Weierstrass Institute for
Applied Analysis und Stochastics

Optical Pulses in Nonlinear Photonic Devices

June 29 – July 01 2026

Berlin

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Organizers

Shalva Amiranashvili
Uwe Bandelow
Mindaugas Radziunas
(WIAS Berlin)

Contact

Veronica Bove (WIAS Berlin)
opnpd26@wias-berlin.de

For more information please visit the workshop website

wias-berlin.de

Weierstrass Institute
Anton-Wilhelm-Amo-Str. 39
10117 Berlin
Germany

Edited by
Weierstraß-Institut für Angewandte Analysis und Stochastik (WIAS)
Anton-Wilhelm-Amo-Straße 39
10117 Berlin
Germany

World Wide Web: http://www.wias-berlin.de

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1 General Information

Dear Participant,

Welcome to the Weierstrass Institute for Applied Analysis and Stochastics in Berlin! We hope you enjoy your stay both at the institute and in our city.
For your convenience, please find some useful information below:

- **Building Access:** Entry to the building is granted upon showing your participant badge. Please ensure you wear it at all times when entering the premises.
- **Lectures:** All lectures will take place in the Erhard Schmidt Lecture Room, located on the ground floor.
- **Smoking Policy:** Smoking, including electronic cigarettes, is strictly prohibited inside the building. As coffee breaks will be held on the ground floor, please use this opportunity to step outside if you wish to smoke.
- **WiFi Access:** You can connect to WiFi using the personal login card provided at registration. Altenatively, Eduroam is also available throughout the building
- **Informal Dinner:** An informal dinner on a self-payment basis will take place at Maximilians Restaurant, Friedrichstr. 185-190, 10117 Berlin on **Tuesday, June 30 at 6:00 PM.**

If you have any questions or need assistance, please don't hesitate to contact a member of the organizing team.
Yours sincerely,

Organizers.

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3 Abstracts

Numerical stability of split-step algorithms

Amiranashvili, Shalva

WIAS Berlin, Germany

Deep connections between wave theory and numerical analysis will be discussed. Several fundamental phenomena characteristic of nonlinear waves – such as wave mixing, resonances, and modulation instability – play an important role in determining the stability bounds of commonly used numerical schemes, particularly fractional-step methods. In turn, these mathematical results help applied scientists perform fast and accurate calculations and avoid numerical artifacts.

Self-consistent thermal-opto-electronic model for the dynamics in high-power semiconductor lasers

Bandelow, Uwe

WIAS Berlin, Germany

High-power broad-area diode lasers (BALs) generate significant heat, which impacts their performance. We present a 2+1D traveling wave (TW) model that incorporates heating effects through an iterative coupling of electro-optical (EO) and heat-transport (HT) solvers. This method analyzes heat sources, temperature profiles, and thermally induced refractive index changes. Moreover, it describes self-consistently the dynamics of high-power BA lasers, including current spreading and self heating effects. In conclusion we find multimode-dynamics rather than filamentation to be the origin of the spatio-temporal chaos in high-power broad-area diode lasers.

The Quantum Split-Step Fourier Algorithm

Biancalana, Fabio

Heriot-Watt University, United Kingdom

I will introduce a new numerical scheme, which I call the Quantum Split-Step Fourier (QSSF) algorithm, that computes the von Neumann (entanglement) entropy of selected spectral portions of an optical pulse dynamically during propagation. Using Gaussian continuous-variable methods, QSSF couples a standard split-step solution of the NLS mean field to a symplectic Bogoliubov evolution of quantum fluctuations, yielding reduced covariances and entropies step-by-step. I will apply it to soliton-driven resonant radiation (RR) in fibers and show how dispersive-wave formation is accompanied by measurable growth of multimode entanglement between the RR band and the soliton core. I will also describe how to apply this algorithm when in presence of Raman effect.

Phase resetting in the Yamada model of a Q-switched laser.

Broderick, Neil

University of Auckland, New Zealand

Phase resetting is the process whereby an oscillating system returns to the periodic orbit after an external perturbation. In this work we investigate the effect of external perturbations on a Q-switched laser, modelled by the Yamada equations. We present phase transition curves (PTCs) for perturbations in the laser intensity and the gain, and show how the phase of the reset oscillations are affected by the size of the perturbation, and the time at which it is applied. This work can be generalised to other mode-locked lasers and is expected to lead to insights into the frequency noise and stability of optical frequency combs.

