of the Faculty of Physics and Astronomy

The Scientific Advisory Board of the Faculty of Physics and Astronomy was set up by the Rector in 2005, on suggestion of the Faculty Council and the Structural Committee.

The Scientific Advisory Board is a panel consulted by the Dean and the Faculty Council with regard to the further development of the Faculty. This includes the Faculty's overall concept, but also the content orientation of the various chairs in case of vacant positions advertised. The Advisory Board offers suggestions about the scientific equipment, staff and space required by the Faculty and its institutes, and about the organizational structures most favourable for fulfilling the tasks in research and teaching. In selected cases, the Dean will ask the Advisory Board to participate in outlining the contents of chair position advertisements and in deciding on who is given the chair.

According to its statute, the board comprises at least seven members, viz. two each from the departments of Solid-State Physics/Materials Science, Optics/Quantum Electronics and Theory, plus one from Astrophysics. The members are appointed by the Rector for a four-year term. On suggestions of the Institutes, the following persons were appointed to the Scientific Advisory Board of the Faculty of Physics and Astronomy for another four years (ending at the end of 2015):

- for Optics/Quantum Electronics:

Prof. Dr. Gerd Leuchs,
Institute of Optics, Information and Photonics , University of Erlangen - Nürnberg
He was the Chairman of the Advisory Board up to 2014.

Prof. Dr. Günter Huber,
Department of Physics, University of Hamburg

- for Soolid State Physics /Materials Science:

Prof. Dr. Paul Müller,
Institute of Physics, University of Erlangen-Nürnberg

Prof. Dr. Ludwig Schultz,
Scientific Director of the Leibniz Institute of Solid-State and Materials Research, Dresden

- for Quantum Theory and Theory of Gravity:

Prof. Dr. Friedrich W. Hehl,
Faculty of Mathematics and Natural Sciences, University of Cologne

Prof. Dr. Olaf Lechtenfeld,
Institute of Theoretical Physics, Gottfried Wilhelm Leibniz University of Hannover
He is the Chairman of the Advisory Board since 2015.

- for Astrophysics:

Prof. Dr. Rolf Chini,
Faculty of Physics and Astronomy, Ruhr-Universität Bochum

With respect to the particular importance of the questions the scientific advisory board would have to deal with in the next years the Faculty of Physics and Astronomy plans to renew it gradually. Therefore since 2015 two new members have been appointed:

Prof. Dr. Jan-Michael Rost
Max Planck Institute for the Physics of Complex Systems,
Dresden

Prof. Dr. Jörg Neugebauer
Director of the Max-Planck- Institut für Eisenforschung,
Düsseldorf

At its 4th meeting in July 2015, the Scientific Advisory Board discussed the implementation of the Faculty's strategy for the period until 2020. A number of retirements and appointments to other institutions as well as the economies decreed by the Thuringian government make it necessary to draw up and implement a structural and development plan. This will especially affect the Institute of Applied Optics and the cryophysics professorship. Confident that new chances and opportunities will arise, the Faculty, in close cooperation with its scientific advisory board, is prepared to take up the challenge with new ideas and concepts.

10. 2. Astrophysical Institute and University Observatory

Providing of expertise, activities in committees, participation in program committees of international conferences

R. Errmann

- Member of the LOC of the international conference "Multi-Object Spectroscopy in the Next Decade: Big Questions, Large Surveys and Wide Fields", Santa Cruz de La Palma, March 2–6, 2015

Prof. Dr. Alexander Krivov

- Deputy member of the Academic Commission of the senate of the FSU
- Deputy member of the Faculty Council of the PAF
- Member of the Evaluation Commission of the faculty
- Member of the Scrutiny Committee of the FSU
- Examiner for the First State Examination (teaching degree for astronomy)
- Speaker of the DFG Research Unit FOR 2285
- Referee of the Alexander-von-Humboldt-Foundation
- Referee for several journals

Dr. Torsten Löhne

- Referee for Astronomy & Astrophysics

Dr. Markus Mugrauer

- Referee for OPTICON

Prof. Dr. Ralph Neuhäuser

- Director of AIU
- Faculty's astrophysics lecturer in charge for modules and schedule
- Referee for several journals
- Examiner for the First State Examination (teaching degree for astronomy)
- Advisory board member of the ethics center (FSU)
- Member of a dissertation commission at the University of Bochum
- Member of a dissertation commission at the University of Rostock
- Referee for the filling of a full professorship at a University of the USA
- Referee for a tenure track process in Israel
- New member of the editorial board of the international refereed journal Astronomical Notes since 2015
- Member of the major evaluation commission at the Kiepenheuer Institute for Solar Physics Freiburg

Support of schools and pupils

T. Löhne

- Juror of the pupils' competition "Exciting physics" during "Highlights of Physics" in Jena

Dr. Markus Mugrauer

- Juror for the 20th regional competition "Jugend forscht", Mittelthüringen
- Referee for several seminar papers

N. Pawellek

- Referee and co-referee of seminar papers

Ch. Schüppler

- Assistant in the school project "Unsere Sonne" for pupils from the Angergymnasium
- Co-referee of a seminar paper

10. 3. Institute of Applied Optics

Peer review work, memberships

Prof. Kowarschik

- Member of the board of directors of the Center of Medical Optics and Photonics (CeMOP)
- Member of the DFG Review Board „Optics, Quantum Optics, Atoms, Molecules, Plasmas" and of the DFG Review Panel "Medical Technology"
- Reviewer of international journals, publics institutions BMWT, TMWFK and Research Societies (DFG, DAAD, Foundations)

- Member of the Advisory Board MedWays e.V.
- Vice-chairman of the scientific Advisory Board of the IPHT Jena

Dr. Duparré
- Accredited member in the National Standardization Committees AA O 18 „Laser“ and AA O 18 AK1 „Begriffe, Prüfgeräte und Prüfverfahren“
- Accredited member in the International Standardization Committee ISO/TC 172/SC9/WG 1 & ISO/TC 172/SC9/JWG 1
- Active in peer-review for „Applied Optics“, “JOSA A”, “Optics Letters” “Optics Express” and “Journal of Pure and Applied Optics”
- Reviewer for „National Research Foundation South Africa“

10. 4. Institute of Applied Physics

Peer review work, memberships

Prof. Dr. A. Tünnermann
- Council member of the Faculty
- Member of program committee „Optische Technologien“, BMBF
- Member of the VDI / VDE-GMA Advisory Board FB 8 "Optical Technologies of the Society for Measurement and Automation"
- Board of trustees MPA, Heidelberg
- Board of trustees MPQ, Garching
- Board of trustees IOM, Leipzig
- Chairman „AG Naturwissenschaften“, Wissenschaftliche Gesellschaft Lasertechnik
- Spokesman Abbe Center of Photonics, FSU Jena
- Editor Applied Physics B
- Stakeholder Photonics 21-Plattform
- Member of the steering committee Fraunhofer Gesellschaft
- Member of the technical council Fraunhofer Gesellschaft
- Member of the executive Board OptoNet e. V. Member of acatech „Deutsche Akademie der Technikwissenschaften“
- Member of Honor „International Society of Optics and Photonics SPIE“
- Referee for several scientific journals

Prof. Dr. S. Nolte
- Conference Chair of the SPIE Photonics West Conference "Frontiers in Ultrafast Optics: Biomedical, Scientific and Industrial Applications (LASE)"
- Person responsible for EU-US Atlantis Program, Cooperation in higher Education and Training, „MILMI“ - International Master Degree in Laser, Material Science and Interaction, Univ. BORDEAUX (France), FSU Jena, Univ. Central Florida und Clemson Univ. (USA)
- Chair of the Faculty´s Budget Commission and member of the Budget Board of the Senate
- Member Optical Society of America (OSA)
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Member of Scientific Committee “Lasers in Manufacturing (LIM)”, 2015
- Member of Scientific Committee CLEO Europe, Materials Processing with Lasers (2015)
- Member of SPIE
- Coordinator of the BMBF Association "Ultrashort Pulse Laser for High Precision Machining"
- Referee for several scientific journals
- Member of jury “Jugend forscht”

Prof. Dr. T. Pertsch
- Vice Dean of the Faculty
- Council member of the Faculty
- Member of the board directors of the Abbe Center of Photonics
- Spokesman of the Abbe School of Photonics
- Spokesman of the research initiative "Photonic Nanomaterials PhoNa"
- Coordinator of the study program "Master of Science in Photonics"
- Fellow of the Optical Society of America
- Referee for several international journals

- Local coordinator of Erasmus Mundus Program – NANOPHI – Nonlinear Nanophotonics
- Member of conference program committees: ETOP - Education and Training in Optics & Photonics, Bordeaux, 2015

