Workshop

NONLINEAR OPTICS IN GUIDED GEOMETRIES

Berlin, May 18 – 20, 2009

Weierstrass Institute for Applied Analysis and Stochastics (WIAS)

Organizing Committee:

Shalva Amiranashvili (WIAS), Uwe Bandelow (WIAS)
Ayhan Demircan (WIAS), Günter Steinmeyer (MBI), and Andrei Vladimirov (WIAS)

Organized by:

Weierstrass Institute for Applied Analysis and Stochastics (WIAS), Berlin
Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI), Berlin

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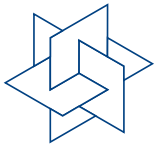


DFG Research Center MATHEON
Mathematics for key technologies

Max Born Institute for Nonlinear
Optics and Short Pulse Spectroscopy

Contents

Equipment: The lecture room is equipped with a blackboard, two overhead projectors, and a beamer with a laptop (Windows system), as well as intranet and internet.

Workshop "Nonlinear Optics in Guided Geometries"

Berlin, May 18 – 20, 2009

The workshop aims at bringing together researchers working both, experimentally or theoretically, in the following fields:

- Ultrashort and few-cycle optical pulses
- Femtosecond filamentation
- Pulse self-compression
- Solitons in photonic-crystal media
- Optical dissipative solitons

INVITED SPEAKERS

Stephane Barland (Nice, France)
Luc Bergé (Arpajon, France)
John Dudley (Besançon, France)
Oleg Egorov (Jena, Germany)
Carsten Fallnich (Münster, Germany)
Michael H. Frosz (Lyngby, Denmark)
Goëry Genty (Tampere, Finland)
Eleftherios Goulielmakis (Garching, Germany)
Joachim Herrmann (Berlin, Germany)
Anton Husakou (Berlin, Germany)
Paul Kinsler (London, UK)
Vladimir Konotop (Lisbon, Portugal)
Kyriaki Kosma (Berlin, Germany)
Fedor Mitschke (Rostock, Germany)
Kurt E. Oughstun (Burlington, USA)
Luis Roso (Salamanca, Spain)
Emilia Schulz (Hannover, Germany)
Dmitry Skryabin (Bath, UK)
Stefan Skupin (Dresden, Germany)
Kestutis Staliunas (Barcelona, Spain)
Kamil Stelmaszczyk (Berlin, Germany)
Andrey A. Sukhorukov (Canberra, Australia)
Majid Taki (Lille, France)
Mustapha Tlidi (Brussels, Belgium)
Sergei K. Turitsyn (Birmingham, UK)

Location: Weierstrass Institute for Applied Analysis and Stochastics (WIAS),
Erhard Schmidt lecture room (first floor)

MONDAY, MAY 18 **ERHARD SCHMIDT LECTURE ROOM**

Duration of talks includes 5 minutes for discussion.

08:00 - 09:00	Registration
09:00 - 09:15	Opening
Session M1 – Rogue Waves and Turbulence in Fibers **Chairman: Dmitry Skryabin (Bath)**	
09:15 - 09:45	**Optical rogue wave formation** Majid Taki, Lille
09:45 - 10:15	**Optical turbulence in ultra-long fibre lasers** Sergei K. Turitsyn, Birmingham
10:15 - 10:45	Coffee Break
Session M2 – Rogue Waves II **Chairman: Carsten Fallnich (Münster)**	
10:45 - 11:15	**Optical rogue wave instabilities: Dynamics and experiments** John Dudley (Pierre Lacourt), Besançon
11:15 - 11:45	**Optical rogue wave instabilities: Further insight and route to control** Goëry Genty, Tampere
11:45 - 13:15	Lunch Break
Session M3 – Novel Hollow Fiber Geometries **Chairman: Michael H. Frosz (Kongens Lyngby)**	
13:15 - 13:45	**High-power soliton-induced supercontinuum generation in metal-dielectric hollow waveguides** Joachim Herrmann, Berlin
13:45 - 14:15	**High-coherence supercontinuum and single-cycle soliton compression in metal-dielectric hollow waveguides** Anton Husakou, Berlin
14:15 - 14:40	**A chirped photonic crystal fiber for high-fidelity guiding of sub-100 fs pulses** Jens Bethge, Berlin
14:40 - 15:10	Coffee Break
Session M4 – Advances in Modeling **Chairman: Luc Bergé (Arpajon)**	
15:10 - 15:40	**Towards the far end of that fibre: Pulse propagation models with minimal assumptions** Paul Kinsler, London
15:40 - 16:10	**Dispersive pulse dynamics in the few-cycle pulse limit** Kurt Oughstun, Burlington
16:10 - 16:35	**Modeling of medium dispersion for ultrashort optical pulses** Shalva Amiranashvili, Berlin
16:35 - 17:05	Coffee Break
Session M5 – Few-Cycle Pulses **Chairman: Goëry Genty (Tampere)**	
17:05 - 17:35	**Supercontinuum generation at the single optical cycle limit: New routes to lightwave electronics** Eleftherios Goulielmakis, Garching
17:35 - 18:00	**Analytical study of intense light propagation in highly nonlinear media** Larisa Tatarinova, Kassel
19:00 - 23:00	**WORKSHOP DINNER** (Restaurant Brauhaus Georgbraeu)

TUESDAY, MAY 19 **ERHARD SCHMIDT LECTURE ROOM**

Duration of talks includes 5 minutes for discussion.

Session T1 – Feedback Systems **Chairman: Sergei K. Turitsyn (Birmingham)**	
09:00 - 09:30	**Supercontinuum from a feedback configuration** Fedor Mitschke, Rostock
09:30 - 10:00	**Nonlinear dynamics of femtosecond supercontinuum generation with feedback** Carsten Fallnich, Münster
10:00 - 10:25	**Solitary wave solutions for few-cycle optical pulses** Uwe Bandelow, Berlin
10:25 - 10:55	Coffee Break
Session T2 – Bloch Waves **Chairman: Kestutis Staliunas (Barcelona)**	
10:55 - 11:25	**Dissipative Bloch waves** Vladimir Konotop, Lisbon
11:25 - 11:55	**Bloch cavity solitons** Oleg Egorov, Jena
11:55 - 13:25	Lunch Break
Session T3 – Localized Structures and Pattern Formation **Chairman: Majid Taki (Lille)**	
13:25 - 13:55	**New aspects of multiple filamentation and supercontinuum generation in experiments on manyfold supercritical beams (P>10 000 Pcr)** Kamil Stelmaszczyk, Berlin
13:55 - 14:25	**Localized structures in photonic crystal fiber resonators** Mustapha Tlidi, Brussels
14:25 - 14:55	**Stability properties of bidimensional localized states in a cavity soliton laser** Stephane Barland, Valbonne
14:55 - 15:25	Coffee Break
Session T4 – Solitons **Chairman: Vladimir Konotop (Lisbon)**	
15:25 - 15:55	**Polariton solitons in semiconductor microcavities** Dmitry Skrabin, Bath
15:55 - 16:25	**Bandgap solitons and subdiffractive solitons** Kestutis Staliunas, Barcelona
16:25 - 16:55	**Polychromatic light control in nonlinear photonic lattices** Andrey A. Sukhorukov, Canberra
16:55 - 17:25	Coffee Break
Session T5 – Semiconductor Devices **Chairman: Andrei G. Vladimirov (Berlin)**	
17:25 – 17:55	**Supercontinuum generation in ultralong semiconductor optical amplifiers** Patrick Runge, Berlin
17:55 – 18:20	**Wide range 40-GHz passive mode-locking operation of an AlGaInAs 1.55-µm strained quantum well laser** Julien Javaloyes, Glasgow

WEDNESDAY, MAY 20 **ERHARD SCHMIDT LECTURE ROOM**

Duration of talks includes 5 minutes for discussion.