Soliton interaction and bound state formation in coupled Kerr resonators

Dolinina, Daria

Ferdinand-Braun-Institut, Germany

We investigate the interaction and self-organization of dissipative solitons in a minimal system of two weakly coupled Kerr microresonators, each driven by an independent coherent pump. While soliton dynamics in single Kerr cavities is well understood, the coupled-cavity regime remains largely unexplored despite its relevance for integrated photonics and frequency comb generation. Using a pair of coupled Lugiato-Lefever equations, we combine asymptotic analysis in the weak-coupling limit with systematic numerical simulations to uncover the mechanisms governing soliton interaction. We demonstrate the existence of multiple types of stable and unstable soliton clusters, including “bunching” states with zero separation, “anti-bunching” states with maximal separation, and bound states with finite equilibrium spacing determined by soliton tail interactions. Our analysis reveals that the relative phase of the driving fields plays a central role in selecting and stabilizing these configurations, effectively controlling whether solitons attract, repel, or form bound states. Furthermore, we show that small asymmetries, such as cavity length mismatch, provide an additional tuning mechanism that modifies soliton separation and can induce transitions between synchronized and drifting regimes. The analytical predictions are in excellent agreement with numerical results. These findings identify new regimes of dissipative soliton organization and offer practical strategies for controlling soliton ensembles in coupled photonic platforms.

From photonic machine learning to data-driven discoveries in nonlinear fiber optics

Ermolaev, Andrei V.

Université Marie et Louis Pasteur, Institut FEMTO, France

Optical computing architectures provide a promising platform for unconventional computation, enabling ultra-fast and high-bandwidth data processing, however, predicting their performance and understanding their limits remains an open question. In this talk, we consider two aspects: the development of predictive dimensionality and separability metrics for photonic neural networks, and their application across multiple platforms and datasets. Specifically, we analyze fiber-based extreme learning machine, coupled nonlinear oscillator deep neural networks, and vertical-cavity surface-emitting laser using both numerical simulations and experimental data on benchmark classification tasks. Our results show that the proposed separability criterion shows strong correlation with classification performance across both simulations and experimental data, providing a consistent measure of system behavior. The separability criterion can be effectively used to guide the evaluation and optimization of photonic neural networks.

Analysis of nonlinear stationary modes in medium-area edge-emitting semiconductor Lasers

Facao, Margarida

Universitat Politècnica de Catalunya, Spain

The complex intracavity dynamics of medium- to broad-area edge-emitting semiconductor lasers (EESLs) have been attributed to the interplay of the supported lateral modes [1,2]. Previous studies have typically relied on linear analyses incorporating built-in modifications to the refractive index profile as well as time-averaged changes in the effective complex refractive index arising from current injection and additional losses.. In this work, we investigate the nonlinear stationary modes of medium-area EESLs. The model consists of two coupled partial differential equations describing the temporal dynamics of the optical field and carrier density along a single lateral spatial dimension. By reducing these equations to a set of ordinary differential equations, we determine the stationary modes and analyze their stability, and compare the results with the full model dynamics. The analysis reveals features associated with spontaneous symmetry breaking, leading to asymmetric modes, and oscillatory behavior that explain the complex beam characteristics of these lasers. The study is further extended to devices with transverse current modulation, providing insight into the selection of favored and suppressed modes and offering guidelines for beam quality control.

[1] P. Crump et al., Semiconductor Science and Technology 27, 045001 (2012).
[2] A. Zeghuzi et al., IEEE Journal of Quantum Electronics 55, 1 (2019).

Collisions of self-bound quantum droplets

Gallemí, Albert

Universitat de les Illes Balears, Spain

The binary collisions of quantum droplets in ultracold atomic mixtures are characterized by a transition between merging and separation, governed by the relative velocity of the colliding pair. The critical velocity v_c required for separation varies with the atom number N, reflecting a fundamental crossover in the system's nature. In the low-N limit, the droplets exhibit soliton-like dynamics where the binding energy dominates. As N increases, the system enters an incompressible regime governed by surface tension, where the droplets behave as liquid-like entities. This non-monotonic dependence of v_c on N highlights the transition from quantum-mechanical particles to a state that closely resembles classical liquid droplets.