Prof. Dr. H. Gross
- Referee for several international journals
- Program committee for SPIE conference "Optical Systems Design"
- Member in the expert committee of the Baden-Würtemberg foundation of Optical Technologies

Prof. Dr. F. Wyrowski
- Member of the Technical Program Committee: OSA Conference on Digital Holography and Three-Dimensional Imaging
- Member of the Technical Program Committee: EOS Topical Meeting on Diffractive Optics
- Referee for several scientific journals
- Study Advisor of the Faculty of Physics and Astronomy
- President of the Light Trans GmbH
- President of Wyrowski Photonics UG
- Visiting Professor at the Chinese Academy of Science, China
- Visiting Professor at the Institute of Technology (HIT), China
- Conference Co-Chair: SPIE Conference on Optical Modelling and Design
- Member of the Technical Program Committee SPIE Conference on Optics and Photonics for Information Processing
- Member of the Technical Program Committee: SPIE Conference on Modeling Aspects in Optical Metrology

Jun.-Prof. Dr. J. Limpert
- Member of the Program Committee SPIE Photonics West Conference "LASE 2015"
- Referee for several scientific journals

Jun.-Prof. Dr. A. Szameit
- Program committee for CLEO/QELS conference FS5: Nonlinear optics and novel phenomena
- Member Optical Society of America (OSA)
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Referee for several scientific journals, including Nature, Nature Photonics, and Nature Physics

Dr. E.-Bernhard Kley
- Member of the Program Committee SPIE Photonics West Conference "Advanced Fabrication Technologies for Micro / Nano Optics and Photonics"
- Member of the Program Committee SPIE Photonics West Conference "High Contrast Metastructures"
- Member of the GMM-Technical Committee meeting FA 4.7 Micro-Nano Integration
- Referee for several scientific journals

PD Dr. U. Zeitner
- Referee for several scientific journals

Dr. J.Rothhardt
- Member of the extended directory board of the Helmholtz Institute Jena
- Program committee for CLEO Europe conference
- Program committee for IEEE photonics conference
- Member Optical Society of America (OSA)
- Referee for Optics Letters, Optics Express, J Phys B, Appl. Phys B, Applied Optics, European Physical Journal D
- Lecturer at the 3rd Joint HGS-HIRe & RS-APS Lecture Week on Atomic and Laser/ Plasma Physics

Dr. F. Schrempel
- Council member of the Faculty
- Coordination of the Institute of Applied Physics at the Beutenberg Campus e.V.
- Referee for several scientific journals

Dr. I. Staude

- Organizer of a focus session at the PIERS conference 2015 in Prague, Czech Republic (Progress in Electromagnetic Research; focus session title: SC3: Optical Properties of Resonant Dielectric and Plasmonic Nanostructures)
- Session Chair at SPIE Micro & Nano Materials, Devices and Applications 2015 (Sydney), PIERS 2015 (Prague), CLEO/Europe-EQEC 2015 (Munich)
- Reviewer for several scientific journals including Nature Materials., ACS Nano, Advanced Materials and Optica.
- Member of Deutsche Physikalische Gesellschaft (DPG)

10. 5. Institute of Solid State Physics

Reviewer duties, membership in committees, etc.

Prof. Dr. Torsten Fritz

- Deputy Director of the Institute of Solid State Physics
- Deputy member of the faculty board
- Reviewer for several scientific journals (Nature Materials, Phys. Rev. Lett., Phys. Rev. B, Appl. Phys. Lett., Organic Electronics, Advanced Materials, etc.)
- Reviewer for the Fonds zur Förderung der wissenschaftlichen Forschung (FWF), Österreich
- Reviewer for the Deutsche Forschungsgemeinschaft (DFG), the Deutschen Akademischen Austauschdienst (DAAD), for the Studienstiftung des deutschen Volkes e.V., and for the Friedrich-Ebert-Stiftung e.V.
- Editor of "Datasets in Physics"
- Member of scientific societies: Deutsche Physikalische Gesellschaft (DPG), Deutscher Hochschulverband (DHV)

Prof. Dr. Carsten Ronning

- Speaker of the DFG research unit FOR1616
- Director of the Institute of Solid State Physics
- Member of the faculty board
- Member of the committee for student issues
- Member of hiring committees
- Reviewer for scientific journals (Nature Photonics, Nano Letters, Phys. Rev. Lett. , Appl. Phys. Lett., Nanotechnology, Thin Solid Films, etc.)
- Reviewer for funding agencies: Deutsche Forschungsgemeinschaft (DFG), BUndesministerium für Forschung (BMBF), Deutscher Wissenschafts-rat, National Science Foundation (NSF, USA), Humboldt Stiftung, etc.
- Member of scientific societies: Deutsche Physikalische Gesellschaft (DPG), Materials Research Society, USA (MRS)

Prof. Dr. Paul Seidel

- Member of the „Studienkommission Physik“, the „Prüfungsausschuss Materialwissenschaft“ and the teacher educational board
- Referee for Supercond. Sci. Technol., Physical Review, Appl. Phys. Lett. , J. Appl. Phys.
- Referee for different organizations, e.g. DFG, DAAD, AvH Stiftung, Carl Zeiss Stiftung, BMWT, EURONORM
- Board member of the European Society of Applied Superconductivity (Secretary since summer 2015)
- Editor of “Applied Superconductivity – Handbook on Devies and Applications”
- Co-editor of „Jenaer Beiträge zur Geschichte der Physik“
- Deputy head of the Alumni association of the PAF
- Board member of international conferences (ISEC 2015 in Nagoya,, Japan,EUCAS 2015 in Lyon, France)
- Member of scientific societies: Deutsche Physikalische Gesellschaft (DPG), Materials Research Society, USA (MRS)

Prof. Dr. Frank Schmidl

- Member of the teacher educational board
- Deputy head of the panel steering the natural science education of medical students (dentists)
- Member of the expert commission “Sachverständigenkommission des IMPP”

Prof. Dr. Elke Wendler

- Member of International Committee of „Radiation Effects in Insulators“ (REI)
- Member of International Committee of “Ion Beam Modifications of Materials” (IBMM)
- Member of Advisory Board of Journal Nuclear Instruments and Methods in Physical research (B)
- Referee for Nucl. Instr. and Methods, Physical Chemistry Chemical Physics, Physica Status Solidi B, Vacuum

Dr. Claudia S. Schnohr

- Member of the council of the institute
- Member of the committee *Career paths for postdocs*
- Deputy equal opportunity commissioner of the faculty
- Member of scientific societies: Deutsche Physikalische Gesellschaft (DPG), Komitee Forschung mit Synchrotronstrahlung (KFS), International X-Ray Absorption Society (IXAS), Materials Research Society, USA (MRS)

Dr. Ronny Nawrodt

- Member of the faculty board
- Member of the evaluation committee
- Member of the exam committee for medical students (dentists)
- Referee for scientific journals (e.g. Cryogenics, Class. Quantum Grav., J. Appl. Phys., New J. Phys., Appl. Phys. Lett., Optics Letters, Optics Express)

Dr. Cornelia Jäger

- Reviewer for the Deutsche Forschungsgemeinschaft (DFG)
- Reviewer for the Astrophysical Journal
- Guest editor for Planetary and Space Science
- Member of the program board of the DFG priority program “The Physics of the Interstellar Medium”
- Member of the scientific organization committee of the ‘’The 8th meeting on Cosmic Dust‘‘, Tokio, August 2015)

Dr. Gaël Rouillé:

- Reviewer of a research proposal at the invitation of a national commission for scientific research

Dr. Roman Forker

- Member of the council of the institute
- Reviewer for scientific journals
- Member of scientific societies: Deutsche Physikalische Gesellschaft (DPG)

Dr.-Ing. Volker Tympel

- Lectureship University of Applied Sciences Erfurt “Open and closed loop control systems”
- Lectureship Business University Wuhan, China “Measurement instrumentation”