Session W1 – Self-Compression in Filaments - Theory **Chairman: Fedor Mitsche (Rostock)**	
09:00 - 09:30	**Pulse self-compression mediated by filamentation: From UV to IR** Luc Bergé, Arpajon
09:30 - 10:00	**Self-healing mechanism of compressed femtosecond filaments** Stefan Skupin, Dresden
10:00 - 10:25	**Quasi-hydrodynamic spatio-temporal shaping in filamentary propagation of femtosecond pulses** Carsten Brée, Berlin
10:25 - 10:55	Coffee Break
Session W2 – Novel Nonlinear Optical Effects **Chairman: Stefan Skupin (Dresden)**	
10:55 - 11:25	**Nonlinear microstructured polymer optical fibres** Michael H. Frosz, Kongens Lyngby
11:25 - 11:55	**Different schemes to generate high energy filaments in the near infrared** Luis Roso (Julio San Roman), Salamanca
11:55 - 12:20	**Optical amplification by four-wave mixing in gases using quasi-phase matching with ultrasound waves** Ihar Babushkin, Berlin
12:20 - 13:50	Lunch Break
Session W3 – Self-Compression in Filaments – Experiments and Applications **Chairman: Günter Steinmeyer (Berlin)**	
13:50 - 14:20	**Supercontinuum generation through filamentation in argon** Kyriaki Kosma, Berlin
14:20 - 14:50	**Generation of high-order harmonics with ultra-short pulses from filamentation** Emilia Schulz, Hannover
14:50 - 15:15	**Filamentation: A versatile source for advanced spectroscopic applications** Torsten Siebert, Berlin
15:15 - 15:30	**Closing**

Modeling of medium dispersion for ultrashort optical pulses

Shalva Amiranashvili
Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Berlin, Germany

Description of light with a very broad spectral bandwidth, e.g. an ultrashort optical pulse or supercontinua, requires knowledge of medium dispersion for all frequencies of interest. Here, an available dispersion curve is usually approximated by a polynomial, the corresponding expansion coefficients are further used to construct an envelope equation with the differential dispersion operator. We demonstrate that the dispersion curves are more naturally represented by rational functions. The latter correctly reproduce asymptotic behavior of the refractive index. Moreover, the fulfillment of the causality principle and the Kramers-Kronig relation can be established. In the simplest case such rational function reduces to the Padé approximant for the refractive index. Pulse propagation is now described by a nonlocal envelope equation with the pseudodifferential dispersion operator. The model can be solved numerically by a straightforward application of the split-step Fourier method. Unphysical effects and numerical stiffness are avoided and artificial spectral filters are not necessary.

Coauthors: U. Bandelow and A. Mielke

Optical amplification by four-wave mixing in gases using quasi-phase-matching with ultrasound waves

Ihar Babushkin
Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Berlin, Germany

Quasi-phase-matching in periodically pooled $\chi^{(2)}$ crystals is limited by their transparency range and material damage. We propose a novel scheme of quasi-phase matching of four-wave mixing (FWM) in gases in waveguides or in bulk, based on a periodical modulation of the pressure in an $\chi^{(3)}$ gas, which is created by a standing ultrasound wave in the direction of light propagation. Nobel gases have no rotational and vibrational absorption bands at low frequencies and therefore possess an extremely broad transparency range up to vacuum ultraviolet. We calculate the amplified signal pulse by FWM and study the conditions of optimal amplification and quasi-phase matching. The achievable signal frequency range is limited by the ultrasound absorption.

Solitary wave solutions for few-cycle optical pulses

Uwe Bandelow
Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Berlin, Germany

The well-established theory of envelope equations is applicable if the width of pulses is much bigger than the wavelength of the underlying carrier wave. For very short pulses these envelope equations are no longer appropriate as the frequency spectrum is widened too much. Ultrashort pulses even contain only a few optical cycles, and corresponding mathematical models are rare. We consider the propagation of ultrashort optical pulses in nonlinear dispersive media without using slow envelope approximations.
In the frame of short pulse equations we have found a family of ultrashort traveling-pulse solutions of Maxwell equations in a Kerr medium within the anomalous dispersion regime. We directly observed a continuous transition between envelope and non-envelope solitons and obtained the shortest possible pulse shape and duration in a given medium.

Coauthors: Sh. Amiranashvili and A.G. Vladimirov

Stability properties of bidimensional localized states in a cavity soliton laser

Stephane Barland
Université de Nice Sophia-Antipolis
Institut Non Linéaire de Nice (INLN)
Valbonne, France

On the basis of a simple but original experimental setup, we explore the stability properties of localized states in coupled semiconductor lasers, one of which is acting as a saturable absorber. Contrary to most experiments, the system we consider does not involve any kind of coherent forcing such as the injection of an optical beam. The resulting phase freedom leads to rather different and exciting results as compared to better known laser injection experiments.

Pulse self-compression mediated by filamentation: From UV to IR

Luc Bergé
Commissariat à l'Energie Atomique (CEA/DAM/DIF)
Arpajon, France

We report numerical results on the self-compression of ultrashort filaments in pressurized gas cells. Few-cycle output pulses operating at various wavelengths between 266 nm and 2 microns follow either from direct filamentation or from frequency conversion processes.

A chirped photonic crystal fiber for high-fidelity guiding of sub-100 fs pulses

Jens Bethge
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Berlin, Germany

Photonic crystal fibers usually confine the light by means of a periodic cladding, consisting of several layers of identical cells. This design resonantly decreases the transmission losses of such fibers to values of a few dB/km in a narrow wavelength range. However, the rather narrowband transmission bands and the detrimental third order dispersion characteristics of this single-cell design generally render application of such hollow-core fibers difficult in the femtosecond range. Therefore, no fiber-based concept can currently provide guiding of sub-100 fs pulses over extended distances. By introducing a radial chirp into the photonic crystal we demonstrate here a novel concept for photonic crystal fibers that breaks with the paradigm of lattice homogeneity and enables a new degree of freedom in photonic crystal fiber design, eliminating much of the pulse duration restriction of earlier approaches. We demonstrate that the small GVD of chirped photonic crystal fibers allows for surprisingly weak stretching of 13 fs pulses, which only double their duration within 1 m of guided propagation.

Quasi-hydrodynamic spatio-temporal shaping in filamentary propagation of femtosecond pulses

Carsten Brée
Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Berlin, Germany

Filament self-compression is a remarkably simple new way for generating intense laser pulses with sub-10 fs pulse duration. Despite the experimental simplicity, the physical situation in femtosecond filaments is quite involved. We will show, however, that the formation of short pulses in the filamentary channel can already be well understood in a reduced model that isolates three major mechanisms. In particular, this model implies vanishing flow of energy between adjacent temporal slices of the pulse. In this quasi-hydrodynamic scenario, a self-induced pinching of the photon density and a characteristic spatio-temporal inhomogeneity of filamentary pulses are observed. We will provide analytical and numerical arguments that filamentary self-compression is due to this spatial concentration of energy.