Tailored and spontaneous generation of OAM beams in multimode optical fibers via nonlinear propagation

Genty, Goëry

Tampere University, Finland

Orbital angular momentum beams in optical fibers provide a versatile platform for structured light generation, nonlinear beam shaping, and mode-selective light control. In this talk, we will discuss two complementary routes to OAM generation in multimode fiber systems.

Degenerate laser cavities: A tool for exploring spatio-temporal nonlinear dynamics and their applications

Giudici, Massimo

Institut de Physique de Nice - Université Côte d'Azur, France

I will review recent experimental results obtained with degenerate-cavity Vertical External Cavity Surface-Emitting Lasers (VECSELs). I will demonstrate that this platform enables the observation of complex spatio-temporal dynamics, including time-localized, non-homothetic patterns, and allows for the arbitrary structuring of the laser's transverse emission. These results demonstrate that degenerate VECSELs constitute a versatile platform for studying nonlinear dynamical phenomena such as excitability, spatio-temporal chaos, and pattern formation in extended optical systems, thereby opening new perspectives for the implementation of neuromorphic and information-processing schemes based on laser dynamics.

Multipulse dynamics in the Haus master equation for active mode-locking

Gurevich, Svetlana

Universität Münster, Germany

The modelling of passive and active mode-locked lasers can be developed at various levels of complexity, ranging from the direct solution of Maxwell's equations on a sub-wavelength grid to coarse-grained approaches such as partial differential equations, multimode rate equations, and time-delayed systems. The latter approach is comparatively simple while still providing a realistic description. Moreover, time-delayed models offer the advantage of enabling extensive numerical simulations as well as bifurcation analysis. Another salient model that has demonstrated remarkable versatility is the Haus master equation. While it is one of the paradigmatic models for passive and active mode-locking, it has only recently been extended to include appropriate boundary conditions, leading to an improved formulation that incorporates carrier memory from one round-trip to the next. This extension enables not only the determination of steady-state pulse characteristics, but also the investigation of dynamical regimes such as harmonic mode-locking transitions and Q-switching instabilities. However, a comprehensive bifurcation analysis of this improved Haus model is still lacking. In this contribution, we show how such a model can be implemented within path-continuation framework. We apply this approach to active mode-locking and present a detailed bifurcation analysis of the emergence of subharmonic transitions, the so-called discrete time-crystal states recently observed in active mode-locked semiconductor lasers. Furthermore, we discuss how stiff systems (such as erbium-doped cavities, where the carrier lifetime is extremely long) could be studied within the same framework.

Information processing of nonlinear optical fibers

Jaurigue, Lina

Technische Universität Ilmenau, Germany

In recent years nonlinear optical fibers have become popular as a computational resource in the context of photonic computing. The idea being to utilise the nonlinear transformation of optical pulses as they propagate through a fiber to solve computing tasks. Typically, input information is encoded into the spectral phase of the pulse. After propagation through the fiber, the spectrum is recorded and can be used to perform calculations. We investigate information processing metrics to quantify the computational potential of such fibers, as well as other complex input-output systems.

Time crystals and winnerless competition in active mode-locked laser system

Javaloyes, Julien

Universitat de les Illes Balears, Spain

Active mode-locked (AML) lasers generate regular trains of optical pulses by directly modulating the field intensity transmission, for instance using optoelectronic or acousto-optic modulators. The periodic opening of those short transmission windows creates an effective potential that traps the field intensity, with a balance established between gain and chromatic dispersion.

It has recently been shown that long-cavity AML lasers operating in the multi-pulse (harmonic) regime can spontaneously transition to subharmonic states, in which only one out of every P temporal slots imposed by the modulation is occupied, while the others are suppressed. In contrast to the standard transitions observed in passive mode-locked lasers—where the pulse number changes incrementally as $N \to N \pm 1$—these transitions follow $N \to N/P$ and such behavior has been more generally interpreted within the framework of dissipative (discrete) time crystals.