Matthias Thürk

- Referee for DFG, DKV, Cryogenics

Ralf Neubert

- Deputy member of the faculty board

Support of schools and girls

Prof. Dr. Elke Wendler

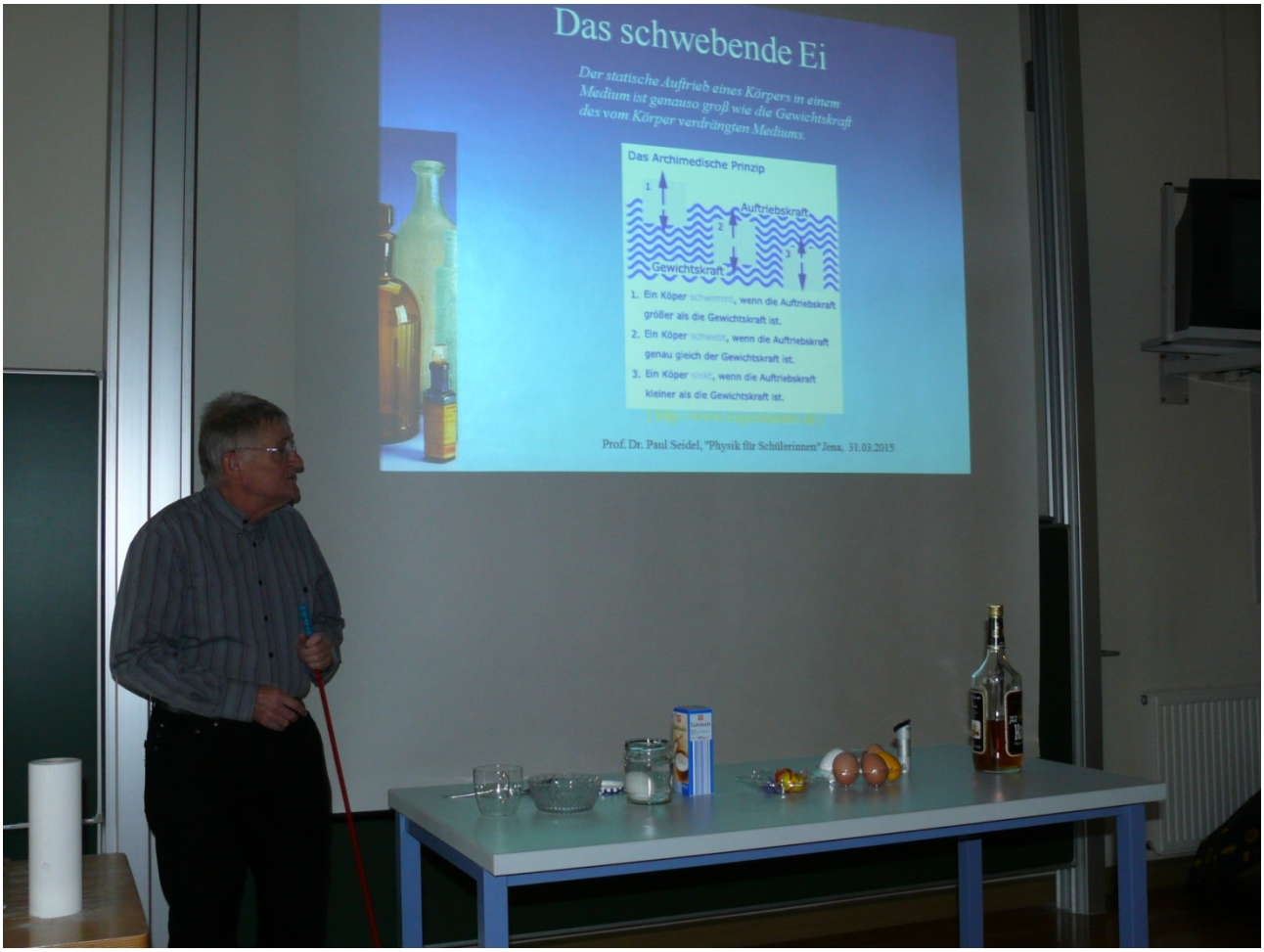
- Workshop „Physik für Schülerinnen“ March 2015,
  concept and organisation with Dr. Angela Unkroth
- GirlsLab – project for school girls from grade 5 forcing natural sciences and technics,
  Abbe-Gymnasium Jena-Winzerla, concept and organization with Dr. Silvana Fischer
- Referee of “Seminarfacharbeit“ Rutherford-Weitwinkelstreuung leichter Ionen als Analysemethode von Elementen innerhalb von Festkörpern, Theresa Schröer, Kevin Baumgärtel, Berkay Günes und Konrad Biedermann, Abbe-Gymnasium Jena-Winzerla
- Abbe-Gymnasium Jena-Winzerla, concept and organization with Dr. Silvana Fischer

Dr. R. Nawrodt, Dr. C. Schwarz

- Introductory lecture “Elektromagnetische Induktion” and hands-on experiments, Leuchtenburg-Gymnasium Kahla
- Lab tours dedicated to school classes
- Support for “Jugend forscht”

Prof. Dr. P. Seidel

- Lecture at Workshop “Physik für Schülerinnen” 2015
- Supervisor of a “Seminarfacharbeit” at the Carl-Zeiss-Gymnasium Jena



Prof. Seidel hielt im Rahmen des Workshops "Physik für Schülerinnen" eine Vorlesung zur "Physik in der Küche rund ums Ei"

R. Neubert

- Girls Day 2015
- Experiments at the open day at the Talschule/Jena

Prof. Dr. F. Schmidl

- Introductory lecture „Superconductivity - research and application“ at the Gymnasium Sondershausen
- Introductory lecture „Superconductivity” 50years Carl Zeiss Gymnasium Jena
- Introductory lecture „Superconductors – from basics to application“ 20 year Osterlandgymnasium Gera

Dr.-Ing. V. Tympel

- Member of the jury of the nationwide schools competition “exciting physics 2015”

10. 6. Institute of Solid State Theory and Optics

Engagement in institutions of academic self-administration

Prof. Dr. Ulf Peschel
- Director of the institute
- Member of the board of the Erlangen Cluster of Excellence Engineering of Materials (EAM)
- Member of the board of the Erlangen Graduate School of Applied Optical Technologies (SAOT).

Prof. Dr. Silvana Botti
- Editor for European Physics Journal B
- Member of the committee of experts of GENCI (Grand Équipement National de Calcul Intensif)
- Member of the evaluation committee of the FRQNT "Fonds de recherche du Québec – Nature et Technologie" (Comité 918C Physique Matériaux C), Co-chair of the management board of the European Theoretical Spectroscopy Facility (ETSF) infrastructure

Prof. Dr. Falk Lederer
- Member of the board of the Abbe Center of Photonics

Other activities (referee, committee memberships,…)

Prof. Friedhelm Bechstedt
- Referee for different science organisations DFG, NSF, MIUR, ANR, etc
- Referee for many journals (z.B. PRL, PRB, Nature Materials)
- Member of Advisory Board FHI-MPG Berlin
- Member of Advisory Board Int. Max Planck Research School of Surface Science
- Beamline Review Panel of BESSY II

Prof. Falk Lederer
- Referee for different scientific journals (e.g. Nature, Nature Physics, Nature Photonics, Nature Materials, Physical Review Letters)
- Referee for different science organisations (DFG, Humboldt foundation, EPSRC, NRC, FOM Netherlands)
- Member of the advisory board of the Fraunhofer IOF Jena

Prof. Ulf Peschel
- Referee for different scientific journals (e.g. Nature Physics, Nature Photonics, Physical Review Letters)
- Referee for different science organizations (DFG, GIF, EPSRC)

Prof. Silvana Botti
- Referee for different scientific journals (e.g. Physical Review Letters, Physical Review B, Journal of the American Chemical Society, Journal fo Chemical Physics, Applied Physics Letters, Journal of Applied Physics, ACS Nano)
- Referee for different science organizations (Research National Agency (ANR) of France ,DFG, Fund for Scientific Research of Belgium)

Dr. Jürgen Furthmüller
- Referee for Phys. Rev. Lett., Phys. Rev. B, APL

Dr. Oleg Egorov
- Referee for international journals Opt. Express, Opt. Lett.

10. 7. Otto Schott Institute of Materials Research

Reviewing activities, Committee work , Collaboration in program committees of international conferences

Prof. Dr. M. Rettenmayr

- Member of Faculty Council of the Faculty of Physics and Astronomy
- Editor: Journal of Crystal Growth
- Editorial Board: Practical Metallography
- Reviewer: Acta Materialia, Surface Science, Journal of Crystal Growth, Materials Science and Engineering, Materials and Metallurgical Transactions, International Journal of Materials Reserach, Journal of Materials, etc.
- Reviewer: DFG, DAAD, further national research associations (Austria, Czech Republik)

Prof. Dr. K. D. Jandt

- Deputy member of the faculty council of the Faculty of Physics and Astronomy, FSU Jena
- Editorial boards: Colloids and Surfaces B: Biointerfaces, Elsevier; Acta Biomaterialia, Elsevier; Dental Materials, Elsevier; Advanced Healthcare Materials, Wiley-VCH; Advanced Engineering Materials, Wiley-VCH; Hacettepe Journal of Biology and Chemistry
- Member of the board of the German Materials Society (DGM) Executive Committee
- Scientific spokesman for all DGM-Panels of Experts
- Member of the DFG-funded excellence graduate school Jena School for Microbial Communications (JSMC)
- Founder and chairman of the panel of experts “Biomaterials” of the German Materials Society (DFG)
- Reviewer for Nature Materials; ACS Nano; Journal of Materials Science; Journal of Materials Science - Materials in Medicine; Macromolecules; Biomacromolecules; Chemistry of Materials; Biomaterials; Dental Materials; Advanced Engineering Materials; Langmuir; Journal of Applied Polymer Science; etc.
- Reviewer for the German Research Foundation (DFG); European Social Fund (ESF); European Research Council (ERC); Alexander-von-Humboldt-Foundation; European Science Foundation; European Commission; Engineering and Physical Sciences Research Council (EPSRC), GB; Biotechnology and Biological Sciences Research Council (BBSRC), GB; Medical Research Council (MRC), GB; National Institutes of Health (NIH), USA; etc.