Optical rogue wave instabilities: Dynamics and experiments

John Dudley (Pierre-Ambroise Lacourt)
Université de Franche-Comté
Institut FEMTO-ST (Franche-Comté Electronique Mecanique
Thermique et Optique - Sciences et Technologies)
Besançon, France

We examine in detail the dynamics leading to the formation of optical rogue waves in the context of supercontinuum generation in highly nonlinear fibers. We also report on experiments showing that such – statistically rare – rogue wave events can be observed under different pumping regimes and can be detected using a straightforward direct detection setup.

Bloch cavity solitons

Oleg Egorov
Friedrich-Schiller-Universität Jena
Institute of Condensed Matter Theory and Solid State Optics
Jena, Germany

We predict a novel type of dissipative solitons, Bloch cavity solitons, existing in nonlinear resonators with the refractive index modulated in both longitudinal and transverse directions and for both focusing and defocusing nonlinearities.

Nonlinear dynamics of femtosecond supercontinuum generation with feedback

Carsten Fallnich
Westfälische Wilhelms-Universität Münster
Physics Department
Institute of Applied Physics
Optical Technologies Group
Münster, Germany

Meanwhile the use of mode-locked ultra-short light pulses and microstructured fibers is a common procedure to generate broadband supercontinua for precision frequency metrology, ultrafast spectroscopy or coherence tomography. Octave-spanning supercontinua can be generated reliably as high intensities are easily achieved inside the small fiber core diameter and as soliton formation is accomplished by dispersion management related to the specific Bragg cladding structure. But the generation of all these new optical frequency components is depending on a mixture of nonlinear effects, like self-phase modulation, self-steepening, four-wave mixing, and Raman scattering.
Therefore, the stability in amplitude and phase of the supercontinuum – meaning the coherence from pulse to pulse – can be substantially reduced. In order to counteract, the driving pump pulses of the supercontinuum generation have to be controlled in amplitude and phase below certain limits depending on the needed measurement accuracy. In contrast to further improving only the stability of the laser system, we investigated the nonlinear dynamics of femtosecond supercontinuum generation with feedback and, hence, a synchronously pumped white-light oscillator is set up. We observed that such a supercontinuum oscillator is able to show different nonlinear dynamics like period multiplication, limit cycles as well as chaotic behaviour. By exploring these regimes in more detail we are gathering for optimum parameters that probably a self-stabilization of the supercontinuum generator can be observed, meaning a self-synchronization of several ten thousands of longitudinal modes within the broad supercontinuum spectrum.
The talk will present numerical simulation results based on the generalized nonlinear Schrödinger equation and first experimental verifications of the above mentioned nonlinear dynamics in synchronously-pumped supercontinuum generation using a polarization-maintaining microstructured fiber driven with mode-locked femtosecond pulses from a Titanium-Sapphire laser.

Nonlinear microstructured polymer optical fibres

Michael H. Frosz
Technical University of Denmark
DTU Fotonik
Department of Photonics Engineering
Kongens Lyngby, Denmark

The huge interest in silica photonic crystal fibres (PCFs) has largely been due to the possibility of manipulating the dispersion profile by modifying the microstructure. This has allowed researchers to shift the zero-dispersion wavelength of silica fibres to below 800 nm by reducing the core size. The combination of a small core size and zero-dispersion wavelength at the operating wavelength of widely available femtosecond Ti:sapphire lasers led to an extensive research in supercontinuum generation and other nonlinear effects in PCFs. It is crucial for the efficiency of many nonlinear mechanisms that the pump laser wavelength is close to the zero-dispersion wavelength and that the core size is small.
Recently, work in fabricating PCFs from materials other than silica has intensified. One of the advantages of using alternative materials can be a higher inherent material nonlinearity, which is potentially the case for microstructured polymer optical fibres (mPOFs). Another advantage is that polymer materials have a higher biocompatibility than silica, meaning that it is easier to bond certain types of biosensor materials to a polymer surface than to silica. As with silica PCFs, it is difficult to accurately obtain a small core size while maintaining small structural variations during fibre drawing. This talk will give a presentation of how the mPOFs are fabricated and the route to obtaining nonlinear effects in them.

Optical rogue wave instabilities: Further insight and route to control

Goëry Genty
Tampere University of Technology
Institute of Physics
Optics Laboratory
Tampere, Finland

We present further discussion of optical rogue wave generation in nonlinear fiber propagation in terms of soliton turbulence, and present a more general discussion of possible links to their oceanic counterparts. We show that higher-order dispersion is sufficient to localize rogue soliton structures, and Raman scattering effects are not required. Furthermore, we examine in detail the degree to which stability of optical rogue waves can be harnessed through a suitable input pulse modulation.

Supercontinuum generation at the single optical cycle limit: New routes to lightwave electronics

Eleftherios Goulielmakis
Max Planck Institute for Quantum Optics
Garching, Germany

Nonlinear transformations of few-cycle and quasimonocycle pulses in gaseous media have been experimentally explored. They have been found to offer great potential for realizing next generation light sources which are controlled and crafted with sub-optical cycle resolution.

High-power soliton-induced supercontinuum generation in metal-dielectric hollow waveguides

Joachim Herrmann
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Berlin, Germany

Many applications require light sources, which share with a laser its unidirectional and coherent properties but have a broad spectral range like a lamp. A coherent white-light source was achieved by the application of photonic crystal fibers (PCF). Supercontinuum generation in PCFs is based on a spectral broadening mechanism which is connected with the soliton dynamics in the anomalous dispersion region of the PCFs. Unfortunately, the small radii in PCFs and material damage limit severely the maximum spectral peak power densities to tens of W/nm. In the talk we theoretically study a novel approach for high-power supercontinuum generation by using metal-dielectric hollow waveguides, which allow anomalous dispersion in the visible. As will be shown, such waveguides have small loss at diameters in the range of 20 to 80 μm and anomalous dispersion at optical frequencies as required for the soliton-induced mechanism of supercontiunuum generation. We show that in such wave guides two-octave broad super continua can be generated with five orders of magnitude higher spectral peak power density than in standard PCFs.

High-coherence supercontinuum and single-cycle soliton compression in metal-dielectric hollow waveguides

Anton Husakou
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Berlin, Germany

We consider supercontinuum generation in dielectric-coated metallic hollow waveguides filled with a noble gas, and study two aspects of this process: solitonic pulse compression in the single-cycle region, and coherence preservation due to plasma contribution. We predict the compression of a 20-fs pulse to a duration of 1.7 fs with an energy of 6 microjoule by soliton-effect compression, without external chirp compensation. We study the physical factors determining the limitations on shortest pulses in the single-cycle regime. It is shown that a small but nonzero value of the third-order group velocity dispersion is the key factor to achieve the compression below one optical cycle. We also show that the carrier-offset phase is preserved during the compression in spite of the short output pulse duration. The suppression of coherence degradation in high-power soliton-induced supercontinuum generation is shown to be caused by the influence of plasma contributions. It is related to the formation of coherent seed components by the abruptly rising plasma density at the peak of the pulse. In contrast, in the low-intensity regime the strong coherence degradation is caused by the generation of seed components from noise by four-wave-mixing. The coherence properties of white light are studied for different input pulse durations and GVD regimes.