Although numerical simulations based on time-delayed models tailored to semiconductor to large semiconductor laser gain and losses, as well as partial differential equation approaches, successfully reproduce these phenomena in detail, an intuitive understanding is still lacking. In this work, we reformulate the original model using analytical techniques to derive a low dimensional dynamical system, in which each pulse is characterized by its energy and temporal offset within its potential well evolution on the round-trip time scale and in which coupling arises from nonlinear gain-mediated interactions. This reduced model enables an analytical description and an explanation for the emergence of time-crystal states. Furthermore, we identify diverging, non-homoclinic periodic orbits, which can be classified as instances of winnerless competition. Finally, we discuss how such dynamics could be observed experimentally in the presence of noise.

Third order dispersion effects in V-shaped passively mode locked VECSELs

Lüdge, Kathy

Technische Universität Ilmenau, Germany

Passively mode-locked vertical external-cavity surface-emitting semiconductor lasers (VECSELs) composed of a gain chip and a semiconductor saturable absorber arranged in a V-shaped geometry have been drawing much attention due to their excellent performance figures regarding pulse width and timing stability. In these devices, complex dynamics emerges depending on the geometry and besides fundamental mode locking also high order mode locking, pulse cluster emission, irregular pulsations and phase incoherent photonic molecules emerge due to the nonlocal coupling with the gain medium [1,2,3]. Different modelling concepts exist that range from Haus master equations to delay differential equations (DDE) [4]. They differ in their ability to incorporate dispersion effects. Specifically the third-order dispersion is overwhelmed by filtering losses in DDE models [5]. In this contribution, a delay algebraic equation (DAE) model will be derived for the V-shaped mode locked VECSEL. The model is based on the approach presented in [5] and treats the VECSEL setup as two coupled micro-cavities (gain and absorber chip). The resulting DAE model allows for a more realistic description of the important time scales and the gain bandwidth while still being simple enough for reasonable computation times. We will compare the emission dynamics of the V-shaped VECSEL that result from DDE and DAE approaches by using path continuation and numerical bifurcation analysis. For a realistic comparison we will provide conversions for the unsaturated absorption, pump parameter, cavity losses and bandwidth parameter. The results indicate that third-order dispersion can strongly influence the bifurcation boundaries and lead to new instabilities in the DAE approach. For small round trip times new pulse structures with additional satellite pulses emerge at the leading edge of the mode-locked pulse while at intermediate round-trip times, these satellites are amplified strong enough to deplete the gain and destabilize the main pulse.

[1] S. Meinecke and K. Lüdge, *Phys. Rev. Appl.* **18**, 064070 (2022).
[2] J. Hausen, S. Meinecke, B. Lingnau and K. Lüdge, *Phys. Rev. Appl.* **11**, 044055 (2019).
[3] J. Hausen, S. Meinecke, J. Javaloyes, S. V. Gurevich and K. Lüdge, *Phys. Rev. Appl.* **14**, 044059 (2020).
[4] J. Hausen, K. Lüdge, S. V. Gurevich and J. Javaloyes, *Opt. Lett.* **45**, 6210 (2020).
[5] C. Schelte, P. Camelin, M. Marconi, A. Garnache, G. Huyet, G. Beaudoin, I. Sagnes, M. Giudici, J. Javaloyes and S. V. Gurevich, *Phys. Rev. Lett.* **123**, 043902 (2019).

Quantifying beam filamentation in broad area lasers using information-theory measures

Masoller, Cristina

Universitat Politècnica de Catalunya, Spain

Beam filamentation is a well-known phenomenon that limits the performance and applications of high-power, broad-area semiconductor lasers. In these lasers, the beam's lateral profile splits into multiple filaments, which become more pronounced with increasing pump current. This phenomenon has attracted considerable interest for decades, and various models have been proposed to understand its underlying mechanisms. However, methods for quantifying the degree of filamentation are still lacking. In this presentation I will discuss the ability of information-theoretic measures to characterize and quantify spatial heterogeneities of laser beams. Specifically, I will consider Shannon entropy (H) and Fisher information (F), which can be calculated for a laser beam profile after normalizing it so that the area under its curve equals 1, and therefore, it can be treated as a probability distribution function. Using experimentally recorded and simulated lateral profiles, I will show that the H-F plane provides an effective representation for distinguishing different profiles with varying degrees of filamentation. Furthermore, I will discuss the systematic validation of the H-F plane using synthetic one-dimensional and two-dimensional profiles constructed with linear superpositions of Gaussian distributions.