Prof. Dr. Frank A. Müller

- Member of the Faculty Council of the Faculty of Physics and Astronomy
- Reviewer: DFG, NSC (Poland)
- Reviewer: Acta Biomater., Ceram. Int., Diam. Relat. Mater., J. Am. Ceram. Soc., J. Appl. Phys., J. Mater. Sci: Mater. Med., J. R. Soc. Interface, Mater. Design, Mater. Sci Eng. C,
- Editorial Board Member: Journal of Biomaterials Applications, Mater. Res.
- Scientific Advisory Board: 11th CMCEE, Vancouver, Canada

Prof. Dr. M. Sierka

- Deputy member of the academic Senate of Friedrich Schiller University Jena
- Chair of the examination committee (Materials Science)
- Coordinator of the study program (Materials Science)
- External member of the Center of Computational Sciences Adlershof in Berlin
- Reviewer: Angewandte Chemie International Edition, Journal of Chemical Physics, Journal of Physical Chemistry, Physical Chemistry Chemical Physics, Journal of Computational Chemistry, Nanoscale, Physical Review B, Nature Communications

Prof. Dr. Enrico Gnecco

- Reviewer: Nature Nanotechnology, Physical Review Letters, Physical Review B, Physical Review E, Applied Physics Letters, Nanotechnology, Journal of Chemical Physics, Tribology Letters
- Reviewer: American Chemical Society (ACS), Israel Science Foundation (ISF), Swiss National Science Foundation (SNF), Latvian Council of Science, Estonian Research Council
- Short-Term Scientific Missions Coordinator – COST Action MP1303

AOR PD Dr. J. Bossert

- Reviewer for Acta Biomaterialia; Advanced Engineering Materials; Journal of the American Ceramic Society; Fuel; Surface Science; Journal of the European Ceramic Society, Composites Part A: Applied Science and Manufacturing; Materials Letters
- Reviewer for the Latvian Science Council
- Head of the group „Antimicrobial Materials“ of the DGM-technical committee biomaterials

Dr. Stephan Gräf

- Reviewer: Opt. Expr., Mater. Design., J. Appl. Phys.

10. 8. Institute of Optics and Quantum Electronics

Reviewing activities, Committee work , Collaboration in program committees of international conferences

Prof. Dr. G. G. Paulus

- Dean of the Faculty
- Memberships on Boards and Advisory Committees
- Member of the board of directors of HI Jena
- Member of the Scientific Advisory Committees of
  CILEX-APOLLON, Frankreich
  ELI-ALPS, Ungarn
  CLPU, Spanien
- Member of the Program Committees of the conference ISUILS

Prof. Dr. Ch. Spielmann

- Member of the board of Abbe Center of Photonics
- Deputy speaker of the Abbe School of Photonics
- Deputy member of the faculty council of the Faculty of Physics and Astronomy, FSU Jena
- Speaker of the Graduiertenkolleg “Advanced Photon Science”, HI Jena
- Member of the curatorship of the Fraunhofer Institute IOF
- Member of the advisory committee of the Leibnitz Institut für Photonische Technologien
- Member of the Editorial Board of the following international Journals: Nature Scientific Reports (Nature Publishing Group), Conference Papers in Physics (open access)
- Reviewer for international Journals and research funding organisations

Prof. Dr. M. C. Kaluza

- Deputy member of the faculty council of the Faculty of Physics and Astronomy, FSU Jena
- Member of Editorial Board of „Applied Sciences“
- Member of International Advisory Board of the Karlsruhe Institute of Technology (KIT) for the Helmholtz-Programme „Matter and Technology“
- Reviewer for the following Journals: Physical Review Letters, Physical Review E, Physics of Plasmas, New Journal of Physics, Physical Review Special Topics – Accelerators and Beams, Nature Physics
- Reviewer for Deutsche Forschungsgemeinschaft, Czech Academy of Sciences, Humboldt Foundation
- Coordinator of the study program in experimental physics

Prof. Dr. Th. Stöhlker

- Director of the Helmholtz Institute Jena, deputy research director GSI Darmstadt, speaker of the program topic of the Helmholtz programme “Matter and Materials and Life”
- Science Council IMP, Lanzhou, China; Science Council Extreme Matter Institute, Darmstadt, Germany; Helmholtz International Center for FAIR
- Member of the international board of the SPARC collaboration
- Member of the international board of the FLAIR collaboration
- Member of the Board of Editors of the European Physical Journal D

Prof. Dr. A. Pfeiffer

- Reviewer for the following Journals: Scientific Reports, Journal of Physics B: Atomic, Molecular and Optical Physics, Physical Review Letters, Nature Physics

Prof. Dr. E. Förster

- Reviewer for international Journals

Prof. Dr. M. Zepf

- ELI Beamlines, Prag – Scientific Advisory Committee
- Prioritisation Panel, LCLS, Stanford, USA
- Reviewer for EPSRC
- Science and Technology Facilties Council Advisory Board
- HILAS conference committee
- ICEL Romnia, Scientific Committee

10. 9. Institute of Theoretical Physics

Expert activities, commitee works, participation in the program committees of international conferences

Prof. M. Ammon

- Referee for various international journals
- Referee for European Research Council (ERC), Netherlands Organisation for Scientific Research (NWO), Czech Academy of Science, Alexander-von-Humboldt foundation, for Studienstiftung des deutschen Volkes and for Swiss National Science Foundation
- Organisation of the spring school "Perlen der theoretischen Physik"

Prof. M. Ansorg

- Coordinator of the study program in theoretical physics
- Board Member of the FV Gravitation und Relativitätstheorie of DPG
- Reviewer for international journals.

Prof. B. Brügmann

- Board Member of the FV Gravitation und Relativitätstheorie of DPG
- Board Member of the Committee of the International Society of General Relativity and Gravitation
- Editorial Board of Living Reviews in Relativity
- Council of the Faculty
- Referee for international science foundations and international scientific journals and publishers

Prof. S. Fritzsche

- Principal Editor of Computer Physics Communications
- Board Member of the International Program Committee of the Int. Conference on Atomic & Molecular Data and Their Applications
- Reviewer for Science Organizations and international journals
- Reviewer of the Project Review Panel PRP1 "VUV- and soft X-ray" at PETRA III at DESY, Hamburg
- Organizing Committee: DPG Symposium on *Interactions between twisted light and particles* at the DPG Frühjahrstagung, Sektion AMOP, Heidelberg, 27. 03. 2015
- Organizing Committee: ECT* workshop on *The interplay between atomic and nuclear physics to study exotic nuclei*, Trento, Italy, 24.-27. 08. 2015

Prof. H. Gies

- Member of the extended Directorate Helmholtz Institute Jena (HI Jena)
- Board Member of the Helmholtz Research School “Advanced Photon Science”
- Council of the Faculty
- Senate of FSU Jena
- Referee for international science foundations and international scientific journals and publishers
- Organizinger: Workshop on Strongly-Interacting Field Theories, Jena, November 5-7, 2015.

Prof. R. Meinel

- Deputy Member of Council of the Faculty
- Reviewer for Science Organizations and international journals.

Prof. Schäfer (retd.)

- Chairman Scientific Advisory Board of Physikzentrum Bad Honnef.
- Juror in Chain Reaction of Pupil Contest, Highlights der Physik, FSU Jena (25.09.2015)
- Reviewer for Science Organizations and International Journals.

Prof. Wipf

- Director of the TPI
- Speaker of the Research Training Group “Quantum and Gravitational Fields”, GRK 1523
- Member of Council of the Faculty
- Head of the FV Theoretische und Mathematische Grundlagen der Physik of the DPG
- Board member of Graduate Academy at FSU Jena
- Editor of “Graduate Texts in Physics”, Springer
- Co-Organisator of the W.E. Heraeus Summer School "Saalburg" for Graduate Students on "Foundations and New Methods in Theoretical Physics", 2 weeks in September
- Co-Organisor of the Topical Workshop at Mainz Institute for Theoretical Physics: “Quantum Vacuum and Gravitation”, Mainz, 22. - 26. Juni 2015
- Reviewer for Science Organizations and international Journals.

