PROGRAM AND ABSTRACTS

Premises: Escola Politècnica Superior de Gandia, Carrer del Paranimf, 1, 46730 Gandia, Valencia
URL: https://grupo.us.es/gfnl/JSLoc2024/
Organizers: JFR Archilla (Universidad de Sevilla), Masayuki Kimura (Setsunan University),
Víctor J- Sánchez-Morcillo (Universitat Politècnica de Valencia) and Yusuke Doi (Osaka University).

PROGRAM:

Monday, 04/03/2024

Welcome meeting: 17:30-19:30:
Laboratory of Applied Physics: Experiments with breathers and other localized excitations. Research at the Laboratory of the Group of Applied Physics (UPV). Chair: VJ Sánchez-Morcillo.

Visit to Grau de Gandia and dinner at Barracuda restaurant.

Tuesday 05/03/2024

Opening: 10:00: Juan FR Archilla

Project Presentations Session. Chair: Jānis Bajārs
10:30 Muriel Botey/Ramón Herrero
Exploring complex spacetime systems for unconventional light control
11:00: Víctor Sánchez-Morcillo/Ruben Picó
Exploring complex spacetime systems for unconventional sound control

11:30 Coffe break

Lecture Session 1. Chair: Ruben Picó
12:00 Yusuke Doi, Osaka University
Dynamics of waves in pairwise interaction symmetric lattice
12:30 Yosuke Watanabe, Setsunan University
Measuring velocity of supratransmission in mass-spring chain
13:00 Masayuki Kimura, Setsunan University
Experiments on localized vibrations in magneto-mechanical resonators arrays

Lunch at the university restaurant

15:00 Laboratory visit and discussions: Exploring complex spacetime systems for unconventional sound control. **Chair: Ruben Picó**

17:00 Visit to Ducal Palace in Gandia
18:00 Guided visit to Gandia city
20:30 Conference Dinner at Restaurant Vines i Mes in Gandia

Wednesday 06/03/2024

Lecture Session 2. Chair: Masayuki Kimura.
9:00 Juan FR Archilla, Universidad de Sevilla
Nonlinear excitations in a silicate chain. Experiments and theory
9:30 Jānis Bajārs, University of Latvia
Efficient thermostatting of semiclassical Hamiltonian lattice dynamics
10:00 Kestutis Staliunas, Universitat Politècnica de Catalunya
Hermitian and Non-Hermitian Light Propagation Effects in Thin Films
10:30 Ramón Herrero, **Universitat Politècnica de Catalunya**
Stabilization of laser and laser array emission by symmetric and asymmetric couplings from non-Hermitian potentials

11:00 Coffe break
Lecture Session 3. Chair: Muriel Botey.
11:30 Rubén Picó, Universitat Politècnica de València
Time-Varying and Dynamic Acoustic Metamaterials
12:00 Víctor Sánchez-Morcillo, Universitat Politècnica de Valéncia
Localized waves in highly nonlinear lattices: theory and experiments.

PhD Student Lecture Session. Chair: Muriel Botey.
12:30 Salim B Ivars, Universitat Politècnica de Catalunya
Hybridisation of the different scenarios leading to spatial localisation: hybrid frequency combs in non-Hermitian Kerr Cavities.
12:50 Nayeem Akhter, Universitat Politècnica de Catalunya
Unidirectional mode coupling in non-Hermitian waveguides
13:10 Jaime Galiana, Universitat Politècnica de Valéncia
Simulation methods for the study of time-varying acoustic systems.
13:30 Lunch: Fideua at Hogar del Pescador within the port of Grau de Gandia
15:30 Discussions: Exploring complex spacetime systems for unconventional sound control
17:30 Lighthouse walk. Dinner at No Name in Grau de Gandia.

Thursday 07/03/2024
10:00 Discussion panel 1: Breathers in molecular dynamics. Chair: Yusuke Doi
12:00 Discusssion panel 2: Experiments on breathers: Chair: Yosuke Watanabe
Lunch:
15:00: Private discussions
Cultural activities: Guided visit to Real Monasterio de San Jeroni de Cotalba.