Acknowledgments: Research funded by the Cátedra Chip UPC, funded by the Ministry for Digital Transformation and the Civil Service and by the European Union Next Generation EU (TSI-069100-2023-0015). We thank Dr. M. Facao and Monocrom technical staff for providing the simulated and experimental data analyzed in this work.

Co-author: O. R. Mejia Parra (Universitat Politecnica de Catalunya)

Broadband frequency comb generation in high-quality-factor fiber Fabry-Perot resonators

Mussot, Arnaud

Université de Lille, France

High-quality-factor fiber Fabry-Perot resonators are emerging as a powerful platform for broadband frequency-comb generation. In this seminar, we will present recent results demonstrating how these resonators combine low-loss operation with plug-and-play integration into photonic systems via standard FC/PC connectors. Leveraging the unique flexibility of fiber technology, these platforms enable dispersion engineering and spatial multiplexing, opening the way to the generation of single and multiple all fiber broadband frequency combs in the GHz range. Depending on the operating regime, the observed comb states originate from cavity solitons, switching waves, or the interplay between Kerr and Brillouin effects. We will further discuss recent proof-of-concept demonstrations of coherent multi-comb generation in these devices exploiting spatial multiplexing.

Universality of ultrafast strong-field-induced excited-states lasing in atomic gases

Richter, Maria

Universität Rostock, Germany

Research into the electron dynamics in atoms subject to strong laser fields with intensities ranging from $10\text{TW}/\text{cm}^2$ to $10\text{PW}/\text{cm}^2$ has received significant attention in recent decades, driven by continuous advances in laser pulse generation, spectroscopic techniques, and theoretical modeling. It has led to the discovery of various fascinating, and in some cases surprising effects, including (resonance-enhanced) multiphoton ionization, multiphoton Freeman resonances and channel closing, high-harmonic generation, frustrated tunneling and adiabatic stabilization, self-focussing and femtosecond laser filamentation, the higher-order Kerr effect, and light amplification by "nearly free electrons".

While often overlooked, strong-field excitation of populations into bound states is ubiquitous, with excitation levels reaching 10% or more, paving the way for applications in spectroscopy, sensing, and cavity-free lasing. To elucidate the effect of bound state population dynamics during the propagation of intense pulses, we have developed a first-principles model for the accurate simulation of spatio-temporal light pulse dynamics, which employs a (2+1)D unidirectional pulse propagation equation (UPPE). At each propagation step, the system's full microscopic response is provided by the 3D time-dependent Schrödinger equation. Our model thus accounts for the (bound and free) multi-level structure of the system, the system's subcycle response to the field, and the feedback of the generated light to the driver. We show that, for ultrashort pulses, the excited-state population can lead to coherent emission, and demonstrate the universality of this phenomenon over a wide range of intensities and frequencies of the driving field. We also show that a rigorous description of the microscopic population dynamics of the bound states in the atom, in conjunction with the spatiotemporal dynamics of the laser field, is a prerequisite for capturing the lasing effect. Based on our numerical investigation, we link this universality to the preferential transition to higher Rydberg states under strong-field excitation with femtosecond laser pulses.

High-order dispersion cavity solitons in passive Kerr resonators

Runge, Antoine

Institute of Photonics and Optical Science (IPOS) & ARC Centre of Excellence for Optical Microcombs for Breakthrough Science (COMBS), Australia

State-of-the-art frequency comb generation relies on the excitation of temporal cavity solitons (CSs) in passive optical resonators. These CSs are ultrashort nonlinear pulses arising from the double balance of parametric gain and loss, as well as anomalous chromatic dispersion and Kerr nonlinearity.