Dr. A. Sternbeck

- Chair of the IT-Team at the TPI-Jena. Coordinates with third party IT provider in regards to new hardware acquisition, hardware upgrades and server maintenance.
- Referee for international journals like Physical Review D or Physical Review Letters.

10. 10. Research Group - Teaching Methodology in Physics and Astronomy

Expert activities, commitee works, participation in the program committees of international conferences

Prof. Dr. K.-H. Lotze

- Dean of Students
- Member of the editorial board of the Journal „Astronomie + Raumfahrt im Unterricht"
- Board Member of the "Studium Generale" at FSU Jena

Dr. Silvana Fischer

- Member of the Study Commission of the PAF
- Deputy equal opportunities representative of the PAF
- Member of the working group "Physical Laboratory" (DPG) and its comission for teaching materials
- Working group "Praxissemester"

Stefan Völker

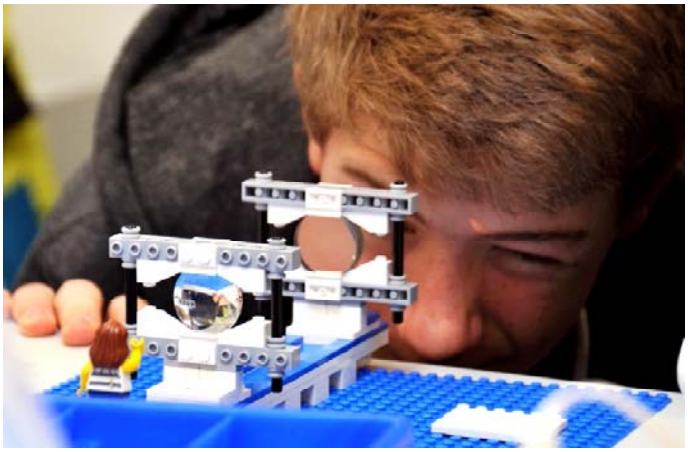
- Member of the Board of education of the Astronomical Society
- Member of the editorial board of the Journal " Astronomie + Raumfahrt im Unterricht"

Support of schools and school students

- Workshops "Wenn Licht um Ecken und Kurven geht.." within the jun.iversity program and at the Anger-Gymnasium
- February 2015: Opening of the Physics Lab for School Students in Helmholtzweg 5
- Experiment days with school classes (mostly grade level 10-12), 444 school students
- Two Workshops on the Future Day (Girls Day) at FSU Jena
- Girls Lab at the Ernst-Abbe Gymnasium Jena (supervised exclusively by student teachers, project on criminology)
- Preliminary works for the setup of a school student lab: build up a large database of experimental setups for schools
- Workshop „Vom freien Fall zur Schwerelosigkeit“
- On the Physics Day: Observation of the solar eclipse and didactic guidance for pupils Workshop with pupils of primary schools: Finsternisse -Tagbogen -Sonnenuhr (Eclipses - The daily path of the sun - Sundial)

Girls Lab: Project on Criminology

- Experimental day for the participants of the IPHT summer school
- Highlights der Physik: Several stations in the exhibition tent



In the Physics Lab for school students: Optical Experiments with LEGO bricks

11. Central Institutions of the Faculty of Physics and Astronomy

11. 1. Branch Library Physics of the Thüringer Universitäts- und Landesbibliothek

Although the library budget was not adequate to compensate the annual rise in prices, it was possible to keep up the good offer of information of the Faculty of Physics and Astronomy.
In 2015 the ThULB could acquire the license of the e-book series "*UTB-studi-e-book*" (print and download functions are implemented).

With the launch of *BibApp* (via iOS App Store) the ThULB is offering another mobile service. Now it is possible to use the ThULB user account (e.g. renew borrowed or reserve library items, searching in library catalogs) by mobile devices having iOS or Android systems software.

Within the project *Profillinie "LIGHT"* the library got 4,000 € to improve the inventory of books especially in the field of optics and photonics.

To impart information literacy, the ability to know when there is a need for information, to be able to identify, locate, evaluate, and effectively use that information for the issue or problem, several training courses were carried out. For new enrolled students five introductory courses for using the library with altogether 92 people were realized.

On 2015/06/30 the *ThULB-Info-Tag* was organized. Lectures about discovering literature, generating bibliographies, bibliometric analysis and databases were given.
The course "Vom Thema zur Literatur" is still an integral part of the course "Biomaterialien und Medizintechnik" for students in the field of materials science (5th semester).

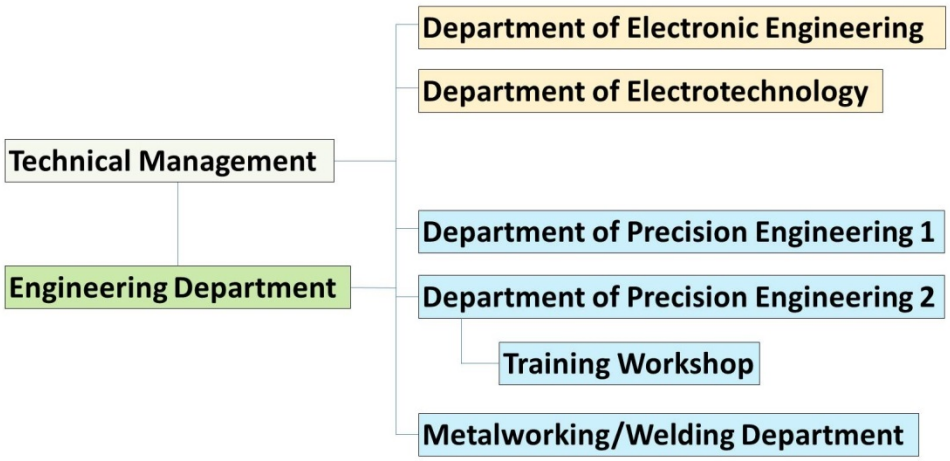
In the Departmental Library Physik 4073 borrowing and 6184 users of the library were registered.

Reading room of the branch library physics

11.2. Scientific Workshops of the Faculty of Physics and Astronomy

The Scientific Workshops of the Faculty of Physics and Astronomy fulfill a central function as technical backup for research and teaching of the institutes and for central service units. The workshops are organized in a separate entity. They are headed by the Technical Manager who is directly responsible to the Dean.

Structure:



Their responsibilities range from planning, development, and construction of devices and equipment , teaching and demonstration models to installation of experimental facilities for research, including commissioning, maintenance, and repair. This requires to work not only service-oriented, but also to be involved directly in research and teaching. These activities are accompanied by an own internal cash flow, inventory management, cooperation with external contractors, and vocational training.

In addition, there will be provided service to other faculties and institutions of the university according to the available capacity.

Getting a new order, the technological procedure is fixed after consultation with the Technical Management, the Engineering Department, and the managers of the departments.

In case of extensive projects, cost estimate is submitted to the sponsor, cooperation alternatives are compared and first quotations on necessary material and standard parts are requested.
The orders are settled according to a system that distinguishes between costs incurred in teaching or research (financed by budget or third party funded). The cost-effectiveness of each order is checked.

Stuff 2015

January 2015: in total 34 employees, in which 8 engineers, 7 masters, 19 skilled workers
December 2015: in total 33 employees, in which 9 engineers, 7 masters, 2 state-certified technicians, 16 skilled workers

This stuff development is a result of a temporarily pension and a delegation to staff council (2 skilled worker). It is very enjoyable that two skilled worker received qualification for state-certified technician.

The number of employees includes also 6-8 apprentices who get their training in the Training Workshop for industrial mechanics 2.

Departments of the Scientific Workshops

Department of Precision Engineering 1 and 2 (16 coworkers, in which 2 third party funded)

The tasks of the Departments of Precision Engineering include planning, development, construction, maintenance and repair of devices and experimental equipment for teaching and research. Depending on the scale and complexity, the drawing and engineering documents are prepared by the Engineering Department or the managers of the coworkers of the other departments respectively

Among conventional manufacturing methods (turning, milling, grinding, drilling, sawing, etc.) 4 universal-purpose CNC milling machine, 1 CNC lathe and 3 digitally controlled screw cutting and bar lathes are available. A cycle controlled lathe was financed by the Helmholtz Institute Jena. Furthermore, 6 conventional lathes were overhauled financed by central funds of the faculty.
These investments provide possibilities for an excellent manufacturing and the basis for creation of complicated shapes.

