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(*Nonlinear Physics Group*)

Presentation

During the last two decades, an impressive volume of theoretical and experimental work has been devoted to the existence, stability and dynamics of localized excitations. Such coherent structures have been identified as critical components of numerous continuous and discrete dynamical systems and, depending on the context (and their particular form), they may be referred to as solitons, instantons, kinks, breathers, or quodons, among many others. We nowadays think of such localized nonlinear excitations as being ubiquitous in nature due to their experimental realization in many diverse systems including, but not limited to, optical fibers and waveguide arrays, photonic crystals, Bose-Einstein condensates, molecular crystals, quasi-one-dimensional solids, Josephson-junctions and arrays thereof, layered silicates, micromechanical cantilever arrays, uranium crystals, pendulum arrays, water waves, electrical transmission lines, ferromagnetic and antiferromagnetic materials, granular crystals and so on. Additionally, they are also conjectured to play an important role in denaturation transitions and bubble formation in DNA, protein folding, atom ejection and defect migration in crystals, low-temperature reconstructive transformations, and many others.
The study of nonlinear localized excitations is a long-standing challenge for research in basic and applied science, as well as engineering, due to their importance in understanding and predicting phenomena arising in nonlinear and complex systems, but also due to their potential for the development and "design" of novel applications.
The LENCOS Conferences were born in 2009 with the aim of becoming in a reference forum where experimental and theoretical physicists, chemists, biologists, and applied mathematicians, working in the broad field of nonlinear localized modes, can interchange ideas and promote the research in this multi-faceted and diverse thematic area.

About the organizers

The meeting is organized the Nonlinear Physics Group (Grupo de Física No Lineal) of the University of Sevilla. This research group has organized recently some events on the some subject such as Moving Breathers in Nonlinear Lattices (2003), Macroscopic Effects of Nonlinear Excitations (2004), New Horizons in Stochastic Complexity and Nonlinear excitations: theory and experiments (2005) apart from the first edition of the LENCOS Conference (2009).

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Talks

Interaction forces among two-dimensional bright solitons and many-soliton molecules
Author: **Usama Al Khawaja**
Affiliation: **United Arab Emirates University – Abu Dhabi, UAE**

We consider two-dimensional bright matter-wave solitons in two-dimensional Bose-Einstein condensates. From the asymptotic form of their wavefunction, we derive an analytic expression for the force of interaction between solitons in the large separation limit which turns out to decay with solitons separation Δ as $F(\Delta) \propto \exp(-\Delta)/\sqrt{\Delta}$. Simulating the dynamics of two solitons using the relevant Gross-Pitaevskii equation, we obtain the force of interaction for the full range of Δ which turns out to be of molecular type. We show that many-soliton molecules can exist as a result of such a molecular-type of interaction. These include a string-shaped, ring-shaped, or regular-lattice-shaped soliton molecules. By calculating their binding energy, we have investigated the stability of these structures. Contrary to one-dimensional soliton molecules which have no binding energy, two-dimensional molecules of a lattice of solitons with alternating phases are robust and have a negative binding energy. Lattices of size larger than 2×2 solitons have many discrete equilibrium values of the separation between two neighboring solitons.

On the nonlinear stability of mKdV breathers
Author: **Miguel Á. Alejo-Plana**
Affiliation: **University of Copenhagen, Denmark**

A mathematical proof for the nonlinear stability of mKdV breathers is announced. The proof involves the existence of a nonlinear equation satisfied by all breather profiles, and introduces a new Lyapunov functional, at the H^2 level, which allows to describe the dynamics of small perturbations, including oscillations induced by the periodicity of the solution, as well as a direct control of the corresponding instability modes. In particular, degenerate directions are controlled using low-regularity conservation laws.

Degree of freedom coupling in nonlinear localized mode dynamics
Author: **Tristram Alexander**
Affiliation: **University of New South Wales – Canberra, Australia**

Nonlinear localized modes can have many particle-like characteristics, and one of the most striking is the possibility of particle-like degrees of freedom. This talk will begin with the problem of pumping energy into the spatial degree of freedom of a soliton-like mode described by the nonlinear Schrödinger equation. It will be revealed that there are two distinct driving regimes for motion of the mode in the presence of a time-varying potential. The more general case of coupling between spatial degrees of freedom and amplitude dynamics for extended nonlinear modes will then be considered. It will be shown that energy in spatial degrees of freedom may be transformed into regular amplitude (Josephson-like) oscillations in these nonlinear modes. Finally the role of spatial degrees of freedom in long-range coupling between two localized modes will be examined. It will be shown that small perturbations in the positions of the modes can lead to large changes in the energy exchange between these states.

Coding of nonlinear states for the Gross-Pitaevskii equation with periodic potential and repulsive nonlinearity

Author: **Georgy Alfimov**
Affiliation: **National Research University of Electronic Technology (MIET) – Moscow, Russia**
Collaborator: **Alexei Avramenko**

The talk is devoted to nonlinear modes of the 1D Gross-Pitaevskii equation with periodic (cosine) potential and repulsive nonlinearity. We make use of the following observation: *most part* of the solutions for ODE which describes these modes are singular, i.e. they collapse at some finite point of the real axis. The set of non-collapsing solutions of this ODE is scanty; we report on numerical evidence that at some areas of parameter space these solutions can be described in terms of dynamics on hyperbolic set for an area-preserving Poincaré map associated with this ODE.

Oblique dark solitons and half-solitons in polariton superfluids

Author: **Alberto Amo**
Affiliation: **Laboratoire de Photonique et de Nanostructures (CNRS) – Marcoussis, France**

Polaritons are bosonic mixed light-matter quasiparticles arising from the strong coupling between quantum well excitons and confined photons in a semiconductor microcavity. Their photonic component results in a very light mass (five orders of magnitude lower than the free electron mass) and allows their excitation and manipulation with the use of lasers. Thanks to the decay of polaritons into photons leaking out of the microcavity, all the properties of the polariton gas (density, momentum, wavelength, phase, coherence) can be accessed by standard optical detection techniques and they can be manipulated using laser beams. Contrary to standard non-linear optical systems, their quaisparticle nature with an excitonic component results in very strong interparticle repulsive interactions.
A remarkable characteristic of polaritons is that their very light mass and large spatial modal size allow for their bosonic condensation in a single quantum state [1] at temperatures ranging from 5 to 300K. Polaritons thus share non-linear properties both with standard Kerr non-linear optical systems [2] and with ultracold atomic Bose-Einstein condensates, with novel properties arising from the out of equilibrium nature of polaritons [3].
In this work we will concentrate on the experimental observation of oblique dark solitons, a kind of 1D topological excitations in a 2D polariton condensate [4]. They are formed in the wake of an obstacle present in the flow path of the polariton gas when kinetic energy dominates over interaction energy [5]. We will show that if the spin structure of the polariton condensate is taken into account, oblique dark solitons take the form of half-solitons, mixed spin-phase excitations. Interestingly, half-solitons behave like magnetic monopoles, being accelerated along a magnetic field [6].

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Kink solitons in Coulomb's chains
Author: **Juan F.R. Archilla**
Affiliation: **Universidad de Sevilla, Spain**
Collaborators: **Yuri A. Kosevich**

Chains of identical ions, for which the dominant interaction is the electrostatic repulsion, appear in layered silicates. The ions can move almost from site to site. The chains do not explode because the surrounding media has a net negative charge which screens the Coulomb's repulsion and become attractive when the ions separate two much. Moreover there is a border effect which keeps the ions within the crystal.
We have been able to obtain moving supersonic kinks that keep their shape and cross nicely one with each other and can travel over the surrounding sea of phonons. Their energies can be very different, from the order of eVs to hundreds of them. Therefore they can influence many different processes within silicates.

Numerical study of Faraday waves in binary non-miscible Bose-Einstein condensates
Author: **Antun Balaz**
Affiliation: **Institute of Physics Belgrade, Serbia**

We show by extensive numerical simulations and analytical variational calculations that elongated binary non-miscible Bose-Einstein condensates subject to periodic modulations of the radial confinement exhibit a Faraday instability similar to that seen in one-component condensates. Considering the hyperfine states of Rb-87 condensates, we show that there are two experimentally relevant stationary state configurations: the one in which the components form a dark-bright symbiotic pair (the ground state of the system), and the one in which the components are segregated (first excited state). For each of these two configurations, we show numerically that far from resonances the Faraday waves excited in the two components are of similar periods, emerge simultaneously, and do not impact the dynamics of the bulk of the condensate. We derive analytically the period of the Faraday waves using a variational treatment of the coupled Gross-Pitaevskii equations combined with a Mathieu-type analysis for the selection mechanism of the excited waves. Finally, we show that for a modulation frequency close to twice that of the radial trapping, the emergent surface waves fade out in favor of a forceful collective mode that turns the two condensate components miscible.

Optical solitons in PT-symmetric nonlinear couplers with gain and loss
Author: **Igor V. Barashenkov**
Affiliation: **University of Cape Town, South Africa**

The two-dimensional PT symmetric coupler with gain in one waveguide and loss in the other, supports two families of solitons. We show that their stability properties are completely determined by a single self-similar function of the gain/loss coefficient of the waveguides and the soliton's amplitude. Despite the presence of gain and loss, the evolution of small perturbations about the soliton is conservative.
One of the two types of solitons is found to be stable when its amplitude is lower than a certain threshold. The other soliton is always unstable but the instability growth rate becomes exponentially small when its amplitude decreases. The unstable solitons disperse, blow up or seed long-lived breathers.

Solitons in strongly nonlocal nematic liquid crystals
Author: **Milivoj Belic**
Affiliation: **Texas A & M University at Qatar – Doha, Qatar**

In a theoretical and numerical analysis, we investigate optical spatial solitons in strongly nonlocal three-dimensional nematic liquid crystals. To this end, we utilize widely accepted scalar model of beam propagation in uniaxial nematic liquid crystals. Fundamental soliton profiles are calculated using modified Petviashvili's eigenvalue method. We apply variational calculus to the model, to find approximate solutions for the beam amplitude and the reorientation angle of the director, and compare analytical results with numerical simulations. To check the stability of such solutions, we propagate them in the presence of noise. We discover that the presence of any noise induces the fundamental solitons *the so-called nematicons* to breathe, rendering them difficult to observe.

Soliton self-frequency blueshift in Kagome hollow-core photonic crystal fibers
Author: **Fabio Biancalana**
Affiliation: **Max Planck Institute for the Science of Light – Erlangen, Germany**

We show theoretically that the photoionization process in a hollow-core photonic crystal fiber filled with a Raman-inactive noble gas leads to a constant acceleration of solitons in the time domain with a continuous shift to higher frequencies, limited only by ionization loss. This phenomenon is opposite to the well-known Raman self-frequency redshift of solitons in solid-core glass fibers. We also predict the existence of unconventional long-range nonlocal soliton interactions leading to spectral and temporal soliton clustering. Furthermore, if the core is filled with a Raman-active molecular gas, spectral transformations between redshifted, blueshifted, and stabilized solitons can take place in the same fiber.