Wide range 40-GHz passive mode-locking operation of an AlGaInAs 1.55-μm strained quantum well laser

Julien Javaloyes
University of Glasgow
Faculty of Engineering
Department of Electronics and Electrical Engineering
Glasgow, United Kingdom

We develop a comprehensive theoretical description of passive mode-locked semiconductor lasers based on a coarse grained time-domain approach. Under the approximation of intraband quasi equilibrium, our model accounts for the dispersion of gain, absorption and refractive index, nonlinear gain saturation from ultrafast processes, self-phase modulation, and spontaneous emission noise. We compare the predictions of our model with the performances of a quasi-40-GHz passively mode-locked AlGaInAs 1.55-μm strained quantum well laser.

Towards the far end of that fibre: Pulse propagation models with minimal assumptions

Paul Kinsler
Imperial College London
Department of Physics
Photonics Group
London, United Kingdom

Simple pulse propagation models don't need numerous approximations. We just use one of the most obvious features of optical pulses in waveguides – the direction they're heading. This directional nature allows us to rewrite our initial model – either Maxwell's equations or a second order wave equation – in terms of its oppositely propagating components. Then, for weak coupling, we can reduce the model to a first order one describing only the forward field. Co-moving frames, smooth envelopes, and negligible second order derivatives are not needed. I discuss both factorization and directional field approaches, and compare their advantages and disadvantages. E.g., directional fields allow easy description of guides with both electric and magnetic responses.

Dissipative Bloch waves

Vladimir Konotop
University of Lisbon
Centro de Física Teórica e Computacional, and
Faculty of Sciences, Department of Physics
Lisbon, Portugal

It is shown that nonlinear optical cavities under periodic modulations can exhibit dissipative Bloch waves. This can be achieved by a proper choice of the injected external field that must compensate for losses and match with the modulation period. Dissipative Bloch waves, unlike their conservative counterparts, emerge in non-equilibrium systems and hence correspond to attracting solutions. This makes it possible to experimentally visualize the band structure of the cavity medium. As an illustration of this phenomenon we perform analytical investigations on a degenerate optical parametric oscillator with a modulated transverse refractive index.

In collaboration with: V.A. Brazhnyi and M. Taki

Supercontinuum generation through filamentation in argon

Kyriaki Kosma
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Berlin, Germany

Focusing few-cycle pulses of 10 fs duration and 0.25-0.35 mJ energy into Ar at atmospheric pressure gives rise to filamentation (self-focusing) and a very broad supercontinuum spectrum extending in the UV to 250 nm. The outcoming radiation shows no conical emission and the short-wavelength part is temporally as short as the fundamental incoming 800-nm pulses. The features of the spectrum depend on the incoming pulse energy, duration and chirp, filament length, gas pressure, while the third harmonic is found not to contribute to the generation of such broad supercontinuum.

Supercontinuum from a feedback configuration

Fedor Mitschke
Universität Rostock
Institut für Physik
AG Experimentalphysik: Optik
Rostock, Germany

Optical supercontinuum, broadband light with good spatial coherence, finds many uses. Currently it is typically produced by passing short light pulses through a piece of photonic crystal "holey" fiber, thereby widening the spectrum by nonlinear interactions. Here we report on a scheme which uses a fiber resonator for optical feedback to enhance the effect. This approach provides additional degrees of freedom for optimization, and it reduces power requirements.

Dispersive pulse dynamics in the few-cycle pulse limit

Kurt Oughstun
University of Vermont
College of Engineering & Mathematical Sciences
School of Engineering
Burlington (Vermont), USA

The asymptotic and group velocity descriptions of dispersive pulse dynamics are compared in a causally dispersive attenuative medium for both ultrashort and few-cycle optical pulses. Both the singular and weak dispersion limits are considered.

Different schemes to generate high energy filaments in the near infrared

Luis Roso (Julio San Roman)
Universidad de Salamanca
Facultad de Ciencias
Grupo de Laseres Pulsados Ultraintensos
Salamanca, Spain

The single filament formation is a well-established post-compression technique. One of the major limitations that is present in this technique is the throughput energy that can be achieved. We are trying to find schemes to enhance the energy coupled into the filament in a typical post-compression set-up, in order to obtain ultra-intense short pulses. We have tried two different strategies: to change the polarisation state of the input pulse and to change the input chirp. Both of them work fine in the sense that with both we have been able to increase the throughput energy of the filament above the millijoule, which seems to be the natural barrier of a traditional filament based post-compression scheme.

Supercontinuum generation in ultralong semiconductor optical amplifiers

Patrick Runge
Technische Universität Berlin
Institut für Hochfrequenz- und Halbleiter-Systemtechnologien
Fachgebiet Hochfrequenztechnik - Photonics
Berlin, Germany

The tremendous Four-Wave Mixing efficiency of ultralong SOAs is used to create a supercontinuum from two CW input signals. As a result, widely tunable short pulses are generated. Due to the tunability and the ability for integration, multiple applications for optical communication or THz imaging are conceivable.

Generation of high-order harmonics with ultra-short pulses from filamentation

Emilia Schulz
Leibniz Universität Hannover
Institute of Quantum Optics
Hannover, Germany

For generation of isolated attosecond laser pulses few cycle infrared pulses are necessary. After filamentation in argon and compression with double chirped mirrors 7-fs-pulses with pulse energy of 0.3 mJ are obtained. We present our first experimental results applying these pulses to high harmonic generation in a semi-infinite gas cell in different noble gases. Spectral broadening of high-order harmonics in xenon and argon is observed. In neon, an extended continuous cut-off region down to 10 nm (124 eV) is obtained.

Filamentation: A versatile source for advanced spectroscopic applications

Torsten Siebert
Freie Universität Berlin
Institut für Experimentalphysik
Berlin, Germany

A better understanding of the critical parameters that determine and control the filamentation of standard femtosecond amplified laser pulses has allowed for this unique non-linear process to develop towards an easily accessible source for demanding spectroscopic applications. Essential for further advancements towards these means are the enhancement of the process itself and the ease of realization as well as a full analysis and control of the exceptional output. In this context, the compression of single filamentation in air to sub 7 femtosecond pulses is presented and alternatively, the control of the spectral phase over the full octave-spanning output via liquid crystal modulators for compression or the synthesis of a desired pulse form is demonstrated.
The spectroscopy application is exemplified by an optimization of full spectral phase in a genetic algorithm controlled feedback loop of a nonlinear electron photo-detachment and ionization processes in charged molecular species at space-charge limited densities in the gas phase. Accompanying the control and application of the filament source is the analysis of synthesized pulse forms via a transient grating based four-wave mixing FROG. This "Poor Man's" correlator avoids costly and complicated nonlinear and dispersive processes and shows the capability to indiscriminately characterize octave spanning pulses with pulse structures ranging from the lower femto- to picosecond domain in intuitive traces. The simple, highly versatile method of pulse analysis further enhances the application of filamentation to molecular spectroscopy.