Dimensions able to be machined are:

- Turning operations up to Ø 500 x 1000 mm
- Milling operations up to 600 x 400 mm
- Honing operations up to 400 x 300 mm
- Drilling operations up to Ø 40 mm
- Engraving works, as well as laser engraving up to 18 mm

For the construction of equipment for application in laser, low temperatures and astrophysics requires essentially the use of non-ferrous metals, Cr-Ni metals, special materials (molybdenum, tantalum, titanium, tungsten, and ceramics) and all kinds of substitute materials.
The CNC milling machines FP 2a, MH 600, DMU 50T, DMC 635, the CNC turning machine CTX alpha 300 and the cycle controlled lathe Weiler C30 allow to meet the increasing requirements in the physics research and to manufacture not only complicated individual parts but also small series of high precision.

Department of Precision Engineering 1


Department of Precision Engineering 2

Metalworking/Welding Department (3 coworkers)

Coworkers of this department carry out especially works on the production of systems with high vacuum and ultrahigh vacuum vessels, on the construction of equipment systems and large parts (turned parts Ø 500 x 1000, sheet metal parts 1000 x 2000). Therefore, modern welding technology and equipment (tungsten inert gas (TIG), COand electric welding) are applied. There are 2 working areas with transportable extraction unit to carry out welding operations. Steels of all grades, stainless steels (CrNi), non-ferrous metals and plastic materials are machined. Procedures for thermal and surface treatment (Glass bead and sand blasting) are also used. Manufacturing of vacuum and ultrahigh vacuum welded joints by TIG welding technology up to 250A is essential for the research.

Training Workshop (1 trainer, 6 apprentices at present)

The practical part of the three-and-a-half years' vocational training is carried out at the Department of Precision Engineering 2, the theoretical part at the Vocational Training Centre Jena Göschwitz. In addition, the apprentices follow training courses: CNC basic course, basics of welding technology, pneumatics basic level.

The training comprises construction and maintenance of precision mechanical devices (adjustment, measuring, weighing, counting devices), as well as of optical and medical equipment.
After 6 months of initial training, the apprentices carry out parts of current orders for teaching and research. The knowledge gained by this way enter the training.

Metalworking/Welding Department

Training Workshop

Department of Electronic Engineering (7 coworkers)

The main tasks of this department consist of development and construction of commercially unavailable special electronic devices and equipment using analogue, digital, high voltage or measurement, engineering, control technology. The spectrum ranges from small additional devices, high precision positioning and drive systems, special measuring instruments, power supplies for high power to completely computer-controlled systems. These works range from development of a concept in cooperation with the scientists, a circuit, and PCB layouts at modern CAD workplaces to the configuration of modules, as well as the completion, commissioning and testing of the devices.

The tasks of the department include also repair work on electronic devises and equipment, as well as on computer hardware.
Furthermore, the department takes over the technical assistance in the context of research and examination projects. Its tasks include the maintenance and extension of existing data networks in the buildings of the faculty, as well as the procurement and storage of electronic components.

Department of Electronic Engineering

Department of Electrotechnology (3 coworkers)

The tasks of the department include the development and configuration of special electrical components and experimental facilities, as well as the conversion of electrical equipment in research laboratories and for practical courses. Furthermore, the department carries out planning and technical realization of new and extension installations of entire laboratory areas and areas for practical courses. In addition, it is responsible for the mandatory inspection of all electrical devices and equipment according to DIN VDE.

Department of Electrotechnology

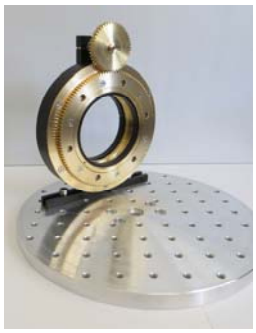
Engineering Department with printing technology up to A0

Engineering Department (3 coworkers)

The tasks of the department consists of development and engineering of different components up to large-scale experiments. The documentation is prepared in close contact with the scientists up to production stage and is passed on to manufacturing at the faculty's workshops or to cooperation partners. This procedure covers also the determination of the input of material, components and standard parts, including offer, order und procurement.

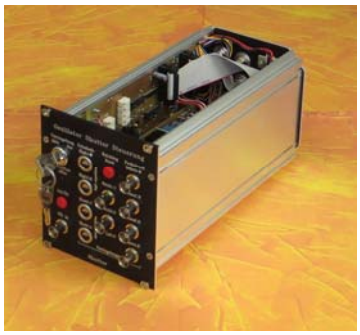
Issues and projects

It would go beyond the scope to list all issues and projects whose technical basis was provided by the Scientific Workshops. The examples here are just a small selection of research projects in 2015:



3 inches rot.-mount

5-phase controller



shutter controller

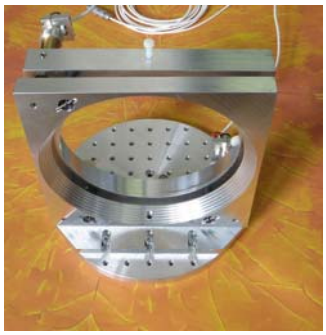
shutter controller

S&H-ADC- controller

vacuum chamber (part)

particle injector

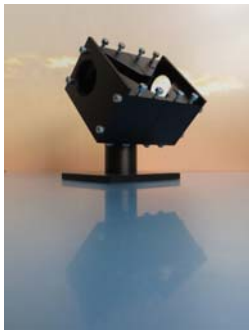
crystal rotator



mirror support

polarisation rotator

motorization

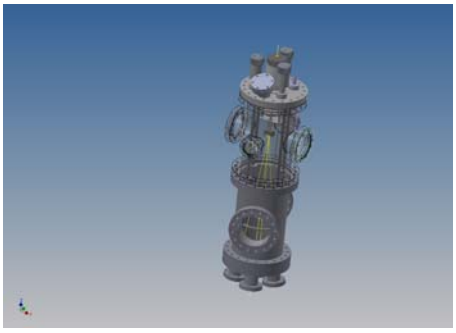


polarization rotator

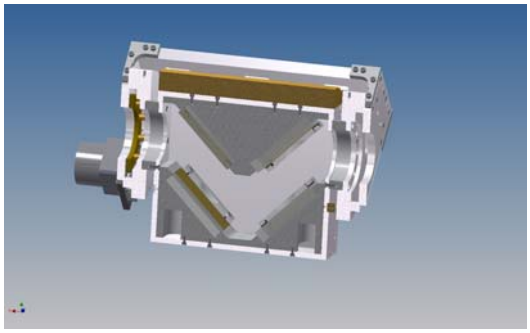
charge exch.cell

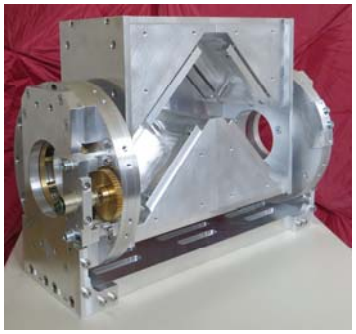
beamline JETI200

driving simulator Eltrilo



organicchamber





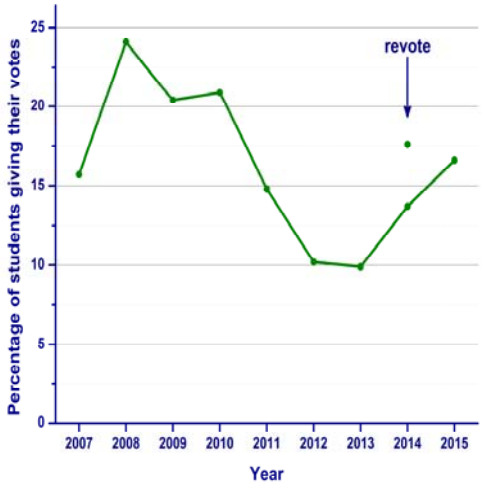
polarisation Rotator (model and product)

11. 3. Student Council (Fachschaftsrat, FSR) of the Faculty of Physics and Astronomy

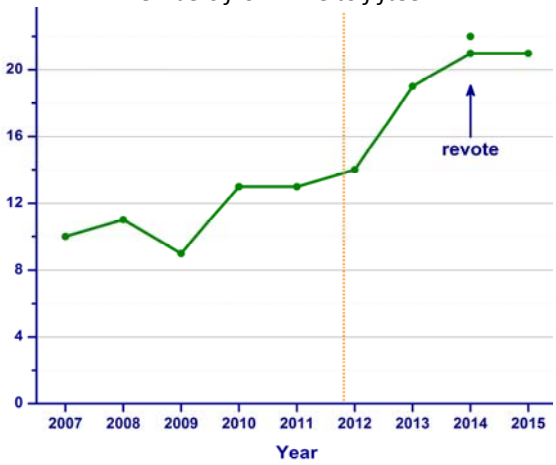
The FSR and what we do

The student council of the Faculty of Physics and Astronomy – referred to as FSR (for "Fachschaftsrat") – is a group of 15 students, elected each year. There were 21 students standing for election in 2015, and 16.6% of the PAF student body were giving their vote. As one can see in the two graphs below, the relative number of voters increased further in comparison to the past three years. Besides, we noticed a constant number of candidates this year.