Friday 08/03/2024. Molecular Science Institute (ICMOL). Burjassot Campus. University of Valencia.
11:00 Optical properties of two dimensional semiconductors
12:00 The Laboratory of thin films at the Molecular Science Institute
Chair and speaker: Andres Cantarero.
14:30 Lunch: Paella at Levante Restaurant in Benisanó.
15:30 Visit to Valencia guided by Profs. Cantarero and LLuis García-Raffi.

Saturday 09/03/2024
Discussion Panel 3: Breathers in electrical lattices. Chair: M Kimura
Closing: Juan FR Archilla

BOOK OF ABSTRACTS

JSLoc2024: 2nd Japanese-Spanish Symposium on Localization and Nonlinear Phenomena in Lattices and Waves

Grau de Gandia, Valencia, Spain, March 4-9, 2024

Premises: Escola Politècnica Superior de Gandia, Carrer del Paranimf, 1, 46730 Gandia, Valencia

URL: https://grupo.us.es/gfnl/JSLoc2024/

Organizers:

Juan FR Archilla
Universidad de Sevilla, Sevilla, Spain

Masayuki Kimura
Setsunan University, Osaka, Japan

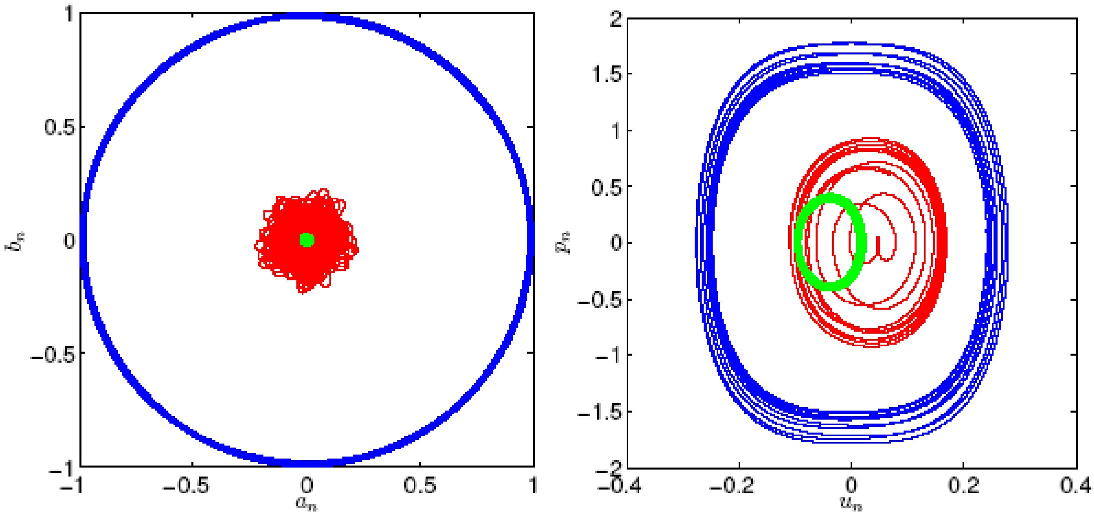
Víctor J Sánchez-Morcillo
Universitat Politècnica de Valencia, Gandía, Spain

Yusuke Doi
Osaka University, Osaka, Japan

Nonlinear excitations in a silicate chain. Experiments and theory.

Juan FR Archilla[1], Jānis Bajārs[2], Yusuke Doi[3], Masayuki Kimura[4]
[1]Universidad de Sevilla, Sevilla, Spain; [2]University of Latvia, Riga, Latvia;
[3]Osaka University, Osaka, Japan; [4]Setsunan University, Osaka, Japan.