Authors: Torsten Siebert, Bruno E. Schmidt, Oliver Gause, Aldo Mirabal, Waldimar Unrau, and Ludger Wöste

Polariton solitons in semiconductor microcavities

Dmitry Skryabin
University of Bath
Department of Physics
Bath, United Kingdom

I will discuss bright and dark solitons and vortices of exciton-polaritons in semiconductor microcavities operating in strong coupling regime. Cavities with and without periodic and other forms of potentials will be considered. The reported structures are promising candidates for applications in all-optical signal processing because their excitation time and required pump powers are few orders of magnitude less than those of their weakly coupled counterparts.

Coauthors: O. Egorov, A. Gorbach, A. Yulin, R. Hartley, and F. Lederer

Self-healing mechanism of compressed femtosecond filaments

Stefan Skupin
Max Planck Institute
for the Physics of Complex Systems
Dresden, Germany

In self-generated filaments, femtosecond pulses experience strong spatial and temporal shaping effects. The dynamical balance between Kerr self-focusing and plasma-induced defocusing gives rise to a self-guiding mechanism, which involves a complex time dependent radial energy flow (dynamical spatial replenishment). This energy flow strongly links spatial and temporal dynamics.
One of the most surprising properties of femtosecond filaments is on-axis self-compression, i.e., pulse shortening in the center of the beam during filamentary propagation. For examining the self-compression regime, experimental set-ups use windowed cells, allowing for careful optimization of the pressure that gives rise to maximum self-compression. Here we will investigate numerically the influence of these exit windows on pulse propagation, which distort the spatio-temporal shape of the exiting pulse considerably and seem to destroy self-compression. However, upon subsequent propagation in, e.g., the atmosphere, a self-healing mechanism takes place. We find that again, as the self-compression mechanism itself, this self-healing process is a result of a time-dependent radial energy flow.

Bandgap solitons and subdiffractive solitons

Kestutis Staliunas
Universitat Politecnica de Catalunya (UPC)
Departament de Fisica i Enginyeria Nuclear
Barcelona, Spain

I will review the theory of the soliton formation in Kerr-nonlinear spatially modulated materials: the formation of band-gap solitons for transverse modulation of the refraction index, and the formation of subdiffractive solitons for the transverse and the longitudinal modulation of index.

New aspects of multiple filamentation and supercontinuum generation in experiments on manyfold supercritical beams (P>10 000 Pcr)

Kamil Stelmaszczyk
Freie Universität Berlin
Institute of Experimental Physics
Berlin, Germany

A filamentary break-up of highly supercritical laser beams is generally known to result form random fluctuations of the laser noise and/or the propagation medium. It is accompanied by efficient supercontinuum generation, emitted preferably in a forward direction. Our recent experiments on multi-filamenting beams show that the stated above features must not be necessarily fulfilled. In the first one the two phase-locked beams were crossed inside a glass block at incident angles of a few degrees. Surprisingly, the emitted white light was not collinear with either of the beams, but propagated parallel to their common symmetry axis. In the second experiment the propagation of 150 TW laser beam in air was studied. Registered intensity profiles revealed a possible new regime of multiple filamentation, where the individual filaments interact with each other and self-organize in one-dimensional structures.

Polychromatic light control in nonlinear photonic lattices

Andrey A. Sukhorukov
The Australian National University
Research School of Physics and Engineering
Nonlinear Physics Centre
Canberra, Australia

This presentation overviews our recent theoretical and experimental results on shaping and switching of light beams in modulated one- and two-dimensional photonic lattices created by arrays of periodically curved coupled optical waveguides. We present a general approach for realizing broadband diffraction management of polychromatic light beams with a spectral width of hundreds of nanometres by introducing appropriate longitudinal modulation of a photonic lattice, and predict a novel type of defect-free surface waves at the structure boundaries. In two-dimensional curved arrays, we reveal the possibility of wavelength-dependent engineering of lattice symmetry. We also predict that all-optical switching of visible light is possible in curved nonlinear waveguide couplers made of a material with intensity-dependent refractive index. These results suggest novel opportunities for flexible manipulation and control of polychromatic light in nonlinear photonic lattices.

Optical rogue wave formation

Majid Taki
University of Lille and
Centre National de la Recherche Scientifique (CNRS)
Laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM)
Unité Mixte de Recherche UMR 8523
Lille, France

Freak waves, or rogue waves, are one of the fascinating manifestations of the strength of nature. These devastating "walls of water" appear from nowhere, are short-lived and extremely rare. Despite the large amount of research activities on this subject, neither the minimum ingredients required for their generation nor the mechanisms explaining their formation have been given. Today, it is possible to reproduce such kind of waves in optical fibre systems. In this context, we demonstrate theoretically and numerically that convective instability is the basic ingredient for the formation of rogue waves. This explains why rogue waves are extremely sensitive to noisy environments.

Analytical study of intense light propagation in highly nonlinear media

Larisa Tatarinova
Kassel University
Fachbereich Naturwissenschaften
Institut für Physik
Theoretische Physik
Kassel, Germany

We demonstrate that the problem of intense light propagation in highly nonlinear media in numerous cases can be studied analytically under the semi-classical approximation with a high accuracy. On the basis of the renormalization group symmetry analysis, for the first time, we constructed an exact analytical solution to the eikonal equation with a saturating refractive index. Several examples of refractive indices and beam profiles are studied approximately. General analytical expressions for the filament intensity are presented. Obtained solutions can serve as a benchmark solution for numerical simulations.

Localized structures in photonic crystal fiber resonators

Mustapha Tlidi
Université Libre de Bruxelles
Faculté des Sciences – Physique
Optique Nonlinéare Théorique (ONT)
Brussels, Belgium

We analyze the beating between intrinsic frequencies that are simultaneously generated by a modulation (Turing) instability in a nonlinear extended system. The model studied is that of a coherently driven photonic crystal fiber cavity. Beating in the form of a slow modulation of fast intensity oscillations is found to be stable for a wide range of parameters. We find that such beating can also be localized and contain only a finite number of slow modulations. These structures consist of dips in the amplitude of the fast intensity oscillations, which can either be isolated or regularly spaced.

Optical turbulence in ultra-long fibre lasers

Sergei K. Turitsyn
Aston University
Photonics Research Group
Birmingham, United Kingdom

An emerging area of optical wave turbulence in fibre lasers will be overviewed. I present results of our recent studies of optical wave turbulence using as a particular example recently demonstrated ultra-long fibre laser. Impact of the laser cavity dispersion on spectral and temporal properties of generated radiation and newly observed state-spectral condensate will be discussed.