Percentage of students giving their votes in FSR election over the past nine years



Number of candidates over the past nine years. In 2012 (orange dashed line) we set the number of members from nine to fifteen.



In the following we list the names of old and newly elected members of the PAF student council.

Members in 2014/15:

- Eric Abraham
- Nils Becker
- Eduard Betko
- Sven Buder
- Hannes Damm (treasurer)
- Annika Gambke
- Maximilian Keller
- Mark Kremer
- Silvia Kunz
- Lukas Maczewski
- Michel Pannier (chairman)
- Stephan Siewert (budget official)
- Sebastian Ulbricht
- Richard Wiedenhöft
- Anna Katharina Wölfl

Members since October 2015:

- Eric Abraham
- Eduard Betko
- Michael Förster
- Max Fricke
- Annika Gambke
- Elisabeth Golbing
- Maximilian Keller (budget official)
- Gloria Kirste
- Silvia Kunz
- Michel Pannier (chairman)
- Fabian Ritschel
- Samuel Ritzkowski (treasurer)
- Sebastian Ulbricht
- Anna Katharina Wölfl
- Marie Zeidler

We are facing a large spectrum of responsibilities. A small overview of tasks is shown below:

A huge part of our work consists of communication with institutions of the faculty (such as the Dean's office, the Office for Student Affairs or “ProQualität Lehre” – especially the regular talks with the Dean have shown to be very fruitful for both of us) and sending student representatives to other councils (such as the university student council *StuRa*, the *FSR-Kom*, the council of the faculty or the committee for lecture evaluation). During the lecture period we coordinate our work in weekly sessions, open to public. Furthermore we offer two or more visiting times per week for students looking for advices or searching for old exams.

Our main budget for all activities comes from the semester contribution of the students. At the moment the university student council gets 7€ per student and semester, from which 1.90€ go to the student councils of the faculties.

For further information (e.g. about our meeting and visiting times or upcoming events), questions or help, please contact us:

Mail	*fsr@paf.uni-jena.de*
Phone	*03641/9-47095*
Web	*www.fsr.uni-jena.de*
Facebook	*Physikalisch-Astronomische Fachschaft Jena*

Events

Here we give a list of all events organized by us in 2015:

- 20.01. Skat tournament at the *Quergasse No. 1*
- 01./02.04. orientation days for new students
- 23.04. summer-welcome-BBQ for ASP students
- 10.05. volleyball tournament with the FSR math and the OSA student chapter
- 28.05. flunkyball tournament with the FSR philosophy
- 24.06. student-professors-meeting
- 02.07. Skat tournament at the *Quergasse No. 1*
- 21.-30.09. ''Mathe-Auffrischungskurs'' (pre-course for the pre-course)
- 01./02.10. orientation days for new students
- 12.-16.10. LaTeX tutorial
- 16.-18.10. ''Ersti-Fahrt''
- 05.11. semester star-up with the FSR engineering/SciTec at the *Rosenkeller*
- 06.12. volleyball tournament with the FSRs math and chemistry
- 07.12. excursion to Leipzig
- 14.12. Christmas party with the FSR psychology at the *Rosenkeller*
- 16.12. Christmas session and the movie ''Feuerzangenbowle''

Furthermore we supported the following external events:

- ''Tag der Physik'' (20.03.),
- ''Perlen der theoretischen Physik'' (30.03.-01.04.),
- excursion of the *Alumni e.V.* to the local company *LASOS* (22.04.),
- *Hochulinfotag* (09.05.),
- ''Highlights der Physik'' (22.-26.09.),
- student-professors-meeting (02.12.),
- Christmas party of the Material Science students (14.12.).

Lecture evaluation

Each semester the FSR organizes an evaluation of all lectures at the PAF (including several service courses of other faculties) in cooperation with the "Universitätsprojekt Lehrevaluation (ULe)". The evaluation aims the assessment of quality and professional level of the lectures seen by the viewpoint of students and gives rise for the lecturers to take a critical review of their teaching. At the same time it gives an orientation for students, for instance when choosing physical elective courses.

On basis of the evaluation the FSR gave the **student body teaching award** in winter semester 2014/15 to Dr. Ronny Nawrodt for his lecture in electronics and the corresponding seminar. In summer semester the award was given to Jun.Prof. Martin Ammon, whose lectures in theoretical physics (quantum field theory I and II) achieved very high ratings. Additional acknowledgement for exceptionally good teaching was given to Stefan Völker.

In summer semester for the first time we used our newly designed questionnaires, which lead to some delay in finishing the summary, due to changing the software, but increased the efficiency of the survey. The complete evaluation can be found at the Dean's Office, the physics library and the FSR office; moreover you will find it online via our website.

Orientation days for new students and "Ersti-Fahrt"

As every semester the FSR organized orientation days for new physics students (1^{st}/2^{nd} April & 1^{st}/2^{nd} October), offering introductions to study regulations, university life and *Friedolin,* as well as a city tour and visits of the institutes of the PAF. This year we recognized slightly increasing number of first semester students: about 10 B.Sc. in Physics students in summer term (who actually appeared to the lectures – in fact there were 31 matriculations) as well as 50 B.Sc. in Physics, 27 Teaching degree and 18 B.Sc. in Material Science students in winter term.

Just as the year before we did our own introduction course to *Friedolin* and handed out the brochure ''Studienführer der Fachschaft Physik'', which summarises most important information for the newcomers.

As every year, we also invited our new students for a weekend trip (''Ersti-Fahrt''), this year for the first time to a nice location named ''Sormitztal'', near the small town Leutenberg.

ZaPF and BuFaTa MatWerk

The **meeting of all physics student bodies** (referred to as ZaPF for "Zusammenkunft aller Physik-Fachschaften") takes place every semester; this year the physics student bodies of Aachen and Frankfurt a.M. organized the conferences in May and November. Of course we participated in both of them and joined work groups dealing with B.Sc. and Teaching degree programs of study, CHE ranking, ethics in science, communication to other student bodies, female quota and many other topics.

Furthermore, a delegation joined the **meeting of all materials science and engineering technology student bodies** (referred to as BuFaTa MatWerk for ''Bundesfachschaftentagung der Fachbereiche Materialwissenschaft/Werkstofftechnologie'') taking place in Karlsruhe in May and

Erlangen in November. Important issues were the CHE ranking planned for the Bachelor degree of study, as well as establishing an official society, similar to the *ZaPF e.V.*

Faculty policy

In 2015 we worked on some important issues concerning the programs of study. One thing we could change nearly immediately was to get foreign language courses accepted as non-physical elective courses. This means, that students are now able to take courses at the Language Center and get at the most 8 credit points for these.

Another topic was the physics M.Sc. program of study and possible improvements thereof with regard to many small lectures, content duplications and missing topics. The aim was to update the module catalogue and find lectures which could fuse to such with an appropriate main emphasis. There already were some talks between students and professors of all four areas, but there is still some work to do in 2016.

After many discussions about the teaching degree of study we achieved a small improvement for regular school teachers: lecturers are asked to provide oral exams for them.

We also participated in discussions with the advisory council (''Beirat'') of the faculty, dealing with the programs of study (especially teaching degree and content duplications in material sciences), the recruitment of new students and administrative things.

Other matters

In April we recieved the results of the CHE ranking of the physics B.Sc. course of study, which was good news: Besides showing the highest participation of students giving their opinion, the faculty can be glad to have achieved the greatest number of indicators rated in the top group. Nevertheless, in cooperation with the Dean's office we focused on critical points, which we identified to be access to free software and a lack of space for working groups. For instance we designed an overview of free lecture rooms, based on *Friedolin* data, and we will establish a new common room in the upcoming year.

A highlight of the year was the project of a group of material sciences students to compete the ''Betonkanu-Regatta''. The competition consisted in building a boat out of concrete and joining a race with it. The tournament was taking place on the river Havel on the 20th June. Unfortunately, the team didn't win a price, but surely this was a nice experience for all participants.

Another long-planned project finally came to it's end: The framework for our outdoor blackboard was finished and we look forward to officially open it, as soon as the first warm days of 2016 set in.

In order to support the student recruitment of the university for scientific courses of study we further enhanced our involvement at fairs for high school graduates. This includes giving talks and accompany the ''Infomobil'' on it's trips through Germany.