Spontaneous symmetry breaking in linear lattices with two nonlinear sites
Author: **Valeriy Brazhnyy**
Affiliation: **Universidade do Porto, Portugal**

Spontaneous symmetry breaking (SSB) is a fundamental effect caused by the interplay of nonlinearity with linear potentials featuring basic symmetries. We present the results where SSB is observed in the linear lattices with a pair of inserted nonlinear sites. As first example we consider discrete linear lattice where cubic nonlinearity the tightly concentrated at two symmetric sites, or in narrow regions around them. This setup can be readily implemented in optics, by embedding two nonlinear cores into an arrayed linear waveguide, and in BEC, by means of the Feshbach-resonance technique applied locally to the condensate trapped in a deep optical lattice. As a second example we consider bichromatic lattice with the second-harmonic-generating ($\chi^{(2)}$) nonlinearity concentrated at a pair of sites.
For both systems we construct families of symmetric, antisymmetric, and asymmetric localized modes. Some of the solutions were obtained in an explicit analytical form. Stability of the discrete localized modes is analyzed by means of the computation of eigenvalues for small perturbations, and verified by direct simulations. The conditions to observe sub- or supercritical SSB ones were found.

Matter wave vortices: the quantum Spirograph
Author: **Ricardo Carretero-González**
Affiliation: **San Diego State University, USA**

Motivated by recent experiments studying the dynamics of configurations bearing a small number of vortices in atomic Bose-Einstein condensates (BECs), we illustrate that such systems can be accurately described by ordinary differential equations (ODEs) incorporating (a) vortex precession induced by the harmonic trap confining the BEC and (b) vortex-vortex interactions. The dynamics is studied in detail at the ODE level, both for the equal and opposite charge vortex pairs. Co-rotating steady states are identified about which perturbations lead to spirographic (epitrochoidal) motion with excellent agreement with experimental observations. A detailed analysis of the ensuing ODEs reveals the possibility of stable asymmetric states bifurcating from symmetric ones in a pitchfork bifurcation with very good agreement with experimental observations. Cases with more than two vortices are also discussed

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Localized excitations induced in nonlinear complex biological systems by high density green photons
Author: **Sorin Comorosan**
Affiliation: **Fundeni Clinical Institute, Romanian Academy – Bucharest, Romania**
Collaborators: **Silviu Polosan and Marian Apostol**

High density photon fluxes, generated by powerful light-emitting diodes (LEDs) which induce multiphoton nonlinear processes, have been used recently by our group to generate antioxidant effects in complex biological systems. High density photons, in the visible band (λ=515 nm) induce in cellular cultures effects of medium polarization, including the contribution of nonlinear electric field components. We present in this paper two clear-cut experimental results, arising from polarization phenomena: inhibition of oxidative action in a specific biological component (superoxide dismutase enzyme-SOD) and the defolding process inhibition of a secondary protein structure. Under ultraviolet (UV) denaturation, the SOD-enzyme, when simultaneously irradiated with λ=515 nm light, preserves its entire activity through a partial photo isomerization of the Cu-Zn link at the enzymic active center. Circular dichroism spectra performed on cellular cultures under UV-irradiation, reveal, when simultaneously irradiated with green light, a protection of the proteins helicity, through photo isomerization of L-D histidine in the secondary amino acids chain structure. These new type of experiments may open a significant field of research, which may be termed biological spectroscopy.

The temperature dependence of the Amide-I band of crystalline acetanilide
Author: **Leonor Cruzeiro**
Affiliation: **Universidade do Algarve – Faro, Portugal**

The double peak structure of the Amide-I band of crystalline acetanilide continues to intrigue theoreticians and experimentalists [1]. In this talk, the generalized Davydov/Scott model previously applied to energy transfer in proteins [2] is modified by adding one more ingredient, namely, the fact that the energy of the Amide-I excitation cannot always increase linearly with the length of the hydrogen bond and the fact that it must also be dependent on the orientation of the hydrogen bond. The application of this modified model to crystalline acetanilide makes it possible not only to reproduce the double peak structure of the amide I absorption spectrum and its temperature dependence, but also to determine the nature of the states that contribute to the two peaks. The differences between these results and the current theory will be emphasized at the end of the talk.

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Control of transport in higher dimensional systems via dynamical decoupling of degrees of freedom with quasiperiodic driving fields

Author: **David Cubero**
Affiliation: **Universidad de Sevilla, Spain**

We consider the problem of the control of transport in higher dimensional periodic structures by applied ac fields. In a generic crystal, transverse degrees of freedom are coupled, and this makes the control of motion difficult to implement. We show that the use of quasiperiodic driving significantly suppresses the coupling between transverse degrees of freedom. This allows a precise control of the transport, and does not require a detailed knowledge of the crystal geometry.

Movability of localized eigenstates in speckle disorder potentials

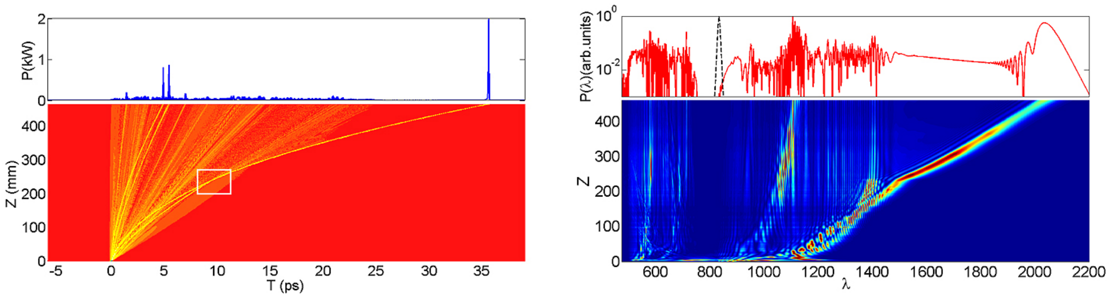
Author: **Sergey Denisov**
Affiliation: **Institut für Physik, University of Augsburg, Germany**

It is well known now that disorder induces localization. Anderson localization is a general phenomenon which has been observed in a large variety of systems, including light and elastic waves. Recent advances in the field of experimental ultracold atom physics provided a new test-ground to study the effect of disorder-induced localization. There are also some new trends have appeared relatively recently in the theoretical domain, including studies of the interplay of disorder and many-body effects (interaction, nonlinearity etc).
In my talk I would like to discuss a new quantum effect which may exist due to joint efforts of disorder and ac-driving. Namely, I want to address the following question, "Can a localized quantum state slide over a disordered potential when it is exposed to an external ac-driving?" Will it move? Or will the driving simply melt down localized states without producing any tangible transport effect?

Accelerated rogue waves generated by soliton fusion at the advanced stage of supercontinuum formation in photonic crystal fibers

Author: **Rodislav Driben**
Affiliation: **University of Tel-Aviv, Israel**

Soliton fusion is a fascinating mechanism that was observed in various fields of physics [1]. Here we report the numerical observation of soliton fusion in a complex process of interactions between Raman-shifted solitons and dispersive waves at the advanced stage of Supercontinuum generation (SC) in photonic crystal fibers. Solitonic and non-solitonic products of initial fission of the injected higher-order soliton [2-4] continue to propagate along the Photonic crystal fiber (PCF) with different frequencies exhibiting multiple interactions [3,4] and generating light with a broad spectrum [2-5]. It was demonstrated that dispersive waves radiated from one soliton may accelerate neighboring soliton causing further collision between them [6]. In most cases the nature of such collisions is quasi-elastic, however soliton fusion and steering is also observed, depending on relative velocity and energy of solitons [7]. In our case of solitons fusion both components combine into single robust structure propagating with the enhanced energy and acceleration (Fig.1 (a)). After the propagation length of 460 mm the output fusion product has experienced significant temporal shift , well-preserving its robust shape and intensity of about twice of the parental solitons.
In the spectral domain this processes result in development of a new significant band at the long wavelength side of the spectrum (Fig.1(b)). As mentioned above, conditions for the fusion are very delicate and assuming small random noise in input, the event becomes a rare one. Obviously fused accelerated soliton is a very attractive candidate for optical analog of rogue waves [8].



(a) Dynamics of 105-fs (FWHM) pulse in PCF in temporal domain. The region of solitons collision with a resultant solitons fusion is highlighted. (b) Spectral domain. Black dotted curve - the input spectrum, red solid - the output.

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Correlated metallic two particle bound states in quasiperiodic chains
Author: **Sergej Flach**
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Single particle states in a chain with quasiperiodic potential show a metal-insulator transition upon the change of the potential strength. We consider two particles with local interaction in the single particle insulating regime. The two particle states change from being localized to delocalized upon an increase of the interaction strength to a non-perturbative finite value. At even larger interaction strength the states become localized again. This transition of two particle bound states into a correlated metal is due to a resonant mixing of the noninteracting two particle eigenstates. In the discovered correlated metal states two particles move coherently together through the whole chain, therefore contributing to a finite conductivity.

Atomic dark-bright solitons: theory and experiments
Author: **Dimitris J. Frantzeskakis**
Affiliation: **University of Athens, Greece**

Based on the Gross-Pitaevskii mean-field theory, we present results for dark-bright solitons in multi-component Bose-Einstein condensates. Employing symmetries of the underlying system, we show that dark-bright solitons can be used for the construction of other vector solitons, such as the regular and beating dark-dark solitons. Soliton dynamics in the trap, soliton interactions, as well as finite-temperature-induced dissipation, are studied analytically. Special attention is paid to the connection between theoretical results and relevant experimental observations.

Multivortex periodic structures in driven magnetic nanodots
Author: **Yuri B. Gaididei**
Affiliation: **Bogoliubov Institute of Physics – Kiev, Ukraine**

Multivortex periodic structures in driven magnetic nanodots are studied. Two types of driving are considered: space and time-varying magnetic fields and spin-polarized electric currents. An interaction of a magnetic vortex with a rotating magnetic field causes the nucleation of the vortex–antivortex pair. The key point of this process is a creation of a dip, which can be interpreted as a nonlinear resonance in the system of the certain magnon modes with nonlinear coupling. The usually observed single-dip structure is a particular case of a multidip structure. Dynamics of the structure with n dips is described as a dynamics of nonlinearly coupled modes with azimuthal numbers $m = 0, \pm n, \pm 2n$.
Current induced vortex lattices are investigated in the frame of Slonczewski-Berger mechanism. The existence of a critical current j_c which separates two regimes: (i) deformed immobile vortex state, (ii) vortex-antivortex periodic structures, is shown. When $j_c < j < J$, where J is the saturation current, periodic vortex-antivortex structures appear. In the close vicinity of the saturation current J the square vortex-antivortex lattice appears. The lattice is stable for disturbances and rotates as a whole around the disk center. For currents close to j_c the system of narrow current ranges exists were stable regular vortex-antivortex structures with symmetries C_2, C_3, C_4 appears. The ring-type structures which are the circularly closed cross-tie domain walls are also observed in this regime.