Second-order dispersion is the dominant effect in standard resonators and waveguides and other dispersion are therefore usually ignored. The existence of a family of solitons balancing arbitrary pure negative even-order dispersion and Kerr nonlinearity has been explored within the framework of the nonlinear Schrödinger equation and confirmed in mode-locked laser experiments. However, it has emerged only recently in the context of driven passive optical resonators.

Here, we review our recent work on cavity solitons in systems with high-order dispersion. By numerically solving a generalized Lugiato-Lefever equation, we determine their properties and find their analytical form in the limit of high pump power and large detuning. In the spectral domain, they correspond to frequency combs with flatter spectra compared to the conventional quadratic-dispersion case. We also show that their energy is related to the pulse duration as $\Delta\tau$ as $\Delta\tau^{-(k-1)}$, where k is the dispersion order.

The study of the dynamical properties of high-order dispersion CSs reveals that perfect soliton crystals (PSCs) can form spontaneously in these systems. PSCs correspond to strongly interacting, equally spaced solitons filling up the resonator. In contrast, the formation of PSCs in resonator with quadratic dispersion is known to require very specific conditions, including a modulated background arising from perturbations such as avoided mode-crossings. By contrast, we show that high-order dispersion PSCs form spontaneously, as their formation is driven by their strong oscillatory tails, an intrinsic feature of high-order dispersion CSs.

High-order dispersion CSs could be used to generate high energy broadband frequency combs for telecommunications and THz applications.

Optical thermodynamics and Townes soliton formation in dissipative optical multimode fibers

Steinmeyer, Günter

Max-Born-Institut, Germany

Multimode optical fibers have recently received increased interest, exhibiting intriguing phenomena such as spatial mode-locking and beam self-cleaning. Most studies to date have been conducted in the conservative regime. Here, we present evidence for far superior beam self-cleaning in dual-clad fibers with an absorbing inner core. The cleaning process is accompanied by the formation of a spatial Townes soliton at power levels below the critical power for self-focusing by two orders of magnitude.

Dynamic cavity solitons and extreme events in spatially extended semiconductor lasers

Tissoni, Giovanna

Institut de Physique de Nice - Université Côte d'Azur, France

In this talk I will review some recent results about extreme events and cavity solitons in a variety of spatially extended laser systems, such as ring semiconductor laser with coherent injection or broad-area semiconductor lasers with saturable absorber or/and coherent injection. Extreme events show strong analogies with dissipative solitons of different nature (transverse spatial solitons - longitudinal phase solitons), and share the same dynamical features, such as modulational and Hopf instability, or Chirality.

Light shift register mechanism of bi-chromatic pulse generation

Turitsyn, Sergei

Aston Institute of Photonic Technologies, Aston University, United Kingdom

Primary methods for generating short pulses in lasers require intracavity elements or physical mechanisms for modulation or the saturable absorption of radiation. I will discuss a method and theory for a minimal model for the synchronous generation of bi-color pulses in a shared laser cavity, without employing saturable absorbers or modulators. The considered mechanism for pulsed lasing is somewhat similar to an optical shift register, with two pulse trains shifting relative to each other by one period after every round trip.

Experimental observation of discrete time crystals and domain-wall dynamics in active mode-locked laser cavities

Weng, Ruiling

Universitat de les Illes Balears, Spain

Active mode-locking is a well-established technique for generating ultrashort laser pulses with a wide range of applications. The concept of time crystals (TCs), first proposed by Wilczek in 2012, describes the spontaneous breaking of time-translation symmetry and offers a novel framework for understanding periodically driven systems. In this work, we present both experimental and theoretical evidence for the emergence of discrete time crystals in a laser ring cavity. The experimental setup consists of a Mach-Zehnder modulator, a semiconductor optical amplifier, a band-pass filter, and an optical coupler. By tuning the modulation frequency and/or the amplifier pumping current, discrete TC states emerge, characterized by the disappearance of every second pulse in the cavity. Two equivalent TC configurations are observed, corresponding to even or odd slot occupation. Moreover, when the system is driven at an odd harmonic of the cavity resonance, transitions between these two TC states naturally occur. These transitions manifest as defects propagating along the cavity and can be interpreted as domain walls, which necessarily appear in pairs. The dynamics of these domain walls lead to a slow coarsening process, occurring over remarkably long time scales (on the order of several minutes). To further investigate this coarsening dynamics, we introduce an additional modulation of the effective potential, creating an energy imbalance between the two TC states and favoring one over the other. This enables the formation of spatial regions dominated by a single TC state, separated by stationary boundaries. By carefully controlling the modulation signal, both the relative size of these regions and the persistence time of each TC state within the cavity can be tuned. All experimental observations are in excellent agreement with theoretical simulations based on a time-delayed model.