11. 4. Alumni Association of the Faculty of Physics and Astronomy

The object of the association is to maintain and strengthen contacts between our graduates and former Faculty members and the Faculty, and to lend spiritual and financial support to the Faculty in the fields of teaching, science, research and the union of theory and practice. The association encourages contacts between present students and former graduates as well as students' visits to industrial enterprises, research labs and institutes in order to point out possible job placements after their studies. Our activities also keep alumni informed about new fields of research and priorities of the Faculty.

The association's affairs are governed by a set of rules. The annual general meeting on 18 November 2015 approved the committee's report and adopted the action programme for 2016.

As the association does not charge any regular membership fees, its activities are funded mainly by sponsors and donations. In particular, we wish to mention the sponsorship agreements with JENOPTIK AG and MLP and the longstanding patronage by Rohde & Schwarz of Munich. A further sponsorship agreement has been entered with PCE Instruments, covering the supply of measuring instruments for the Faculty's practical courses. Further incomes in 2015 resulted from the Job Fair organized by the association and from many individual donations. The association is an officially recognized non-profit organization and is entitled to write out receipts for donations.

A highlight in 2015 was the 2. Physics Day on 18 March which was held with the association's active help and financial support again. On the same day a partial solar eclipse happened between 9:34 and 11:45 with the maximum coverage of the sun of 73.8 %. Therefore we used this rare occurence to attract many people by giving the possibility to observe the solar eclipse on the roof terrace of the faculty's main building and by an attractive supporting programme.

Observation of the partial solar eclipse on the roof terrace of the faculty's main building
(Foto: Jan-Peter Kasper, FSU)

Our funds also went into supporting the workshop „Physics for schoolgirls", the annual student-professor dialogue, the event known as „The Dean informs" and into advertising the Faculty's public Saturday lecture, among other events.

12. Outlook

As for the previous years we hope that our annual report documented the continuation of the positive general development of our faculty. We are looking optimistically into the future and would like to sketch some of the specific developments which we anticipate for 2016.

Based on the achievements in the structure of our faculty and its staff, the quality of our teaching program and our students, as well as our competitive research program and the subsequently attracted funding, we hope that the general positive development will continue also in the future.

Most importantly, our faculty life is strongly connected to the development of the faculty's body, i.e. the opportunities arising from new appointments and the connected challenges resulting from the retirement or leave of precious colleagues. After having appointed three new professors in 2014 we had been very successful in an important appointment also in 2015. Dr. Enrico Gnecco became the new professor for Physics/Mechanics of Functional Materials at the Otto Schott Institute of Materials Research. Thus, for 2016 there remains the challenge for all of us to integrate Enrico Gnecco and the three new colleagues who were appointed the year before smoothly into the faculty and to realize the opportunities which arise from their new input to our research and teaching. Likewise, we are looking forward to fill open faculty positions successfully by similarly promising candidates in 2016, as e.g. the junior professorship for "EUV and X-ray sources", the professorship for "Physics and didactics", as well as the professorships for "Waveguide optics with a focus on fiber optics" and "Solid state physics with the focus on quantum detection", both of which were opened in collaboration with the Leibniz Institute of Photonic Technology e.V. (IPHT).

While from these new professors fresh opportunities will arise, we will also face the challenges connected to the retirement of valuable colleagues. Very prominently are the retirements of Richard Kowarschik (Professor for Experimental Physics / Coherence Optics) and Karl-Heinz Lotze (Professor for Teaching Methodology in Physics and Astronomy). Because of the retirement of Richard Kowarschik the faculty has to develop a strategy to sustain the profile of the Institute of Applied Optics, which is particularly important for the faculty's connection to the fields of life science and medicine and therefore to other faculties of the university. A similarly difficult task will arise from the retirement of Karl-Heinz Lotze, who provided a substantial and very reliable basis of our teaching program over the last years. His retirement will leave us with many challenges to keep up the quality of our education program for physics teachers.

A great challenge and opportunity which we will face in the next years will be the strategic reappointment of a number of positions at the mid-level faculty, i.e. scientific assistants connected to the faculty and its institutes. While historically we had a large number and a high quality of staff members at this level, the cutback process, which was initiated after the reunification in the early 90's, resulted in the situation that this sector is underrepresented today. Thus, together with the university's leadership we must find ways to counteract this development in order to maintain the high level in teaching and research quality.

Looking at our annual report, we hope it became clear that teaching enthusiastic students is truly at the heart of our faculty. Thus, the continuous development of the quality of our teaching programs will be important for us also in the future. Moreover, after the reaccreditation of our course program occupied major resources as part of the system accreditation of the university in the last years, we are now looking forward to concentrate again on working more intensively directly with the students again.

In contradiction to the proud, which we take in our teaching, the entire faculty is still facing the results of the drastic decrease of the numbers of freshly starting students in the last two years. While this trend was to be expected from the simple correlation to the negative development of the local population, its harshness wasn't expected and left us puzzled and searching for possible internal reasons. Even though the drop of the number of beginning students is consistent with the low birth rate in Thuringia 19 years ago, it also shows that we are not sufficiently successful in at-

tracting students from other federal states of Germany – despite of the student-friendly conditions in Jena. Our faculty takes up the challenge to counteract this critical development. Based on the success in international recruitment for our Master program in Photonics we are planning to expand the international scope of our teaching also to our Master program in Physics, which will accept English speaking students in 2016 for the first time. Furthermore, we already started to pay more attention to publicly advertising our teaching programs. First successful activities in this direction are the outstanding results in the last CHE ranking and our ongoing positive encounter with social media platforms through the new Facebook page of our faculty. We are in close contact with our student council in order to further optimize the learning experience from the CHE ranking and to get the message across.

Other important activities in the area of student recruitment are outreach measures. Again we build on longstanding experience which includes the Saturday morning lectures, the Girls' Lab, lectures for pupils at their schools or in our lecture hall, etc. Based on the International Year of Light and the Highlights of Physics the year 2015 was truly outstanding with respect to our visibility in the public. We are challenged to keep our outreach program at this high level and the annual Physics Day organized by our faculty will contribute to such activities. It is quite clear that these outreach and public relation activities have to be strengthened even further in the future if we want to avoid the risk that the positive general development of our faculty is suffering from the low number of students.

During the last years we constantly encountered limitations of our research and teaching activities caused by insufficient rooms and infrastructure. In 2015 the new research building of the Abbe Center of Photonics was handed over to the university. Together with colleagues from the Faculty of Chemical and Earth Sciences and the Faculty of Biology and Pharmacy we are looking forward to moving into this new building in 2016. It will provide high quality laboratories for photonics at the interface to life science, medicine, and chemistry and will therefore strengthen our interaction with partners at these faculties.

The positive development of our faculty, which is documented in the present annual report, is closely connected to our success in attracting external third-party funding for our research. Hence, it will be an important part of our activities to maintain and possibly increase our impact in this direction also in the future. Several activities are launched to attract coordinated funding programs in the research fields of our faculty in the near future.

Eventually, our persistent ambitions to improve the quality of our research and teaching follow a strategy for excellence, which is constantly coordinated with the leadership of the university and the Free State of Thuringia. Having received substantial funding within Thuringia's Pro-Excellence Program, we are looking forward to the future of the Excellence Initiative in Germany. Successful participation in the Excellence Initiative 3 has to be achieved despite the Plan for Structure and Development (StEP) of the Free State of Thuringia, which severely limits the resources of the university for new strategic developments. Our general strategy to cope with this situation will be to continue along the lines that have become the basis of our present success: Increase collaboration across different faculties and with extra-university institutes. For the latter, the exemplary close links of the Faculty with the Fraunhofer Institute, the Helmholtz Institute and the Leibniz Institute of Photonic Technology have created a remarkably profound win-win situation without which the faculty would be in a completely different position. Therefore, it is obvious to seek for and create even more of such opportunities. For this we can rely on established structures, in particular the Abbe Center of Photonics, which already received a strong commitment of the university. Hence, the strengthening of the center's research, which is closely connected to the faculty's associated extra-university research institutes, as well as its education, established as the Abbe School of Photonics, will be important not only for our faculty. Hence, the strategy for the future development of our faculty in coherence with the Abbe Center of Photonics will include the strengthening of the connection to life science and medicine, which we consider important to re-

inforce the profile of the university. One of the next steps will be the start of the new international masters course in Medical Photonics, which our faculty will strongly support.

In view of all the new and persistent challenges as well as of the connected opportunities for new developments the limited central resources will also require setting priorities on the most important subjects. The Faculty of Physics and Astronomy together with its Scientific Advisory Board will take up this challenge also in 2016.

At the end, we would like to thank those who read our annual report for their interest in our work. Despite being a report, we hope that it also inspires discussions for new successful activities.