Localized states with shield-like phase structure in parametrically driven systems
Author: **Mónica García-Ñustes**
Affiliation: **Universidad de Chile – Santiago, Chile**

Under conditions of small injection and dissipation of energy, parametrically driven and damped nonlinear Schrodinger equation (PDDNLS) presents an analytical solution characterized by a uniform phase and a bell-like shaped amplitude. In the present work, we show numerically and analytically that PDDNLS equation describes a new type of localized state with a stationary phase front structure which have been called phase shielding soliton. Possible appearance of such states in different real physical parametrically driven systems in 1D and 2D is discussed.

N-soliton interactions for the Manakov system. Effects of external potentials
Author: **Vladimir Gerdjikov**
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Collaborators: **M. D. Todorov**

We analyze the dynamical behavior of the N-soliton train in adiabatic approximation of the Manakov system (MS) perturbed by external potentials:

$$\begin{aligned} i\vec{u}_t + \frac{1}{2}\vec{u}_{xx} + (\vec{u}^{\,\dagger}, \vec{u})\vec{u}(x,t) = V(x)\vec{u}(x,t), \\ V(x) = V_2 x^2 + V_1 x + V_0 + A_1 \cos(\Omega_1 x + \Omega_0). \end{aligned} \tag{1}$$

The N-soliton train is the solution of eq. (1) with initial condition

$$\vec{u}(x, t=0) = \sum_{s=1}^{N} \vec{u}_{s;1s}(x, t=0).$$

where $\vec{u}_{s;1s}(x,t)$ is the 1-soliton solution of MS with velocity μ_s, amplitude u_s, phase δ_s, position ξ_s and polarization vector $\vec{n}_s$.
We show that the dynamics of the N-soliton train is modeled by a perturbed complex Toda chain for the train parameters which generalizes the results of [1,2]. This fact can be used to predict the asymptotic regimes of the N-soliton train providing the initial soliton parameters are given. We compare the results obtained with those obtained by a direct finite-difference simulation of the vector Schrodinger equation [3] and ascertain the areas of consistency and applicability of the complex Toda chain.
Also, we obtain the critical values $A_{1;\mathrm{cr}}$ of the periodic potential above which the train is stabilized. Possible applications of these results for Bose-Einstein condensates are discussed.

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Complex Hamiltonian dynamics in small systems of coupled waveguides
Author: **Roy Goodman**
Affiliation: **New Jersey Institute of Technology, USA**

We consider the dynamics of light in small arrays of coupled waveguides, modeled by the nonlinear Schrödinger/Gross-Pitaevskii equations, where certain assumptions are made on the spectrum of the potential (i.e. the waveguide). We show that a wide array of bifurcations and behaviors are possible in these systems and that the systematic use of normal form analysis, computed using Lie transforms, makes discovering these phenomena possible. We compare the results in these systems to those seen in small discrete NLS problems.

Perturbation spreading in many particle systems: a random walk approach
Author: **Peter Hänggi**
Affiliation: **Department of Physics, University of Augsburg, Germany**

The propagation of an initially localized perturbation via an interacting many-particle Hamiltonian dynamics is investigated. We argue that the propagation of the perturbation can be captured by the use of a continuous-time random walk where a single particle is traveling through an active, fluctuating medium. Employing two archetype ergodic many-particle systems, namely, (i) a hard-point gas composed of two unequal masses and (ii) a Fermi-Pasta-Ulam chain, we demonstrate that the corresponding perturbation profiles coincide with the diffusion profiles of the single-particle Levy walk approach. The parameters of the random walk can be related through elementary algebraic expressions to the physical parameters of the corresponding test many-body systems [1].

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Quantum signatures of an oscillatory instability in the Bose–Hubbard trimer
Author: **Magnus Johansson**
Affiliation: **Linköping University, Sweden**
Collaborators: **Peter Jason, Katarina Kirr**

We study the Bose-Hubbard model for three sites in a symmetric, triangular configuration, and search for quantum signatures of the classical regime of oscillatory instabilities, known to appear through Hamiltonian Hopf bifurcations for the *single-depleted well* family of stationary states in the Discrete Nonlinear Schrödinger equation. In the regimes of classical stability, single quantum eigenstates with properties analogous to the classical stationary states can be identified already for rather small particle numbers. On the other hand, in the instability regime the interaction with other eigenstates through avoided crossings leads to strong mixing, and no single eigenstate with classical-like properties can be seen. We compare the quantum dynamics resulting from initial conditions taken as perturbed quantum eigenstates, and SU(3) coherent states, respectively, in a quantum-semiclassical transitional regime of 10-100 particles. While the perturbed quantum eigenstates do not show a classical-like behaviour in the instability regime, a coherent state behaves analogously to a perturbed classical stationary state, and exhibits initially resonant oscillations with oscillation frequencies well described by classical internal-mode oscillations.

Two component Bose-Einstein condensates trapped in double-well potentials
Author: **Bruno Juliá-Díaz**
Affiliation: **ICFO: The Institute of Photonic Sciences – Barcelona, Spain**
Collaborators: **Marina Melé-Messeguer, Artur Polls, Muntsa Guilleumas and Anna Sanpera**

The dynamics of binary mixtures of Bose-Einstein condensates trapped in a double-well potential is mapped, in the mean-field approximation, into two coupled Gross-Pitaevskii equations. We investigate what are the situations in which a simpler two-mode approach leads to an accurate description of the dynamics. We also estimate the validity of the most usual dimensionality reductions used to solve the GP equations. To this end, we compare both the semi-analytical two-mode approaches and the numerical simulations of the one-dimensional (1D) reductions with the full 3D numerical solutions of the GP equation. Our analysis provides a guide to clarify the validity of several simplified models that describe mean-field nonlinear dynamics, using an experimentally feasible binary mixture of an $F = 1$ spinor condensate with two of its Zeeman manifolds populated, $m = \pm 1$.

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Escape Dynamics in the Discrete Repulsive ϕ^4-Model
Author: **Nikolaos I. Karachalios**
Affiliation: **University of the Aegean – Karlovassi, Greece**
Collaborators: **Vassos Achilleos, Azucena Álvarez, Jesús Cuevas, Dimitris Frantzeskakis, Panayotis Kevrekidis and Bernardo Sánchez-Rey**

We study deterministic escape dynamics in the framework of the discrete Klein–Gordon model with a repulsive quartic on-site potential. Using a combination of analytical, based on differential and algebraic inequalities and selected numerical illustrations, we derive conditions for collapse of an initially excited single-site unit and escape for multi-site excitations such as initially excited lattice segments and plane wave initial data. For the latter, modulational instability analysis and energy arguments reveals the existence of three distinct regimes, namely, modulational stability, modulational instability without escape and, finally, modulational instability accompanied by escape.

Dark Solitons and Vortices, Double Wells, Ghost States and Nonlinear PT-phase transitions in Defocusing PT-symmetric Media

Author: **Panayotis G. Kevrekidis**
Affiliation: **University of Massachusetts – Amherst, USA**

This talk concerns a theoretical analysis of some aspects of a theme that has received particular attention recently, namely parity-time (PT) symmetric media. In particular, we consider such media with an even real confining potential, an odd imaginary potential and a defocusing nonlinearity and observe a series of interesting phenomena such as:

(a) a destabilizing seemingly-pitchfork bifurcation of dark solitons;

(b) a nonlinear analog of the PT-phase transition where nonlinear eigenstates pairwise collide and disappear in saddle-center bifurcations;

(c) the spontaneous emission of solitary waves past the latter critical point;

(d) the direct generalization of each of the above features in higher dimensional settings.

Yet various open ended questions still remain including the nature of the daughter states of the pitchfork bifurcation. We analyze the so-called ghost states which provide an answer to this question and illustrate their role in the observed dynamics. Importantly, we also derive connections of this problem with the classical PT-symmetric dimer (or coupler) that has been recently investigated experimentally. The role of ghost states and of so-called analytically continued states in the latter model can be elucidated even in a fully analytical fashion, as we demonstrate.

Negative Refraction and Spatial Echo in Optical Waveguide Arrays

Author: **Ramaz Khomeriki**
Affiliation: **Javakhishvili Tbilisi State University, Georgia**

The special symmetry properties of discrete nonlinear Schrödinger equation allow a complete revival of the initial wavefunction. That is employed in the context of stationary propagation of light in a waveguide array. As an inverting device we propose a short array of almost isolated waveguides which cause a relative π phase shift in the neighboring waveguides. By means of numerical simulations of the model equations we demonstrate a novel mechanism for the negative refraction of spatial solitons and signal coding.

Nonlinear modes in the harmonic PT-symmetric potential

Author: **Vladimir V. Konotop**
Affiliation: **Universidade de Lisboa, Portugal**

We describe the families of nonlinear modes of the nonlinear Schrodinger equation with the PT-symmetric harmonic potential. The found modes display a number of interesting features. In particular, even when they bifurcate from the different eigenstates of the underlying linear problem, they can belong to the same family of nonlinear modes. We also show that by proper adjustment of the gain/loss gradient it is possible to enhance stability of small-amplitude and strongly nonlinear modes comparing to the well-studied case of the real harmonic potential. Implications of the above properties for the guidance of optical beams, in particular for giant amplification of the guided modes will also be discussed.

Multibreathers in Klein–Gordon chains with interactions beyond nearest neighbors

Author: **Vassilis Koukouloyannis**
Affiliation: **Technological Educational Institute of Serres, Greece**
Collaborators: **Panayotis G. Kevrekidis, Vassilis Rothos and Jesús Cuevas**

We study the existence and stability of multibreathers in Klein–Gordon chains with interactions that are not restricted to nearest neighbors. We provide a general framework where such long range effects can be taken into consideration for arbitrarily varying (as a function of the node distance) linear couplings between arbitrary sets of neighbors in the chain. By examining special case examples such as three-site breathers with next-nearest-neighbors, we find *crucial* modifications to the nearest-neighbor picture of one-dimensional oscillators being excited either in- or anti-phase. Configurations with nontrivial phase profiles emerge from or collide with the ones with standard (0 or π) phase difference profiles, through supercritical or subcritical bifurcations respectively. Similar bifurcations emerge when examining four-site breathers with either next-nearest-neighbor or even interactions with the three-nearest one-dimensional neighbors. The latter setting can be thought of as a prototype for the two-dimensional building block, namely a square of lattice nodes, which is also examined.