We present some experiments in silicates that show the existence of nonlinear excitations that transport energy and can transport electric charge without the presence of an electric field. The energy of the nonlinear excitations is provided by the impact of alpha particles. We present different models for which it is possible to obtain long-living nonlinear excitations without and with transport of charge. We also present the calculations of the physical parameters, for which we have obtained stationary chaotic breathers coupled with the charge whereas traveling excitations are under current research.



Phase space of the real and imaginary part of the charge amplitude and the position and momentum lattice variables.

References:

[1] JFR Archilla; J Bajārs, Y Doi, M Kimura. A semiclassical model for charge transfer along ion chains in silicates. J. Phys: Conf. Ser. (to appear), arXiv:2308.1518 (2024)

[2] Spectral Properties of Exact Polarobreathers in Semiclassical Systems. JFR Archilla; J Bajārs. Axioms 12, 5 (2023) 437/1-26.

[3] FM Russell; JFR Archilla; JL Mas. Quodon current in tungsten and consequences for tokamak fusion reactors. Phys. Status Solidi RRL 18 (2023) 2300297/1-5.

[4] JFR Archilla, Y Doi, M Kimura. Pterobreathers in a model for a layered crystal with realistic potentials: Exact moving breathers in a moving frame. Phys. Rev E 100, 2 (2019) 022206/1-17.

Acknowledgments

The authors acknowledge the following projects and grants:
JFRA: MICINN PID2022-138321NB-C22, and travel grants of VII PPITUS-2024 of the University of Sevilla.
JB: project from the Faculty of Physics, Mathematics and Optometry, University of Latvia (2024).
YD: JSPS Kahenhi (C) No. 19K03654.
MK: JSPS Kakenhi (C) No. 21K03935

Efficient thermostatting of semiclassical Hamiltonian lattice dynamics

Jānis Bajārs[1], Juan F.R. Archilla[2]
[1]University of Latvia, Riga, Latvia; [2]Universidad de Sevilla, Sevilla, Spain

In this work, we propose mixed canonical-microcanonical equilibrium distribution and develop thermostat methods for semiclassical Hamiltonian lattice equations. In semiclassical Hamiltonian lattice models, the crystal lattice is described by classical Hamiltonian dynamics, whereas an extra charge (electron or hole) is modeled as a quantum particle within the tight-binding approximation. Such models are of significant scientific importance. A particular application is hyperconductivity, i.e., the experimental observation of charge transport without the presence of an external electric field when a silicate is bombarded with alpha particles. The charge is carried through the crystal by nonlinear lattice excitations. In the present work, the canonical equations for a semiclassical Hamiltonian describing the coupled lattice-charge dynamics are coupled to an efficient stochastic thermostat, which drives the system to the equilibrium distribution at a prescribed temperature with minimal perturbations to the Hamiltonian trajectories while at the same time ensuring the conservation of the charge probability. The properties of the proposed efficient thermostatting are explored and numerically demonstrated on a phenomenological semiclassical Hamiltonian lattice model.

References

[1] JFR Archilla, J Bajārs, Y Doi and M Kimura. A semiclassical model for charge transfer along ion chains in silicates. J. Phys: Conf. Ser. (to appear), arXiv:2308.1518 (2024).
[2] JFR Archilla and J Bajārs. Spectral properties of exact polarobreathers in semiclassical systems. Axioms 12, 5 (2023) 437/1-26.
[3] J Bajārs and JFR Archilla. Splitting methods for semi-classical Hamiltonian dynamics of charge transfer in nonlinear lattices. Mathematics 10, 19 (2022) 3460.
[4] FM Russell, MW Russell and JFR Archilla. Hyperconductivity in fluorphlogopite at 300 K and 1.1 T. EPL 127, 1 (2019) 16001.

Acknowledgments

The authors acknowledge the following projects and grants:
Project from the Faculty of Physics, Mathematics and Optometry, University of Latvia (2024);
MICINN PID2022-138321NB-C22, and travel grants from VII PPITUS-2024 of the Universidad de Sevilla.