Shalva Amiranashvili
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
shalva@wias-berlin.de

Ihar Babushkin
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
babushkin@wias-berlin.de

Uwe Bandelow
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
bandelow@wias-berlin.de

Stephane Barland
Université de Nice Sophia-Antipolis
Institut Non Linéaire de Nice (INLN)
1361 route des Lucioles
06560 Valbonne
France
stephane.barland@inln.cnrs.fr

Luc Bergé
Commissariat à l'Energie
Atomique (CEA/DAM/DIF)
Bruyères-le-Châtel
91297 Arpajon
France
luc.berge@cea.fr

Jens Bethge
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Max-Born-Str. 2A
12489 Berlin
Germany
bethge@mbi-berlin.de

Nicoletta Brauckmann
Westfälische Wilhelms-Universität Münster
Physics Department
Institute of Applied Physics
Corrensstr. 2/4
48149 Münster
Germany
brauckmann@uni-muenster.de

Carsten Brée
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
bree@wias-berlin.de

Ayhan Demircan
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
demircan@wias-berlin.de

John Dudley
Université de Franche-Comté
Institut FEMTO-ST (Franche-Comté
Electronique Mecanique Thermique et
Optique - Sciences et Technologies)
16 Route de Gray
25000 Besançon
France
john.dudley@univ-fcomte.fr

Oleg Egorov
Friedrich-Schiller-Universität Jena
Institute of Condensed Matter Theory
and Solid State Optics
Max-Wien-Platz 1
07743 Jena
Germany
Oleg.Egorov@uni-jena.de

Michael H. Frosz
Technical University of Denmark
DTU Fotonik
Department of Photonics Engineering
Oersteds Plads 343
DK-2800 Kongens Lyngby
Denmark
mhfr@fotonik.dtu.dk

Eleftherios Goulielmakis
Max Planck Institute for Quantum Optics
Hans-Kopferman-Str. 1
85748 Garching
Germany
elgo@mpq.mpg.de

Anton Husakou
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Max-Born-Str. 2A
12489 Berlin
Germany
gusakov@mbi-berlin.de

Paul Kinsler
Imperial College London
Department of Physics
Photonics Group
Blackett Laboratory
SW7 2AZ London
United Kingdom
p.kinsler@imperial.ac.uk

Carsten Fallnich
Westfälische Wilhelms-Universität Münster
Physics Department
Institute of Applied Physics
Optical Technologies Group
Corrensstr. 2/4
48149 Münster
Germany
fallnich@uni-muenster.de

Goëry Genty
Tampere University of Technology
Institute of Physics
Optics Laboratory
Korkeakoulunkatu 3
33720 Tampere
Finland
goery.genty@tut.fi

Joachim Herrmann
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Max-Born-Str. 2A
12489 Berlin
Germany
jherrman@mbi-berlin.de

Julien Javaloyes
University of Glasgow
Faculty of Engineering
Department of Electronics and
Electrical Engineering
Rankine Building, Oakfield Avenue
G12 8LT Glasgow
United Kingdom
julien.javaloyes@elec.gla.ac.uk

Vladimir Konotop
University of Lisbon
Centro de Física Teórica e Computacional, and
Faculty of Sciences, Department of Physics
Complexo Interdisciplinar
Av. Prof. Gama Pinto 2
1649-003 Lisbon
Portugal
konotop@cii.fc.ul.pt

Kyriaki Kosma
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Max-Born-Str. 2A
12489 Berlin
Germany
kosma@mbi-berlin.de

Michael Kues
Westfälische Wilhelms-Universität Münster
Physics Department
Institute of Applied Physics
Corrensstr. 2/4
48149 Münster
Germany
m.kues@uni-muenster.de

Pierre-Ambroise Lacourt
Université de Franche-Comté
Institut FEMTO-ST (Franche-Comté
Electronique Mecanique Thermique et
Optique - Sciences et Technologies)
16 Route de Gray
25030 Besançon
France
pierre-ambroise.lacourt@univ-fcomte.fr

Fedor Mitschke
Universität Rostock
Institut für Physik
AG Experimentalphysik: Optik
Universitätsplatz 3
18051 Rostock
Germany
fedor.mitschke.@uni-rostock.de

Kurt Oughstun
University of Vermont
College of Engineering & Mathematical
Sciences (CEM)
33 Colchester Avenue
109 Votey Building
VT 05405-0156 Burlington (Vermont)
USA
oughstun@cems.uvm.edu

Luis Roso
Universidad de Salamanca
Facultad de Ciencias
Grupo de Laseres Pulsados Ultraintensos
Patio de Escuelas 1
37008 Salamanca
Spain
roso@usal.es

Patrick Runge
Technische Universität Berlin
Institut für Hochfrequenz- und
Halbleiter-Systemtechnologien
Fachgebiet Hochfrequenztechnik - Photonics
Einsteinufer 25
10587 Berlin
Germany
runge@hft.ee.tu-berlin.de

Julio San Roman
Universidad de Salamanca
Department of Applied Physics
Optics Group
Plaza de la Merced s/n
37008 Salamanca
Spain
jsr@usal.es

Emilia Schulz
Leibniz Universität Hannover
Institute of Quantum Optics
Welfengarten 1
30167 Hannover
Germany
schulz@iqo.uni-hannover.de

Torsten Siebert
Freie Universität Berlin
Institut für Experimentalphysik
Arnimallee 14
14195 Berlin
Germany
torsten.siebert@fu-berlin.de

Dmitry Skryabin
University of Bath
Department of Physics
The University of Bath Campus - 3 West
BA2 7AY Bath
United Kingdom
d.v.skryabin@bath.ac.uk

Stefan Skupin
Max Planck Institute for the Physics
of Complex Systems
Noethnitzer Str. 38
01187 Dresden
Germany
skupin@pks.mpg.de

Kestutis Staliunas
Universitat Politecnica de Catalunya (UPC)
Departament de Fisica i Enginyeria Nuclear
Colom 11
E-08222 Terrassa/Barcelona
Spain
kestutis.staliunas@icrea.es

Daniel Steingrube
Leibniz Universität Hannover
Institute of Quantum Optics
Welfengarten 1
30167 Hannover
Germany
steingrube@iqo.uni-hannover.de

Günter Steinmeyer
Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy (MBI)
Max-Born-Str. 2A
12489 Berlin
Germany
steinmey@mbi-berlin.de

Kamil Stelmaszczyk
Freie Universität Berlin
Institute of Experimental Physics
Arnimallee 14
14195 Berlin
Germany
kamil.stelmaszczyk@physik.fu-berlin.de

Andrey A. Sukhorukov
The Australian National University
Research School of Physics and Engineering
Nonlinear Physics Centre
Le Couteur Building
ACT 0200 Canberra
Australia
ans124@physics.anu.edu.au

Majid Taki
University of Lille and
Centre National de la Recherche
Scientifique (CNRS)
Laboratoire de Physique des Lasers,
Atomes et Molécules (PhLAM)
Unité Mixte de Recherche 8523
Bât. P5 USTL
59655 Villeneuve d'Ascq
France
taki@phlam.univ-lille1.fr

Larisa Tatarinova
Kassel University
Fachbereich Naturwissenschaften
Institut für Physik
Theoretische Physik
Heinrich-Plett-Str. 40
34132 Kassel
Germany
tatarino@physik.uni-kassel.de

Mustapha Tlidi
Université Libre de Bruxelles
Faculté des Sciences – Physique
Optique Nonlinéare Théorique (ONT)
Campus Plaine, CP 231
1050 Brussels
Belgium
mtlidi@ulb.ac.be