Electromagnetic Rogue Waves and Extreme Events in Magnetized Plasma

Author: **Ioannis Kourakis**
Affiliation: **Queen's University Belfast, UK**
Collaborators: **Jafar Borhanian and Vikrant Saxena**

Extreme wave events appear to occur in abundance in the ocean: an ultra-high "ghost wave" is often reported to appear unexpectedly, against an otherwise moderate-on-average sea surface elevation, propagating for a short while (and sometimes destroying everything in its passing and then disappearing without leaving a trace [1]. Due to their obvious potential catastrophic consequences (claiming human lives and causing material loss many times a year [2]), and arguably also due to the fundamental scientific interest involved, the elucidation of the mechanisms underlying the formation and dynamics of such structures has attracted increased interest. Rogue waves (or freak waves, or monster waves, or rogons) are now recognized as proper nonlinear structures on their own (beyond an initial attempt to identify then as a simple superposition of linear wavepackets). Unlike solitary waves, these events are localized in space and in time (that is, they are short-lived modes). Various approaches exist to model their relevance in ocean surface dynamics, including nonlinear Schrödinger models, Ginzburg–Landau models, kinetic-theoretical models, and probabilistic models, to mention a few. Interestingly, fundamental research has by now gone beyond the standard hydrodynamical problem, tracing rogue waves in nonlinear optics [3], in photonics [4], and even in econophysics (financial crash prediction) [5].
Inspired by the ubiquity of this challenging phenomenon, we have undertaken an investigation, from first principles, of the occurrence of rogue waves in the form of localized events associated with electromagnetic pulse propagation interacting with a plasma. A multiple scale technique is employed to solve the fluid-Maxwell equations describing a weakly nonlinear circularly polarized electromagnetic pulses. We distinguish two cases of fundamental interest, namely collisionless and in collisional magnetized plasmas. A nonlinear Schrodinger (NLS) type equation [6] with complex coefficient is shown to govern the amplitude of the vector potential. For collisionless plasma, a set of non-stationary envelope solutions (Peregrine solitons) of the NLS equation is presented [7], and the variation of their structural properties with the magnetic field have been investigated. The effect of collisionality is also investigated.

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Energy transport and localization in systems of weakly coupled oscillators with slowly-varying frequencies
Author: **Agnessa Kovaleva**
Affiliation: **Space Research Institute, Russian Academy of Sciences**

We develop an analytical framework to investigate the influence of nonlinearity on energy transfer and localization in weakly-coupled oscillatory system with time-dependent parameters, with special attention to an analogy between classical energy transfer and non-adiabatic quantum tunneling. For definiteness, we consider a system of two weakly coupled oscillators in which a linear oscillator with constant parameters is excited by an initial impulse but a coupled nonlinear oscillator with slowly-varying parameters is initially at rest. It is shown that the equations of the slow passage through resonance in this system are identical to nonlinear equations of non-adiabatic Landau-Zener tunneling. Due to revealed equivalence, a recently found analogy between energy transfer in a classical linear system and conventional linear Landau-Zener tunneling can be extended to nonlinear systems. An explicit analytical solution of the nonlinear problem is found with the help of an iteration procedure, wherein the linear solution is chosen as an initial approximation.
While an exact solution to the linear Landau-Zener equation is well-known, it is actually too complicated for any straightforward inferences about the system dynamics, and, after the seminal Landau paper, attention has been focused on quasi-stationary solutions describing energy localization at infinitely large times. Recently we have shown that, in some significant limiting cases, the transient processes in linear systems can be efficiently described in terms of the Fresnel integrals. Using this linear approximation as an initial iteration, we then evaluate the effect of nonlinearity from the higher-order iterations. Correctness of the suggested procedure is confirmed by numerical simulations. The results presented in this paper, in addition to providing an analytical framework for understanding the dynamics of coupled oscillators, suggest an approximate procedure for solving the problem of nonlinear non-adiabatic quantum tunneling with arbitrary initial conditions over a finite time-interval.

Asymmetric Wave Propagation in the open, discrete nonlinear Schrödinger equation
Author: **Stefano Lepri**
Affiliation: **Istituto dei Sistemi Complessi CNR-ISC, Italy**

We consider asymmetric (nonreciprocal) wave transmission thruogh a layered nonlinear, non mirror-symmetric system described by the one-dimensional Discrete Nonlinear Schrödinger equation with spatially varying coefficients embedded in an otherwise linear lattice. We construct a class of exact extended solutions such that waves with the same frequency and incident amplitude impinging from left and right directions have very different transmission coefficients. This effect arises already for the simplest case of two nonlinear layers and is associated with the shift of nonlinear resonances. Increasing the number of layers considerably increases the complexity of the family of solutions. Finally, numerical simulations of asymmetric wavepacket transmission are presented which beautifully display the rectifying effect.

Interaction-induced current-reversals in driven lattices
Author: **Benno Liebchen**
Affiliation: **Center for Optical Quantum Technologies, University of Hamburg, Germany**

A key topic concerning the ratchet mechanism are current-reversals, i.e. The tunability of the orientation of directed currents via system parameters, without changing the symmetry of the system. We demonstrate that long-range interactions can cause, as time evolves, consecutive reversals of directed currents for dilute ensembles of particles in driven lattices, without requiring modulations of external parameters. We analyze these surprising self-driven reversals to be expressions of a more general mechanism based on an interaction-induced accumulation of particles in the regular regions of the underlying single-particle phase space and leading to synchronized single-particle motion as well as an enhanced efficiency of Hamiltonian ratchets.

Collapse and stable self-trapping for Bose-Einstein condensates with $1/r^b$ type attractive interatomic interaction potential

Author: **Pavel Lushnikov**
Affiliation: **University of New Mexico, USA**

We consider dynamics of Bose-Einstein condensates with long-range attractive interaction proportional to $1/r^b$ and arbitrary angular dependence. It is shown exactly that collapse of Bose-Einstein condensate without contact interactions is possible only for $b \geq 2$. Case $b = 2$ is critical and requires number of particles to exceed critical value to allow collapse. Case $b > 2$ is supercritical with expected weak collapse which traps rapidly decreasing number of particles during approach to collapse. For $b < 2$ singularity at $r = 0$ is not strong enough to allow collapse but attractive $1/r^b$ interaction admits stable self-trapping even in absence of external trapping potential.

Bright solitons from defocusing nonlinearities

Author: **Boris A. Malomed**
Affiliation: **University of Tel-Aviv, Israel**
Collaborators: **Olga V. Borovkova, Yaroslav V. Kartashov and Lluis Torner**

The talk aims to give a review of recently obtained results which demonstrate that defocusing cubic media with spatially inhomogeneous nonlinearity, whose strength increases rapidly enough toward the periphery (faster than r^D in the D-dimensional space, $D = 1,2,3$, where r is the radial coordinate), can support a variety of stable solitons in all three dimensions, including one-dimensional fundamental and multihump states, two-dimensional vortex solitons with arbitrary topological charges, and fundamental solitons in three dimensions. Solitons maintain their coherence in the state of motion, oscillating in the nonlinear potential as robust quasi-particles. In addition to numerically found soliton families, particular solutions are found in an exact analytical form, and accurate approximations are developed for the entire families by means of the variational and Thomas-Fermi approximations. Related numerical and numerical results demonstrate the existence of stable dissipative solitons in media with the uniform linear gain and nonlinear loss whose local strength grows toward the periphery faster than r^D.

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Energy exchange, localization and transfer in nonlinear oscillatory chains

Author: **Leonid I. Manevitch**
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It is well known that infinite (or very long) oscillatory chains may exhibit either wave-like (normal vibrations and waves) or particle-like excitations (solitons). However, the study of the dynamical behavior of relatively short chains requires a principally new approach. In these chains, the formation of localized excitations and irreversible energy transfer are preceded by intense energy exchange between some groups of the particles, which are referred to as *effective particles.* Maximal possible energy exchange between the effective particles is described using the notion of limiting phase trajectories. The existence of effective particles in the chain becomes visible after reducing the oscillatory chain to a system of weakly coupled resonant oscillators. Using the reduced model, one can derive an energy threshold associated with the transition from intense energy exchange to energy localization on an initially excited effective particle or to energy transfer along the chain.

From intrinsic localized modes to dynamical superlattices in crystals: How a full view of the dynamical landscape illuminates unexpected phenomena

Author: **Michael Manley**
Affiliation: **Lawrence Livermore National Laboratory, USA**

Intrinsic localized modes (ILMs), *also known as discrete breathers*, are localized excitations that form without structural defects in discrete nonlinear lattices. For crystals in thermal equilibrium ILMs were proposed to form randomly, an idea used to interpret temperature activated signatures of ILMs in U and NaI crystals. More recent measurements on the ILMs in NaI using the ARCS spectrometer at Spallation Neutron Source, however, are challenging the random isolated ILM view. First, with small temperature changes ILMs move as a unit back-and-forth between [111] and [011] orientations. Second, when [011] ILMs lock in at 636 K the transverse optic (TO) mode splits into three modes with symmetry-breaking dynamical structure resembling that of a superlattice, but there are no superlattice Bragg reflections and the pattern itself has crystal momentum. We conclude that this dynamical pattern is not derived from the rearrangement of atoms but from an ordered arrangement of ILMs decorating the crystal lattice. There are two startling aspects of these results. The first is that equilibrium thermal vibrations can, by means of nonlinearity, develop new symmetries without corresponding changes in the crystal lattice. The second is that this dynamical ordered state develops with increasing temperature, the opposite of what is expected since configurational entropy favors disorder at high temperatures. Preliminary thermodynamic measurements shed some interesting new light on this aspect.

Numerical modeling of DNA transcription process as a tool for cancer study

Author: **Alejandro Morales-Peñaloza**
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Collaborator: **Juan José Godina-Nava**

It is known the cancer phenomenon is produced by a DNA anomaly in the transcription process. The reasons how such anomaly is generated are now understood partially, allowing to implement alternative therapies as drugs designed to inhibit the growth of cancer cells. However, the effective evaluation of such therapies has been slow, in part because of the time required. In this sense, numerical modeling arise as an excellent option to reduce the approval time for the same. Actually numerical modeling has shown some fruitful results to describe DNA's process as denaturalization.
In this work, the DNA transcription process is analyzed through the study of the unstable anharmonic modes of a heterogeneous Klein-Gordon chain and the initiation is simulated by a localized external force. The system was solved implementing the perturbed discrete breather in the anti-continuous limit, performing the analytical continuation on Fourier space and making a stability analysis under Krein's theory, found the solutions are uniformly coherent. Finally it is demonstrated that in the continuous limit the nonlinear Schrödinger equation is obtained.

Disorder and nonlinearity induced delocalization enhancement

Author: **Uta Naether**
Affiliation: **Universidad de Chile – Santiago, Chile**

Periodicity, disorder, and nonlinearity are common ingredients of physical systems. A common believe is that a disordered system would promotes localization due to the fact that its eigenstates are spatially localized, the so-called Anderson localization. Therefore, it seems natural, that any initially localized wave-function will be trapped and will get more localized in presence of disorder at finite timescales. We show in experiments and theory that, for some simple one and two dimensional weakly disordered systems, an initially very localized profile expands and delocalizes while it propagates across the lattice. In addition, we found that a focusing nonlinearity facilitates the expansion of the wave-packet by increasing its effective size.

Variational treatment of surface waves in Bose-Einstein condensates
Author: **Alexandru Nicolin**
Affiliation: **Horia Hulubei National Institute for Physics and Nuclear Engineering – Bucharest, Romania**

We investigate analytically the dynamics of trapped, quasi-one-dimensional Bose-Einstein condensates subject to resonant and non-resonant periodic parametric excitations such as the modulation of the transverse confinement of the trap or the atomic scattering length. The dynamics of the condensate is described variationally through a set of coupled ordinary differential equations, and the period of the excited waves is determined using a Mathieu-type analysis. We present a detailed comparison between the resonant waves that emerge for resonant drives and the Faraday waves that appear outside of resonance. Finally, we compare our analytical findings with the experimental data to illustrate the agreement.