Exploring complex spacetime systems for unconventional light and sound wave control (STWaveControl)

Muriel Botey[1], Ramon Herrero[1], Salim B. Ivars[1], Nayeem Akhter[1],, Kestutis Staliunas[1,2].
[1]Universitat Politècnica de Catalunya, [2]ICREA

We present and overview of the current state and ongoing works of the subproject from Universitat Politècnica de Catalunya (UPC) of the coordinated project Exploring complex spacetime systems for unconventional light and sound wave control (STWaveControl) [1,2,3].

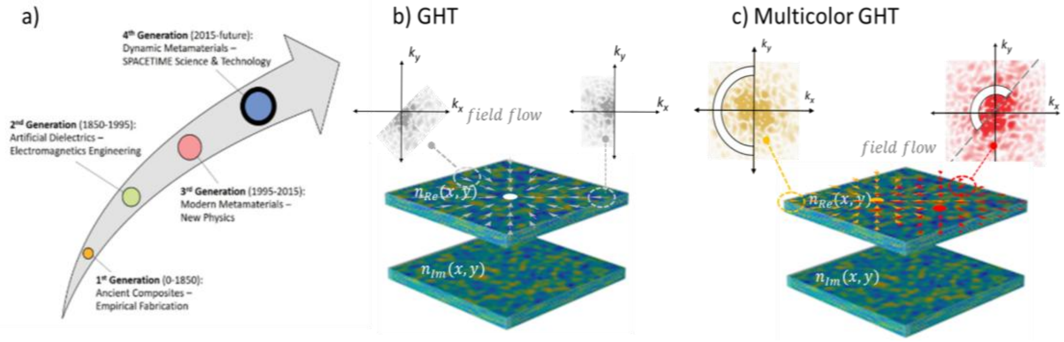


Fig.1. a) Consecutive generations in metamaterial evolution [4]*b) Generalized Hilbert Transform to design non-Hermitian media to control the field flow, corresponding to the 3rd metamaterials generation c) Multicolor-HT to design frequency selective materials*

The present project aims at studying complex artificial metamaterials including spacetime structures for the control of waves, see Fig. 1. The scope of the project holds an intrinsic multidisciplinary character since effects arising from the interaction between waves and artificial spacetime structured materials apply generally to light and sound waves. Such effects form the basis of the present proposal for a collaboration between the Nonlinear Dynamics, Nonlinear Optics and Lasers research group at the UPC and the Acoustics Waves in Complex Media research group at the Universitat Politècnica de Valencia.

References

[1] SB Ivars, M, Botey, R Herrero, K Staliunas, K. (2023). Stabilisation of spatially periodic states by non-Hermitian potentials. *Chaos, Solitons & Fractals*, *168*, 113089.
[2] MN Akhter, M Botey, R Herrero, K Staliunas (2024). Mode-cleaning in antisymmetrically modulated non-Hermitian waveguides. *Nanophotonics*.
[3]SB Ivars, M Botey, R Herrero, K Staliunas. Hybrid patterns and solitonic frequency combs in non-Hermitian Kerr Cavities, submitted
[4] C Caloz, ZL Deck-Léger (2019). Spacetime metamaterials—part I: general concepts. *IEEE Transactions on Antennas and Propagation*, *68*(3), 1569-1582.

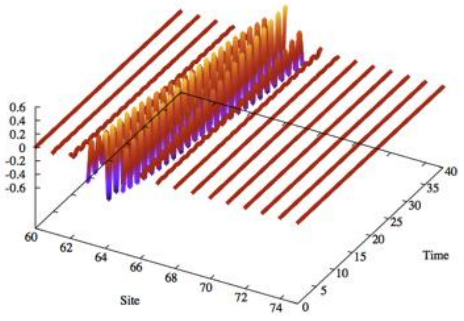
Acknowledgments: The authors acknowledge the project MICINN PID2022-138321NB-C21.

Dynamics of waves in a pairwise interaction symmetric lattice.