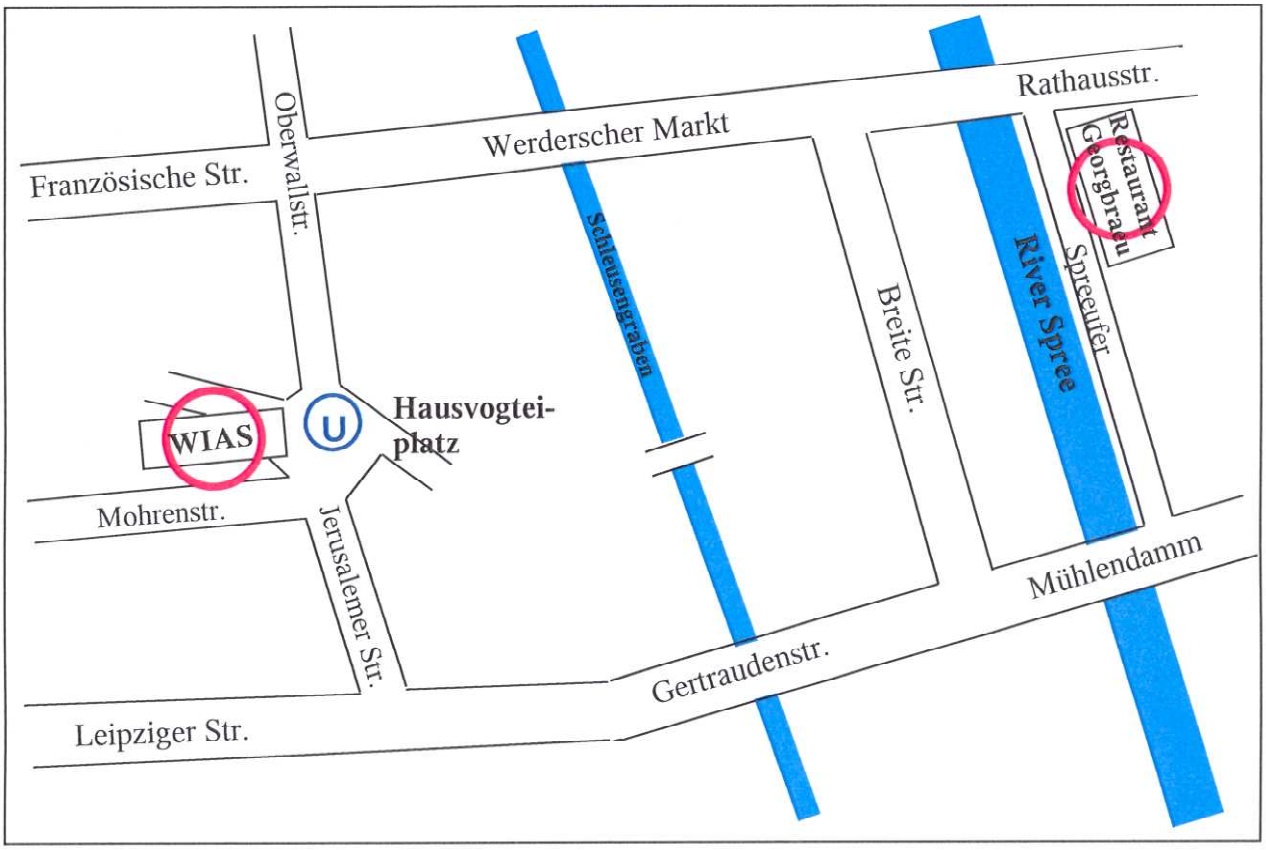
Sergei K. Turitsyn
Aston University
Photonics Research Group
Aston Triangle
B4 7ET Birmingham
United Kingdom
s.k.turitsyn@aston.ac.uk

Andrei G. Vladimirov
Weierstrass Institute for Applied
Analysis and Stochastics (WIAS)
Research Group "Laser Dynamics"
Mohrenstr. 39
10117 Berlin
Germany
vladimir@wias-berlin.de

Till Walbaum
Westfälische Wilhelms-Universität Münster
Physics Department
Institute of Applied Physics
Corrensstr. 2/4
48149 Münster
Germany
twalbaum@uni-muenster.de

Workshop Dinner

- A Workshop Dinner will be held in the restaurant **Brauhaus Georgbraeu** at **7:00 p.m.** on **Monday, May 18, 2009**.
- Brauhaus Georgbraeu is located on the waterfront of the River Spree in the Nikolai Quarter, the old core of Berlin.
- The full address is:
  Brauhaus Georgbraeu, 4 Spreeufer, 10178 Berlin-Mitte, Tel: 24 24 244.
- For further information about the restaurant please see also **Brauhaus Georgbraeu's** homepage at:
  http://www.georgbraeu.de/default.aspx?alias=www.georgbraeu.de&lang=en-GB.



Please note that not all streets are included on this map. Walking distance from WIAS to the restaurant Braushaus Georgbraeu is approximately 15 minutes.

Computer Facilities

All workshop participants have the possibility to check emails in room no. 010 on the first floor (on the right side after passing the reception area). Any workstation in this room may be used.

For login, please enter the following:

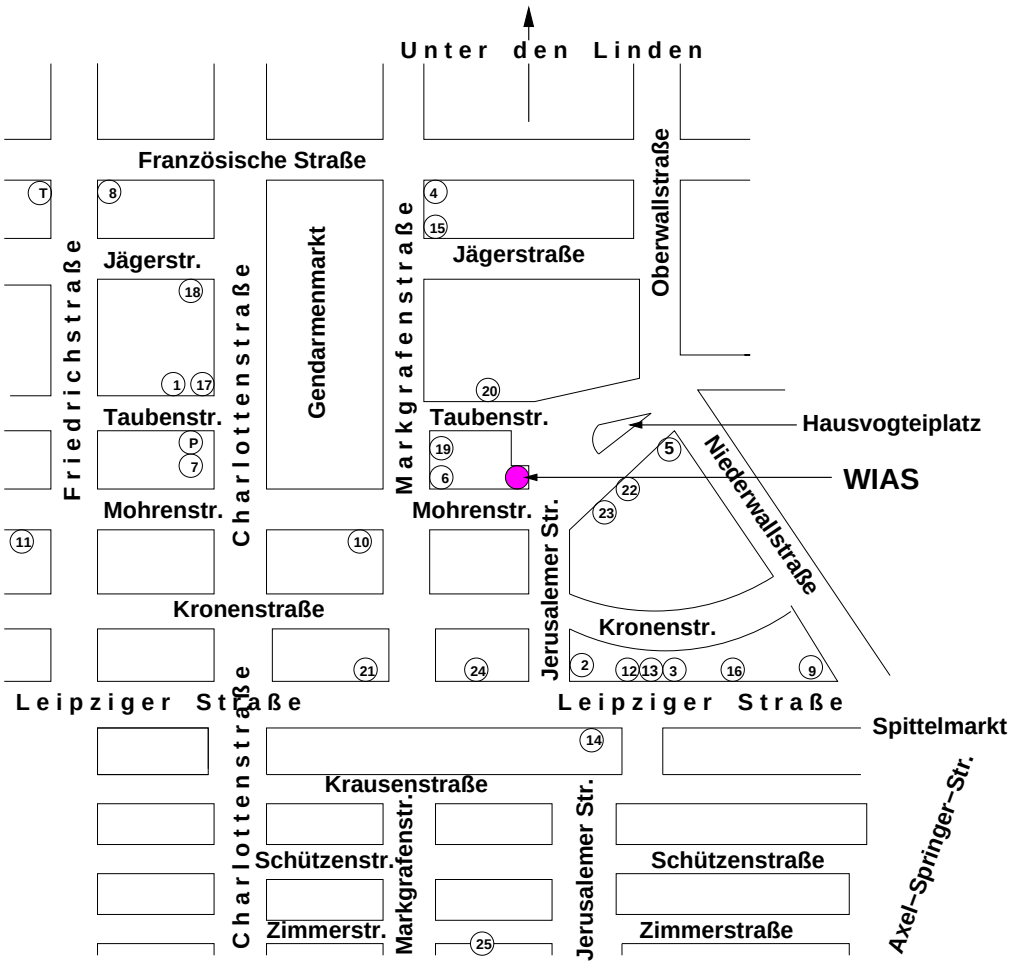
User name:	**nonlin09**	OK
Password:	***Nonlin09**	OK

For logout you can either use the Log out –selection on the root window or the EXIT –button of the desktop.