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Ultrasolitons: multistability and subcritical power threshold from higher-order Kerr terms
Author: **David Novoa-Fernández**
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We show that an optical system involving competing higher-order Kerr nonlinearities can support the existence of *ultrasolitons*, i.e. extremely localized modes that only appear above a certain threshold for the central intensity. Those solitary waves can be produced for powers below the usual Kerr collapse threshold. However, they can also coexist with ordinary, lower-intensity solitons giving rise to an unprecedented situation of soliton multistability. We derive analytical conditions that delimit the parameters space for the occurrence of multistability, and analyze the dynamics of the different kinds of fundamental eigenmodes that can be excited in these nonlinear systems. We also discuss the possible transitions between solitary waves belonging to different nonlinear regimes through the mechanism of soliton switching.

Instabilities of breathers in a discrete NLS
Author: **Panayotis Panayotaros**
Affiliation: **Universidad Nacional Autónoma de México, Mexico**

We review some numerical and analytical results on the continuation of breathers in the cubic discrete NLS equation in a finite one dimensional lattice. Breathers can be viewed as fixed points in a reduced system and we use the stability properties of breathers to obtain information on the topology of the energy hypersurface in a system of three sites. The change to a connected energy hypersurface corresponds to elliptic-hyperbolic breathers, and we study numerically Lyapunov periodic orbits, and their stable and unstable manifolds. We see evidence of homoclinic orbits and we also discuss heteroclinic orbits and the question of transport of energy.

Multi-site breathers in Klein-Gordon lattices: stability, resonances, and bifurcations

Author: **Dmitry E. Pelinovsky**
Affiliation: **McMaster University, Canada**
Collaborators: **Anton Sakovich**

We prove the most general theorem about spectral stability of multi-site breathers in the discrete Klein–Gordon equation with a small coupling constant. In the anti-continuum limit, multi-site breathers represent excited oscillations at different sites of the lattice separated by a number of *holes* (sites at rest). The theorem describes how the stability or instability of a multi-site breather depends on the phase difference and distance between the excited oscillators. Previously, only multi-site breathers with adjacent excited sites were considered within the first-order perturbation theory. We show that the stability of multi-site breathers with one-site holes change for large-amplitude oscillations in soft nonlinear potentials. We also discover and study a symmetry-breaking (pitchfork) bifurcation of one-site and multi-site breathers in soft quartic potentials near the points of 1:3 resonance.

Discrete Breathers and allosteric communication in proteins

Author: **Francesco Piazza**
Affiliation: **University of Orleans and Centre de Biophysique Moleculaire (CBM), France**

Control at the molecular level is essential for the functioning of biological processes, both within molecules and between molecules. Intramolecular control often implies the effect of one ligand on the binding or catalysis of another with no direct interaction between the two effectors. To describe such interaction at a distance, often referred to also as intramolecular signaling, the adjective allosteric (from the Greek *allos*, other and *stereos*, hard, stiff) was coined in 1961 by Jacques Monod and Francois Jacob [1].
Although their importance is now widely recognized, the mechanistic bases of allosteric mechanisms remain rather elusive. Recent findings seem to confirm that in all proteins allosteric signals propagate through multiple, pre-existing fold-rooted pathways. Which pathways dominate depend on protein topologies, specific nature of the binding events, covalent modifications, and cellular (environmental) conditions, such as crowding effects [2]. Such picture is also confirmed by sequence-based statistical methods, suggesting that evolutionarily conserved sparse networks of amino acid interactions represent structural motifs for allosteric transduction [3,4].
In this talk I will illustrate how nonlinear effects in a coarse-grained network model of protein dynamics prove highly effectively in dissecting the relevant *hot-spot* sites and energy transduction pathways [5-9] involved in intramolecular signaling. More precisely, I will illustrate recent numerical and analytical results, showing that the properties of discrete breathers (DB) in our protein model are modulated in a non-trivial fashion by the spatial heterogeneity of protein scaffolds. In particular, I will show how nonlinearity promotes DB-assisted energy transfer to specific regions close to known functional sites, while depressing transfer to generic locations. Finally, I will show how our techniques allow to shed light on the result of recent NMR measurements reporting previously unknown collective motions spanning four beta-strands separated by up to 15 Angstrom in ubiquitin [10].

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Non-linear physics in the dynamics of a Bose-Einstein condensate in a double-well
Author: **Arturo Polls**
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Collaborators: **Marina Melé-Messeguer, Joan Martorell and Bruno Juliá-Díaz**

Cold atom systems have provided a new scenario where non-linear physics plays a crucial role. We use a simple double-well potential to study the complex dynamics of a Bose-Einstein condensate. We investigate the transition from a mean-field regime to strongly correlated regimes characterized by large quantum fluctuations and largely delocalized states. A careful analysis of the dynamics for a broad range of nonlinear couplings allows to identify a region beyond the Josephson non-linear physics in the dynamics of a Bose-Einstein condensate in a double-well and self-trapping regimes, which involves the dynamical excitation of a third mode of the double-well potential. Experimental conditions are proposed to probe this phenomenon.

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Discrete solitons in coupled active cavities
Author: **Yaroslav Prylepskiy**
Affiliation: **Aston University – Birmingham, UK**

We examine the existence and stability of discrete spatial solitons in coupled nonlinear lasing cavities (waveguide resonators), addressing the case of active media, where the gain exceeds damping in the linear limit. A zoo of stable localized structures is found and classified: these are bright and grey cavity solitons with different symmetry. It is shown that several new types of solitons with a nontrivial intensity distribution pattern can emerge in the coupled cavities due to the stability of a periodic extended state.

Breather Stability in Klein–Gordon Equations
Author: **Zoi Rapti**
Affiliation: **University of Illinois at Urbana-Champaign, USA**

We will present results on breather stability in Klein-Gordon equations. First, we will show an algorithm that relates the type of multibreathers — where oscillators can be at rest, in or out of phase — to the number of negative eigenvalues in the perturbation matrix. The perturbation is with respect to the case without coupling between the oscillators. This analysis has been done for discrete Klein–Gordon chains and interactions with up to three neighbors away and weak coupling. In every case a direct count of the unstable eigenvalues can be made. Next, we will show results for continuous Klein–Gordon equations that are approximations of the discrete ones.

Vibrational mechanics in an optical lattice: controlling transport
Author: **Ferruccio Renzoni**
Affiliation: **University College London, UK**

We demonstrate theoretically and experimentally the phenomenon of vibrational resonance in a periodic potential, using cold atoms in an optical lattice as a model system. A high-frequency (HF) drive, with frequency much larger than any characteristic frequency of the system, is applied by phase-modulating one of the lattice beams. We show that the HF drive leads to the renormalization of the potential. We used transport measurements as a probe of the potential renormalization. The very same experiments also demonstrate that transport can be controlled by the HF drive via potential renormalization.

Coherent structures in quasi-one dimensional exciton-polariton systems
Author: **Augusto S. Rodrigues**
Affiliation: **Universidade do Porto, Portugal**
Collaborators: **Jesús Cuevas, Ricardo Carretero-González, Panayotis Kevrekidis and Dimitris Frantzeskakis**

We study the existence, stability, and dynamics of nonlinear excitations in a quasi-one-dimensional polariton condensate in the presence of nonresonant pumping and nonlinear damping. It is shown that these solutions depart from their analogs in the Hamiltonian setting. In particular an inversion of the stability between the nodeless ("ground") state relative to single- and multi-dark-soliton states. In the presence of a double-well potential the bifurcation diagram also departs from the Hamiltonian case, namely, instability of both branches after bifurcation, and a sub-critical instead of supercritical bifurcation for attractive interactions.

Periodic travelling waves of forced nonlinear Lattices
Author: **Vassilis Rothos**
Affiliation: **Aristotle University of Thessaloniki, Greece**

We consider damped and driven nonlinear lattices. We present the existence and uniqueness results of periodic travelling waves of the system. We compare the analytical results for periodic traveling waves with numerical simulations for FPU forced nonlinear lattice.

A new type of energetic mobile nonlinear non-oscillatory lattice excitation in crystals
Author: **Mike Russell**
Affiliation: **Heriot-Watt University – Edinburgh, UK**

Evidence for a new type of nonlinear, non-oscillatory lattice excitation is presented that involves coordinated motions of atoms on multiple adjacent atomic chains. Called pulseons, they are created in energetic atomic scattering events in crystals. The evidence comes from high and intermediate energy nuclear scattering in crystals, augmented by numerical and analogue modelling of crystal excitations. Within a pulseon the energy and momentum propagates along chains in a manner resembling a kink soliton. The excitation propagates at supersonic speed and spreads slowly laterally. It therefore has a finite range for influencing lattice defects. Hence, it contrasts with breathers or quodons that are persistent, compact, self-focusing, sub-sonic excitations. There is no clear upper limit to the energy in a pulseon as its creation can locally disrupt crystal structure. Evidence also is presented for pulseons gaining energy from non-thermal potential energy stored in a lattice. It is anticipated that pulseons will play a significant role in annealing radiation damage in solid materials due to their pulse-like structure acting over a distributed moving front in both layered and non-layered crystals.

Quasi-one-dimensional Bose-Einstein condensates in nonlinear lattices

Author: **Luca Salasnich**
Affiliation: **Department of Physics and Astronomy "Galileo Galilei", University of Padova, Italy**
Collaborator: **Boris Malomed**

We consider the three-dimensional (3D) mean-field model for the Bose-Einstein condensate (BEC), with a 1D nonlinear lattice (NL), which periodically changes the sign of the nonlinearity along the axial direction, and the harmonic-oscillator trapping potential applied in the transverse plane. The lattice can be created as an optical or magnetic one, by means of available experimental techniques. The objective is to identify stable 3D solitons supported by the setting. Two methods are developed for this purpose: The variational approximation, formulated in the framework of the 3D Gross-Pitaevskii equation, and the 1D nonpolynomial Schrodinger equation (NPSE) in the axial direction, which allows one to predict the collapse in the framework of the 1D description. Results are summarized in the form of a stability region for the solitons in the plane of the NL strength and wavenumber. Both methods produce a similar form of the stability region. Unlike their counterparts supported by the NL in the 1D model with the cubic nonlinearity, kicked solitons of the NPSE cannot be set in motion, but the kick may help to stabilize them against the collapse, by causing the solitons to shed excess norm. A dynamical effect specific to the NL is found in the form of freely propagating small-amplitude wave packets emitted by perturbed solitons.