Fractional Laplacians in a mode-locked fibre laser

de Sterke, Martijn

University of Sydney, Australia

Fractional Laplacians, and fractional derivatives more generally, are global operators with a long history. The Fractional Laplacian enters our work in generalisations of the nonlinear Schrödinger equation (NLSE) to other-than-quadratic types of dispersion. Consider the dispersion relation $\beta = -\beta_1|\omega|$, with β the wavenumber, ω the frequency and β_1 a (real) constant. The associated generalised NLSE, which describes pulse propagation with this type of dispersion and a cubic nonlinearity, requires us to express the dispersion relation in the time domain. In the time domain it corresponds to a Laplacian of fractional order and can be written as $(-\nabla^2)^{\alpha/2}$ where the Lévy index $\alpha = 1$.

Our experimental setup, which is based on a fibre laser, allows us to carry out experiments for which the output consists of stationary solutions in the presence of dispersion, fractional or non-fractional, and a cubic nonlinearity. The dispersion is applied using an intracavity programmable phase mask. The solutions we observe consist of pulses which have a kink in their spectrum, reflecting the kink in the dispersion relation, and they decay algebraically in time as $|t| \to \infty$, reflecting the non-local nature of the dispersion operator. The pulses also have a very small time-bandwidth product of approximately 0.05, and their pulse energy is independent of the pulse width.

Different values of α correspond to different dispersion relations. This leads to solitons with different shapes and different degrees of stability. Provided α is not an even integer, their spectrum or one of its derivatives has a kink or cusp, and they decay algebraically. We give an overview of these solutions and some of the underlying mathematics. At a more general level, our experiments offer the unique possibility to perform controlled experiments on a nontrivial system described by a fractional Laplacian.

4 List of Participants

Amiranashvili, Shalva
WIAS Berlin
Germany

Bandelow, Uwe
WIAS Berlin
Germany

Biancalana, Fabio
Heriot-Watt University
Edinburgh, United Kingdom

Broderick, Neil
University of Auckland
New Zealand

Dolinina, Daria
Ferdinand-Braun-Institut
Berlin, Germany

Ermolaev, Andrei V.
Université Marie et Louis Pasteur
Institut FEMTO
Besançon, France

Facao, Margarida
Universitat Politècnica de Catalunya
Terrassa, Spain

Gallemí, Albert
Universitat de les Illes Balears
Mallorca, Spain

Genty, Goëry
Tampere University
Finland

Giudici, Massimo
Institut de Physique de Nice
Université Côte d'Azur
Nice, France

Gurevich, Svetlana
Universität Münster
Germany

Jaurigue, Lina
Technische Universität Ilmenau
Germany

Javaloyes, Julien
Universitat de les Illes Balears
Palma, Spain

Kuen, Lilli
WIAS Berlin
Germany

Kuhn, Eduard
WIAS Berlin
Germany

Lüdge, Kathy
Technische Universität Ilmenau
Germany

Masoller, Cristina
Universitat Politècnica de Catalunya
Terrassa, Spain

Mussot, Arnaud
Université de Lille
France

Radziunas, Mindaugas
WIAS Berlin
Germany

Richter, Maria
Universität Rostock
Germany

Runge, Antoine
IPOS & COMBS
Sydney, Australia

Steinmeyer, Günter
Max-Born-Institut
Berlin, Germany

Tissoni, Giovanna
Institut de Physique de Nice
Université Côte d'Azur
Nice, France

Turitsyn, Sergei
Aston Institute of Photonic Technologies
Aston University
Birmingham, United Kingdom

Vladimirov, Andrei
WIAS Berlin
Germany

Weng, Ruiling
Universitat de les Illes Balears
Palma, Spain

de Sterke, Martijn
University of Sydney
Australia