Please be aware that this account is used by all workshop participants. Therefore, don't leave any confidential data in its home directory. All remaining files will be erased after the workshop.

Places to have Lunch/Dinner

On the following pages you will find a selection of places to eat and drink in the vicinity of WIAS. An indication of the type of cuisine and of the approximate price ranges is given for each restaurant/bar/café.



1	Mensa Konzerthaus	14	China-City Restaurant
2	Efendi Modern Bistro	15	Französischer Hof
3	Croissanterie “Bistro & Baguette”	16	“Diverso” Ristorante Italiano
4	“Bistro am Gendarmenmarkt”	17	Lutter und Wegner
5	“the coffee shop”	18	Café Möhring
6	KAFFEE EINSTEIN	19	Shan Rahimkan Café
7	“Foodcourt” in Friedrichstadtpassage	20	Brasserie
8	“Galéries Lafayette”	21	Löwenbräu
9	Viethaus	22	Good Time
10	“Hilton”	23	Açaí café
11	Leopold’s Kontorhaus	24	Ur-Saalfelder
12	Fontana di Trevi Ristorante	25	Springer Building
13	Irish Times		

P	Post Office	T	Travel Agency “Reiseland American Express”

① Many WIAS collaborators have their lunch in the restaurant for the staff of Konzerthaus am Gendarmenmarkt, entrance via Taubenstrasse, 2nd floor, or in the "Cafeteria" on the 1st floor. A set lunch is typically offered for about *5 €*.

㉕ Another good place for lunch is the Springer Building, Zimmerstrasse, with snack and coffee bars, as well as a restaurant where you can have lunch meals. *5 € upwards*

Please find below a further selection of restaurants, bars, cafés, and snack stalls:

② "Efendi modern Bistro" (Mon.-Sat. 7 a.m.–2 a.m.)
Leipziger Strasse 58
Turkish snacks ("Döner" kebap, shish kebab, salads, etc.) *2–8 €*

③ Croissanterie "Bistro & Baguette" (Mon.–Sun. 7 a.m.–6 p.m.)
Leipziger Strasse 56
Breakfast, coffee, snacks, icecream *from 1 € upwards*

④ "Bistro am Gendarmenmarkt"
(Mon.–Fri. from 11 p.m., Sat./Sun. from 1 a.m.)
Markgrafenstrasse/corner of Französische Strasse
Soups, small snacks *5–9 €*

⑤ "the coffee shop" (Mon.–Fri. 8 a.m.–6 p.m.)
Hausvogteiplatz 13
Bagels, muffins, brownies, croissants, sandwiches *2–4 €*

⑥ "KAFFEE EINSTEIN" (Mon.–Sat. 7:30 a.m.–8 p.m., Sun. 10 a.m.–6 p.m.)
Mohrenstrasse/corner of Markgrafenstrasse
Baguettes, muffins, sandwiches *from 2 € upwards*

⑦ When entering the Friedrichstadt Passage from Mohrenstrasse and going down the escalator to the basement you find the "Foodcourt" with "Nk Insel", "Bistro 'B' ", "Asia-Fast-Food", "MR. BAR-B-Q" and "Orient Grill" where you can have a tasty snack. *6–10 €*

⑧ In the department store "Galéries Lafayette" in Friedrichstrasse, on the basement, you are offered French delicacies (oysters, pies, cheese ...). *from 3 € (snacks) upwards*

⑨ "Viethaus"
"Sen Restaurant" (Mon.–Fri. 12–5p.m. and 6–12p.m.)
"Saigon Café and Bar" (Mon.–Fri. 10.30 a.m.–9:30 p.m.)

⑩ "Hilton", Mohrenstrasse 30
There are several restaurants in the Hilton hotel. The self service restaurant on Markgrafenstrasse (Mon.–Fri. 11:30 a.m.–3 p.m.) is suitable for a short lunch break.
Salad bar, pasta, soups, warm meat and vegetable dishes, ice cream, etc. *3,50–10 €*

⑪ "Leopold's Kontorhaus" (10 a.m.–12 p.m.)
Friedrichstr. 185 - 190 (between Mohrenstrasse and Kronenstrasse) *5–15 €*

⑫ "Fontana di Trevi Ristorante" (12 a.m.–12 p.m.)
Leipziger Strasse 56
Italian food *5–15 €*

⑬ "Irish Times" (Sun.–Thur. 10 a.m.–1 a.m., Fri./Sat. 10 a.m.–2 a.m.)
Leipziger Strasse 56
Irish restaurant *4–10 €*

⑭ "China-City Restaurant" (11:30 a.m.–12 p.m.)
Leipziger Strasse 46
Chinese restaurant *6–15 €*

⑮ "Französischer Hof" (from 11 a.m.)
Jägerstrasse 56
Quick Lunch (8 €), French cuisine *from 14 € upwards*

⑯ Restaurante "Diverso" (8 a.m.–10 p.m.)
Hausvogteiplatz 10
Italian Restaurant *from 5 € upwards*

⑰ "Lutter & Wegner am Gendarmenmarkt"
Charlottenstrasse 56
Gourmet restaurant. There is a brand of champagne bearing this name. *from 18 € upwards*

⑱ "Café Restaurant Möhring" (8 a.m.–12 p.m.)
Charlottenstrasse 55
Café and restaurant *6–10 €*

⑲ "Shan Rahimkan Café" (12 a.m.–12 p.m.)
Markgrafenstrasse 36
Asiatic, Indian, and Persian food *from 10 € upwards*

⑳ "Brasserie" (11:30 a.m.–1 a.m., from 6 p.m. terrace in the courtyard)
Taubenstrasse 30 *from 8 € upwards*

㉑ "Löwenbräu" (11 a.m.–12 p.m.)
Leipziger Strasse 65
Bavarian dishes *from 6 € upwards*

㉒ "Açaí café"
Hausvogteiplatz 10
Snacks, coffee, juice

㉓ "Good Time"
Hausvogteiplatz 11A
Thai dishes *from 7 € upwards*

㉔ "Ur-Saalfelder"
Leipziger Str. 61 *from 4,50 € upwards*

㉕ Springer Building (Lunch meals, Snack bars, Coffee bars)
Zimmerstraße *from 5,00 € upwards*

Ⓣ **Travel Agency**
The travel agency "Reiseland American Express" at 172 Friedrichstrasse is open 9:30 a.m.–6 p.m. Monday to Friday and 10 a.m.–2 p.m. on Saturdays.

Your Notes

Edited by:

Weierstrass Institute for
Applied Analysis and Stochastics (WIAS)
Mohrenstrasse 39, 10117 Berlin, Germany
Phone: +49 30 203720 Fax: +49 30 2044975
Internet: http://www.wias-berlin.de
Email: contact@wias-berlin.de