Spatiotemporal dynamics in a ring of coupled pendula: analogy with bubbles

Author: **Victor Sánchez-Morcillo**
Affiliation: **Universidad Politécnica de Valencia, Spain**

Many systems in nature, like drops, bubbles or some macromolecules present circular or spherical symmetry. Under the influence of some external force, such objects often develop surface patterns whose properties are greatly influenced by the underlying geometry. However, differently from the planar case, patterns in curved geometries have been much less explored. Despite the complexity of the particular physical problems, the basic dynamical features are often captured by simple models of coupled oscillators. Here we present a theoretical and experimental study of the spatial instabilities of circular ring of coupled pendula parametrically driven by a vertical harmonic force. Normal oscillation modes (breathing, dipole, quadrupole) and localized patterns of different types (breathers and kinks) are predicted and observed. The analogy between the considered discrete mechanical system and a gas bubble cavitating under the action of an acoustic field is established. On the basis of this analogy, the oscillation patterns and localized modes observed experimentally in acoustically driven bubbles are interpreted and discussed.

Nonlinear Ionic Pulses along Microtubules

Author: **Miljko V. Satarić**
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Collaborators: **Bogdan M. Satarić**

Microtubules (MTs) are cytoskeletal biopolymers shaped as nanotubes that are essential for cell motility, cell division and intracellular trafficking. Here we investigate their polyelectrolyte character that plays a very important role in ionic transport throughout cellular environment. The model we propose demonstrates an essentially nonlinear behavior of ionic currents which are guided by MTs. These features are primarily due to the dynamics of tubulin's C-terminal tails which are extended out of the surface of the MT cylinder [1,2]. We also demonstrate that the origin of nonlinearity stems from the nonlinear capacitance of each tubulin dimer. This brings about conditions required for the creation and propagation of solitonic ionic waves along the MT axis. We conclude that a MT plays the role of a biological nonlinear transmission line for ionic currents [2]. These currents might be of interest for cell division and perhaps can play some important role even in cognitive processes in nerve cell. We expect that this kind of localized ionic waves could have the basic role in many vital cellular activities. First the process of cell division needs the synchronized depolymerisation of MTs. It can be caused by the localized Ca^{++} waves of our model, reaching MT plus ends and triggering the onset of massive detachment of tubulin dimers from MT tips. If just pure diffusion of Ca^{++} ions through the bulk cytosol is left to rule this depolymerisation, the mistakes in this process would overwhelm the needed coordination. In the very interesting paper [3] it was explained that in hair bundles (kinocilium) in the inner ear, consisting of the MT doublets, the myosin motor-driven oscillations are controlled by Ca^{++} ions directed from ion channels along MTs. These ions cause a fraction of myosin motors to detach and thus tune the oscillations of kinocilium as the reaction on a corresponding acoustic signal. This mechanism can also be explained by the localized Ca^{++} waves elaborated here.

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Patterned deposition and spontaneous formation of density waves in the nonequilibrium dynamics of spatiotemporally driven lattices

Author: **Peter Schmelcher**
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We investigate the nonequilibrium classical dynamics and directed transport in lattices with a spatially-dependent driving. Prototype examples are phase, frequency or amplitude-modulated lattices which, via a tuning of the parameters of the driven unit cell, allow for an engineering of the classical phase space and therefore of the magnitude and direction of the directed currents. Several mechanisms for transient localization and trapping of particles in different wells of the driven unit cell are presented and analyzed. As a major first application we derive a mechanism for the patterned deposition of particles in a spatio-temporally driven lattice. The working principle is based on the breaking of the spatio-temporal translation symmetry, which is responsible for the equivalence of all lattice sites. The patterned trapping of the particles occurs in confined chaotic seas, created via the ramping of the height of the lattice potential. Complex density profiles on the length scale of the complete lattice can be obtained by a quasi-continuous, spatial deformation of the chaotic sea in a frequency modulated lattice. In a second step we explore spatiotemporal superlattices consisting of domains of differently time-driven spatial lattices. Here we demonstrate a novel mechanisms for the conversion of ballistic to diffusive motion and vice versa. This process takes place at the interfaces of domains subjected to different time-dependent forces. As a consequence a complex short-time depletion dynamics at the interfaces followed by long-time transient oscillations of the particle density are observed. The latter can be converted to permanent density waves by an appropriate tuning of the driving forces. The proposed mechanism opens the perspective of an engineering of the nonequilibrium dynamics of particles in inhomogeneously driven lattices.

Efficient integration schemes for the discrete nonlinear Schrödinger (DNLS) equation
Author: **Charalampos Skokos**
Affiliation: **Aristotle University of Thessaloniki, Greece**

We present efficient symplectic integration schemes for Hamiltonian systems describing one dimensional nonlinear lattices. These methods allow the accurate integration of large lattices (comprise a few hundreds of coupled oscillators) for very long time intervals in feasible CPU times. We describe the construction of such integrators and we apply them to the case of the discrete nonlinear Schrödinger (DNLS) equation with disorder.

Polariton solitons
Author: **Dmitry Skryabin**
Affiliation: **University of Bath, UK**

In this talk I will review our recent results in the area of polariton solitons. A particular focus of my presentation will be on polariton solitons in strongly coupled semiconductor microcavities for which we have developed a comprehensive theory and conducted a series of experiments. I will also touch on other types of polariton solitons, including, surface plasmon polaritons.

On Intense Energy Exchanges and Localization in Highly Nonlinear, Degenerate Systems
Author: **Yuli Starosvetsky**
Affiliation: **Technion – Israel Institute of Technology, Israel**

Over the past decades, energy transfer has been the subject of a rapidly growing interest in various fields of physics as the dynamics of multi-body systems, dynamics of fluids, physics of plasmas, semiconductors, wave dynamics, dynamics of granular media, etc. Obviously dynamics of realistic physical models may be rather complicated for straightforward theoretical studies. Therefore, to describe the phenomenon of energy transfer or localization which occurs in quite a variety of physical systems, reduced models of oscillatory systems should be considered. In the present work we analytically study the regimes of intense energy exchanges and localization in degenerate system comprising two strongly nonlinear (i.e. pure nonlinearity, no linear terms are allowed) oscillators coupled via nonlinear spring (of the same type of nonlinearity). We demonstrate the existence of two opposing regimes in the system under consideration; in particular we show that energy initially supplied to one of the oscillators can either get localized on it or gets completely transferred between the oscillators in the recurrent fashion depending on the parameter of coupling. The regime of intense, recurrent transfer of energy between the oscillators is nothing more but a well-known beating mechanism existing in a system of two weakly coupled linear/weakly nonlinear oscillators considered in the broad variety of physical applications. However, surprisingly enough this regime of intense energy exchanges also persists in this purely nonlinear system (in the complete absence of linear terms) where no characteristic frequencies required for the necessary resonant interaction between the oscillators can be defined. In the present study we provide an analytical description of both the regimes as well as a theoretical estimation of a threshold value of the parameter of coupling above which the transition from localization to recurrent energy exchanges occurs. Results derived for a system of coupled oscillators under consideration are further extended to strongly nonlinear scalar models comprising the two weakly coupled strongly nonlinear, one-dimensional chains where the regimes of energy localization (on a single chain) as well as recurrent energy wandering (between the two chains) are studied. We note that the results of analytical model are in a very good agreement with that of numerical simulations.

On the existence of traveling waves for monomer chains with pre-compression
Author: **Atanas Stefanov**
Affiliation: **University of Kansas, USA**

We show that the problem for traveling waves for monomer Hertzian chains with precompression has bell-shaped solutions, for all speeds c above some threshold value c^*. In our recent work on precompression-free model, $c^* = 0$, that is bell-shaped traveling waves exists for all $c > 0$. Our approach is by reformulating the resulting differential advance-delay equation into a constrained maximization problem, where the optimization is subject to functions living on the unit sphere of an Orlicz space.

Soliton interactions in one-dimensional photonic lattices with alternating couplings and saturable defocusing nonlinearity
Author: **Milutin Stepić**
Affiliation: **Vinča Institute of Nuclear Sciences, Belgrade, Serbia**
Collaborators: **Petra P. Beličev, Igor Ilić, Aleksandra Maluckov, Andrey Kanshu and Detlef Kip**

We study numerically the interactions of strongly localized modes in a discrete system characterized with two coupling constants and a self-defocusing saturable nonlinearity. Such a discrete system was proposed for media exhibiting a Kerr nonlinearity in Ref. [1]. A possible optical realization of this complex setup are one-dimensional lithium niobate waveguide arrays in which individual channels of identical width are colinearly aligned and where the spacing between adjacent channels alternates between two distinguishable values. In such lattices an extra periodicity opens an additional mini-gap. In this gap light propagation is forbidden, enabling extended nonlinear light-matter interaction and occurrence of novel, spatially localized structures-lattice solitons. The existence and stability of both bright and dark lattice solitons in defocusing, saturable photonic lattices were recently investigated experimentally and theoretically [2,3]. In this contribution, we further enlighten the dynamics of observed bright optical solitons by a systematic study of their mutual interactions [4], which might be useful for the development of future all-optical photonic devices.

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Existence, stability and nonlinear dynamics of vortex clusters in anisotropic Bose-Einstein condensates
Author: **Jan Stockhofe**
Affiliation: **Center for Optical Quantum Technologies, University of Hamburg, Germany**

We have studied vortex excitations in Bose-Einstein condensates at the level of Gross-Pitaevskii theory, with a special emphasis on the role of anisotropic confinement for the existence, stability and dynamical properties of few-vortex clusters. Our first main tool for analyzing the system consists of a weakly nonlinear (bifurcation) approach which starts from the linear states of the problem and examines their continuation and bifurcation into novel symmetry-broken configurations in the nonlinear regime. The second main tool concerns the highly nonlinear limit where the vortices can be considered as individual topologically charged *particles* which precess within the parabolic trap and interact with each other. The conclusions stemming from both the bifurcation and the interacting particle picture are corroborated by extensive numerical computations.

Optical beam localization and interactions in PT-symmetric nonlinear lattices with gain and loss
Author: **Andrey A. Sukhorukov**
Affiliation: **Australian National University, Australia**

We reveal a number of fundamentally important effects which underpin the key aspects of light propagation in photonic structures composed of coupled waveguides with loss and gain regions, which are designed as optical analogues of complex parity-time (or PT) symmetric potentials. We identify a generic nature of time-reversals in PT-symmetric optical couplers, which enables flexible control of all-optical switching and a realization of logic operations, and demonstrate tunable amplification of solitons scattered on PT localized modes. We also show that light propagation in PT-symmetric structures can exhibit strongly nonlocal sensitivity to topology of a photonic structure. These results suggest new possibilities for shaping optical beams and pulses compared to conservative structures.

Nonlinear phenomena in Granular Crystals
Author: **Georgios Theocharis**
Affiliation: **Université du Maine, France**

Granular crystals, defined as ordered aggregates of elastically interacting particles, have drawn interest the last years. These media come not only in different varieties (homogeneous, heterogeneous, disordered), but can be tailored to have tunable responses, ranging from linear, to weakly and strongly nonlinear. In this talk, I will refer to the emergence of coherent structures such as solitary waves, discrete breathers, and other nonlinear phenomena such as bifurcations, and chaos. An understanding of their underlying nonlinear dynamics can enable the design of novel engineering devices such as acoustic rectifiers.

Existence of periodic and solitary waves for a Nonlinear Schrödinger Equation with nonlocal integral term of convolution type
Author: **Pedro J. Torres**
Affiliation: **Universidad de Granada, Spain**

We prove the existence of periodic solutions and solitons in the nonlinear Schrödinger equation with a nonlocal integral term of convolution type. By separating phase and amplitude, the problem is reduced to an integro-differential formulation that can be written as a fixed point problem for a suitable operator on a Banach space. Then a fixed point theorem due to Krasnoselskii can be applied.

Noise- and drive-induced localization of excitations in bosonic Josephson junctions
Author: **Amichai Vardi**
Affiliation: **Ben-Gurion University, Israel**

We study the collective dynamics of bimodal Bose-Einstein condensates subject to noise [1] or driving [2] in the Josephson interaction regime. For judiciously tailored phase-noise, we find the stabilization of excited coherent states via a Bose-enhanced many body quantum Zeno effect, where the degree of stabilization is enhanced by a bosonic factor of order $N/\log N$ as the particle number N increases. For driving, the classical phase-space is mixed with chaotic and regular components, which determine the ensuing dynamics. For a weak off-resonant drive, where the chaotic component is small, the many-body dynamics correspond to that of a Kapitza phase-pendulum, also resulting in the dynamic stabilization of coherent excitations. The same formalism is extended to the parametric-amplifier-like bimodal atom-molecule BEC system, enabling the quantum Zeno control of stimulated coherent dissociation by noise-induced stabilization of the atomic mode [3]. Most recently we have contrasted the dynamics in the presence of a quantum noise source, and erratic driving with the same fluctuations, finding significant differences. These are explained by statistical analysis of the resulting squeezing factor distributions [4].

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Dynamics of Josephson vortices in active optical cavities
Author: **Alexey Yulin**
Affiliation: **Universidade de Lisboa, Portugal**

The dynamics of the photons in active inhomogeneous cavities is considered. The cavities in question contain two parallel wave guiding channels that can interact to each other due to tunnelling of the photons through the barrier separating the channels. Changing the linear gain it is possible to pump photons in the channels and control optical currents in the system. It is shown that solitons in the area of the barrier can be created by the appropriate distributions of the linear gain. The dynamics of the solitons is studied and it is shown that the photonic current flowing through the barrier leads to the motion of the solitary waves. The analogy between these solitons and Josephson vortices is discussed. It is shown that a different kind of solitons can exist in the wave guiding channels. The latter solitons are analogous to the conventional optical vortices. The dynamical mixed states of the vortices of different kinds are also investigated and discussed.

Macroscopic Zeno effect and stationary flows in nonlinear waveguides with localized dissipation
Author: **Dmitry Zezyulin**
Affiliation: **Universidade de Lisboa, Portugal**

Quantum Zeno effect is a fundamental result in the quantum measurement theory. This effect consists in slowing down the dynamics of a quantum system subjected to frequent measurements or to a strong coupling to another quantum system. The Zeno effect can also be understood in more general terms as the changing a decay law of a quantum system depending on the frequency of measurements. If we apply this definition to a macroscopic quantum system, like a gas of condensed bosonic atoms, and take into account that in the macroscopic dynamics the frequency of measurements can be interpreted as the strength of the induced dissipation, then the effect of the measurement on the decay of the system can be viewed as the effect of dissipation on the macroscopic characteristics of the system. In order to emphasize the distinction of the latter statement of the problem with respect to already standard and widely accepted notion of quantum Zeno effect, we refer to the macroscopic Zeno effect bearing in mind its mean-field manifestation.
We theoretically demonstrate the possibility to observe the macroscopic Zeno effect for nonlinear waveguides with a localized dissipation. We study one-dimensional waveguides governed by the nonlinear Schrödinger equation and show the existence of stable stationary flows, which are balanced by the losses in the dissipative domain in the center of the waveguide. The macroscopic Zeno effect manifests itself in the non-monotonic dependence of the stationary flow on the strength of the dissipation. In particular, we highlight the importance of the parameters of the dissipation to observe the phenomenon. Our results are applicable to a large variety of systems, including condensates of atoms or quasi-particles and optical waveguides.

Kink depinning in the disordered and ac-driven sine-Gordon lattice
Author: **Yaroslav Zolotaryuk**
Affiliation: **Bogolyubov Institute for Theoretical Physics – Kiev, Ukraine**

Depinning of topological solitons in a strongly discrete, damped and ac-driven sine-Gordon is studied. The mechanism of the depinning transition is investigated in detail. We show that the depinning process takes place through chaotization of an initially stable standing mode-locked kink state. Detailed investigation of the Floquet multipliers of the mode-locked periodic orbits shows that depending on the depinning parameters (either the driving amplitude or its frequency) the chaotization process can take place through different scenarios. Spatial disorder generally facilitates the destabilizing bifurcation so that the critical value of the depinning parameter decreases as the disorder becomes stronger.

Posters

Multiscale perturbative approach to SU(2)-Higgs classical dynamics: Stability of nonlinear plane waves and bounds of the Higgs field mass

Author: **Vassos Achilleos**
Affiliation: **University of Athens, Greece**

We study the classical dynamics of SU(2)-Higgs field theory using multiple-scale perturbation theory. In the spontaneously broken phase, assuming small perturbations of the Higgs field around its vacuum expectation value, we derive a nonlinear Schrödinger equation and study the stability of its nonlinear plane wave solutions. The latter turn out to be stable only if the Higgs amplitude is an order of magnitude smaller than that of the gauge field. In this case, the Higgs field mass possesses some bounds which may be relevant to the search for the Higgs particle at ongoing experiments.

Interaction of Dark-Bright solitons with Impurities in a Bose-Einstein condensate with an harmonic trap

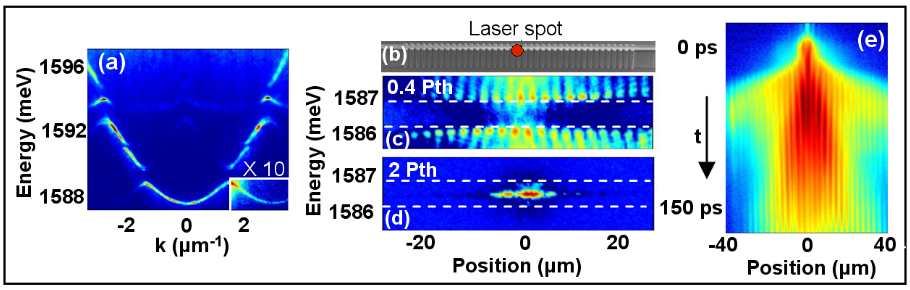
Author: **Azucena Álvarez**
Affiliation: **Universidad de Sevilla, Spain**
Collaborators: **Francisco R. Romero, José María Romero, Jesús Cuevas and Panayotis G. Kevrekidis**

In the setting of multi-component systems of nonlinear waves, we have numerically investigated the dynamics of single Dark-Bright solitons (DBSs) when they collide with impurities in a Bose-Einstein condensate with an harmonic trap. The impurities affecting the dark and bright fields have been modeled by two parametric gaussian functions and they can be attractive or repulsive. After the collisions with the impurities, different outcomes are possible depending on the parameters values. The study has permitted to characterize four outcome regimes: a) reflection regime, if the DBs is always reflected by the impurities; b) transmission regime, if the DBS is always transmitted through the impurities; c) transmission-reflection regime, if some part of the DBS is transmitted and some part is reflected and d) trapping-transmission-reflection regime, if after the first collision with the impurities some part of the DBS is transmited, some part is reflected and some atoms get trapped by the impurities.

Polaritons in a 1D periodic potential: condensation in gap states

Author: **Alberto Amo**
Affiliation: **Laboratoire de Photonique et de Nanostructures (CNRS) – Marcoussis, France**
Collaborators: **D. Tanese, H. Flayac, D.Solnyshkov, A. Lemaître, E. Galopin, R. Braive, P. Senellart, I. Sagnes, G. Malpuech and J. Bloch**

The manipulation of waves in periodic structures has strongly impacted the area of photonics and atomic Bose-Einstein condensates. In photonics, periodic structures allow the creation of photonic crystal and low loss devices (waveguides, high-Q cavities etc). In the case of atoms, periodic potentials have been a tool to better investigate the role of inter-particle interactions.
In this work, we combine both worlds by studying polariton condensates, half-light half-matter quasiparticles, in a one dimensional (1D) periodic potential. The interplay between the interaction properties of polaritons and the engineered band structure strongly determines the spatial behavior of the condensates. We show that polariton condensation occurs in highly localized states located in the gap characteristic of the periodic potential. Under cw excitation, a tightly localized state with a spatial exponential profile appears due to the break up of the periodicity caused by the potential induced by an excitonic reservoir. Under pulsed excitation we find a regime where the reservoir is absent and we observe polariton condensates with a profile typical of a gap soliton, dominated by self interactions. Simulation of these experiments gives an overall understanding of the observed features. Our sample consists in a high quality factor GaAs based microcavity operating in the strong coupling regime. Using electron beam lithography and dry etching, 120 microns long 1D cavities with a periodically modulated section were designed (fig. b). This modulation induces a 1D periodic potential. Angle-resolved luminescence performed on a single modulated microwire directly shows the formation of several polariton sub-bands separated by forbidden energy minigaps (fig. a).
Polariton condensation is studied under non-resonant optical excitation using a tightly focused laser beam (2 microns). In the cw regime, a steady reservoir of uncondensed excitons is injected in the excitation area. Polariton repulsive interactions with this reservoir induce a local blueshift which, in the case of flat wires, results in the expansion of the condensate over several hundreds of micrometers [1,2]. In the case of the modulated wires, the effect of the reservoir is opposite (fig. c-d): the local blueshift creates a defect-like state inside the first band-gap, strongly localized in real space (2 microns), with an exponentially decaying profile. Condensation occurs in this optically created state, due to its large overlap with the excitonic reservoir, which results in enhanced bosonic stimulation.
A different situation is obtained under pulsed excitation. Time-resolved experiments show the spontaneous evolution of the system from propagating to localized states, driven by the time-dependent reservoir population (fig. e). For certain time delays, condensation takes place within the gap, while the reservoir has been strongly depleted. In this case, interactions arise solely from condensed polaritons and we find a hyperbolic secant spatial profile characteristic of a gap soliton [3]. Simulations of the polariton relaxation including both the effect of the excitonic reservoir and of polariton-polariton interactions confirm these interpretations.
The system presented here is of great interest for the investigation of the role of interactions in bosonic systems and, at the same time, can be envisioned as a basic element for more complex polaritonic circuits, in which propagation/localization is fully optically controlled and completely reconfigurable.



a) Far field emission measured at low excitation power of a modulated wire (spatial period: 2.1microns, periodic potential step: 2.5 meV); b) Scanning electron microscopy image of a modulated wire. c-d) Energy and spatially resolved emission measured at low and high excitation power (dashed lines indicate the energy gap boundaries). e) Time and spatially resolved emission measured under pulsed excitation.

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Spatial solitons in graphene metamaterials

Author: **Fabio Biancalana**
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We propose an electrically tunable graphene-based metamaterial showing a large nonlinear optical response at THz frequencies, which we calculate analytically for the first time to our knowledge and arises from the intraband current. The structure sustains a novel type of stable two-dimensional spatial solitary wave, a relativistic version of the Townes soliton. These results can be also applied to any material exhibiting a conical dispersion with massless Dirac fermions.

Size-induced synchronization in a coupled noisy system

Author: **Jesús Casado-Pascual**
Affiliation: **Universidad de Sevilla, Spain**
Collaborator: **María Laura Olivera**

In this poster we investigate the role played by the system size in the phenomenon of stochastic synchronization between switching events and an external driving. In order to do that, we consider an ensemble of coupled nonlinear noisy oscillators driven by a periodic force, and introduce an output frequency associated to a collective variable of the system. By studying the dependence of this output frequency on the system size, we find that there exists a size-induced frequency locking.

Quantum Compactons in an extended Bose–Hubbard model

Author: **Peter Jason**
Affiliation: **Linköping University, Sweden**

The concept of a quantum lattice compacton (QLC) is introduced as an eigenstate with complete localization on a number of consecutive lattice sites. It is shown that, for a Bose-Hubbard model extended with pair-correlated hopping, only one-site QLCs exist as exact eigenstates at parameter values where the one-particle tunneling is exactly canceled by nonlocal pair correlations. These eigenstates correspond in a classical limit to compact solutions of an extended discrete nonlinear Schrödinger model. Classical compactons at other parameter values, as well as multisite compactons, generically get delocalized by quantum effects, but strong localization appears asymptotically for increasing particle number.

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Surface solitons in quasiperiodic nonlinear photonic lattices

Author: **Alejandro J. Martínez**
Affiliation: **Universidad de Chile – Santiago, Chile**

We study discrete surface solitons in semi-infinite, one-dimensional, nonlinear (Kerr), quasiperiodic lattices of the Fibonacci and Aubry-André types, and explore different families of localized surface modes, as a function of nonlinearity and quasiperiodic strength. We find a strong asymmetry in the mode norm as a function of the propagation constant, between the cases of focusing and defocusing nonlinearity, in both models. We also examine the dynamical evolution of a completely localized initial excitation at the lattice surface. We find that, in general, for a given norm, a smaller quasiperiodic strength is required to effect localization at the surface than in the bulk. Also, for fixed quasiperiodic strength, a smaller norm is needed to localize the excitation at the edge than inside the bulk. These results are in marked contrast with those reported for a disordered (Anderson) and nonlinear chain

Two-Dimensional Optical Solitons in Dissipative Systems
Author: **Cristian Mejía-Cortés**
Affiliation: **Instituto de Óptica (CSIC) – Madrid, Spain**

In the present work, we have perform a widely study on dissipative vortex solitons for continuous and discrete media. We have analyzed the existence and stability of several patterns in both media. Radially symmetric ring structures with any vorticity can be stable (bright vortex solitons) in finite range of parameters of the (2+1)D complex Ginzburg–Landau equation with the cubic-quintic combination of nonlinear gain and loss terms. Beyond these two regions, they loose their stability, and new dynamical behaviors appear. On the other hand, for discrete media, we unveil a wide region in the parameter space of the discrete cubic-quintic complex Ginzburg–Landau equation, where several families of stable vortex solitons coexist. All these stationary solutions have simultaneously two different topological charges for two different closed loops encircling, i.e., centered at, the singularity. Their regions of existence and stability were determined, and corroborated directly through propagation. All of these stable composite structures persist in the conservative cubic limit, for high values of their power content. Additionally, we have analyzed the relationship between dissipation and stability for a number of solutions, finding that dissipation favors the stability of the vortex soliton solutions.

Intrinsic localized modes in electrical lattices
Author: **Faustino Palmero**
Affiliation: **Universidad de Sevilla, Spain**
Collaborators: **Jesús Cuevas, Lars Q. English, Ricardo Carretero-González and Panayotis G. Kevrekidis**

We focus on the production of both stationary and travelling intrinsic localized modes (ILMs), also known as discrete breathers, in two closely related electrical lattices. Also, we show experimentally and numerically that an intrinsic localized mode can be stably produced (and experimentally observed) via subharmonic, spatially homogeneous driving in the context of a nonlinear electrical lattice. Comparison between theory and experiments show a reasonable agreement.

Nonlinear lossy light bullets
Author: **Miguel Á. Porras**
Affiliation: **Universidad Politécnica de Madrid, Spain**

In this work we describe the properties and note the physical relevance of nonlinear *lossy* light bullets. They constitute a family of localized wave excitations in homogeneous, isotropic, self-focusing media with nonlinear losses. Their stationarity is supported by a dynamic balance between nonlinear losses and self-focusing, which makes their properties and structure to differ substantially from those of solitary bullets, or from conical and dissipative bullets. Lossy light bullets survive to nonlinear losses and rebuild after obstacles without the need of a compensating gain, but with the continuous energy flux created by self-focusing from a widespread energy reservoir towards the bullet center.
We have studied the stability under perturbations of these lossy light bullets, have and found that their stationary propagation is more stable as they dissipate more energy into the medium. In each nonlinear medium there exists a *most lossy* light bullet with maximum intensity, defined by the medium nonlinearities solely, which acts as an attractor of the multidimensional self-focusing and collapse dynamics with nonlinear losses. Many aspects of collapse and filamentation in self-focusing media with nonlinear losses can be explained in terms of the spontaneous formation of this attractive lossy light bullet.

Study of the B-Z DNA transition during transcription process
Author: **Alba Margarita Reséndiz-Antonio**
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Collaborator: **Juan José Godina-Nava**

Conformational transitions in DNA play an important role in the biological activity and, in some cases, unfavorable implications in the gene expression. Motivated to understand the mechanisms of this structural changes, we model, from the physical point of view, the process of transition from the standard right-handed B-DNA to the left-handed Z-DNA. The understanding of this process would allow to identify the possible harmful genetic mutations occurring in the transcription process.
According with previous work, the transition from a B-DNA to a Z-DNA configuration, require a local denaturation that is analytically described as a breather-like objects (or solitary excitations). Supported in the work *Helicoidal model for DNA opening* of Maria Barbi *et al*, we study the solitonic solutions of a homogenous right-handed DNA and a left-handed DNA. For this, we implement a Z_2 breaking symmetry as well as its physical parameters in the Hamiltonian of the system to differentiate each configuration. In each case, we analyze the solitonic properties of the open states. The comparison will allow differentiate the physical properties of each breather. Finally, with the path integral method, we will look for to obtain the possible trajectories of unwinding and to know the mechanics properties responsible of any change associated with mutations, insertions, losses or duplications in the DNA. The importance of this work is that we could generate an appropriate method to study possible mutations or conformational changes in the double helix. The recognition of the mutated segment would allow to compare the differences among gene expression of healthy and diseased cells, and then, to be able to analyze and repair specific sequences such as those related with cancer cells, among others.

Symmetry reductions and exact solutions of a class of nonlinear reaction-dffusion equation
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In this work, we study a class of nonlinear reaction-diffusion equation from the point of view of the theory of symmetry reductions in partial differential equations.

$$u_t = f(u) + \frac{1}{a(x)}\left(a(x)g(u)u_x\right)_x \tag{2}$$

We focus on two particular cases of this equation, when $a(x) = 1$ and $a(x) = x$. We study the functional forms of $f(u)$ and $g(u)$ for which equation (2) admits the classical symmetry group for $a(x) = 1$ and $a(x) = x$. By using the symmetry reductions, as a basis for deriving new exact solutions that are invariant with respect to the symmetries, we obtain exact solutions. For some functions $f(u)$ and $g(u)$, we derive exact solutions which describe kinks, solitons and periodic solutions.

Travelling wave solutions of a class of nonlinear reaction-ŰdiffusionŰ-convection equations
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In this work we consider the class of nonlinear reaction–diffusion–convection equations, which is a generalization of the nonlinear heat equation,

$$u_t = [A(u)u_x]_x + B(u)u_x + C(u).$$

We obtain travelling wave solutions of this equation, among them we find a set of solutions with physical interest.

Localized modes in two-dimensional discrete systems with long-range nonlinearity
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We study the existence and stability of discrete breathers in a two-dimensional (2D) lattice featuring nonlinear coupling between sites. This model is used to describe a dipolar Bose-Einstein condensate trapped in an optical potential, which exhibits long-range atomic interactions. In marked contrast with the usual discrete nonlinear Schrödinger behavior (no dipolar interactions), our system lacks the norm threshold below which localized solutions cannot exist in 2D lattices. Stability of on-site and inter-site breathers is described by two different methods. As long-range nonlinearity is increased, an exchange of stability between stationary modes is observed. The dynamics of localized solutions is analyzed by numerical simulations, showing very good mobility of 2D discrete solitons for certain magnitudes of nonlocal interactions.

Dynamics of Alfven solitons perturbed by nonlinear Landau damping
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The effect of the nonlinear Landau damping on the dynamics of Alfven solitons propagating either parallel or oblique to the ambient magnetic field is investigated through a perturbed Derivative nonlinear Schrödinger equation (DNLS). Two methods have been implemented: (i) a numerical algorithm based on the inverse scattering transform and (ii) an adiabatic model that describes the dynamics of the system by using the perturbed conservation laws of the DNLS. The evolution of several types of DNLS solutions are considered, including the bright, dark and breather oblique solitons as well as the parallel soliton. The adiabatic model works for the parallel soliton but it fails in the case of the oblique solitons due to the radiation emission and the formation of new solitons. In this latter case multisoliton solutions are required in the adiabatic model.

Universal self-trapping transition in nonlinear lattices
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In this work, we explore the general question about the critical nonlinearity value to dynamically localize energy in a discrete lattice of any dimension and topology. A simple, but strong analytical criterion is developed — for the case of an initially localized excitation — that defines the transition regions in parameter space (*dynamical tongues*) from a delocalized to a localized profile. An estimate of the critical nonlinearity value for which this transition occurs is obtained, that agrees well with numerical computations for the 1D, 2D-square, 2D-honeycomb, 2D-hexagonal, and 3D nonlinear cubic lattices. We discuss the validity and possible extensions of this criterion for other complex lattices.

Analysis of interface conversion processes of ballistic and diffusive motion in driven superlattices

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We explore the non-equilibrium dynamics of non-interacting classical particles loaded into a one-dimensional driven lattice of laterally oscillating potential barriers. In doing so, we focus on superlattices where the barriers are driven differently in different domains (or *blocks*) each containing many barriers. In a simple setup build up out of only two blocks we demonstrate the occurrence of conversion processes from diffusive to ballistic motion at the position where the two blocks connect. As a hallmark of these processes we find peaked velocity distributions as well as the emergence of correlations between velocities and phases for particles which leave the setup. Additionally, the parameter dependence of the resulting velocity distributions is investigated in detail and is explained by means of the underlying phase space. A detailed understanding of this mechanism allows us to tune the resulting velocity distributions at distinguished positions in superlattices containing many blocks by applying local variations of the parameters of the driving. As an intriguing application we present a scheme how initially diffusive particles can be transformed into a monoenergetic pulsed particle beam whose parameters such as its energy can be varied.