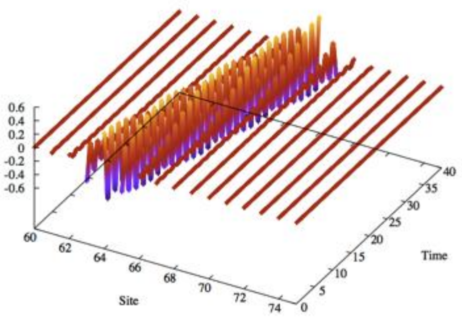
Yusuke Doi
Osaka University, Osaka, Japan

The pairwise interaction symmetric lattice (PISL) is a nonlinear lattice that supports smooth mobility of discrete breathers (DBs) by introducing long-range nonlinear interactions satisfying a certain symmetry of interactions[1, 2]. In this talk, we introduce the structure of the PISL. Moreover, somenumerical results of dynamics of waves in the PISL such as modulational instability of zone boundary mode and interaction between moving DBs and normal modes are presented.

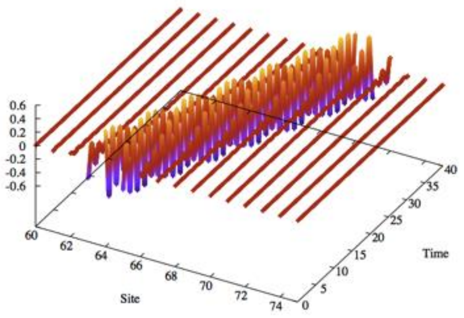
$T = 2.0$, v=1/10



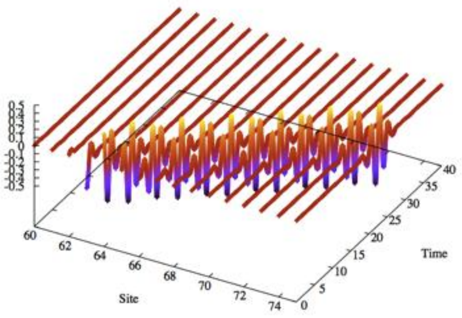
$T = 2.0$, v=1/5



$T = 2.0$, v=1/3



$T = 2.0$, v=1/1



References:

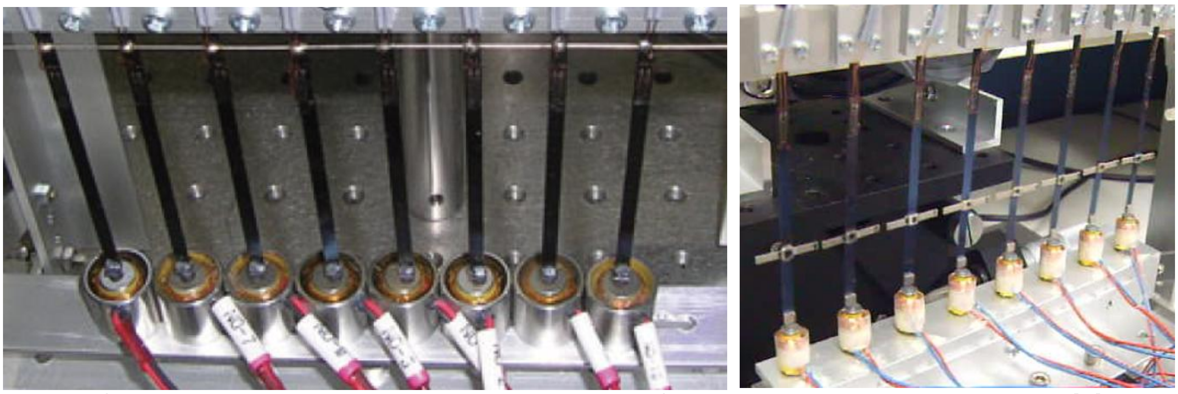
[1] Y Doi, K Yoshimura, Phys. Rev. Lett., Symmetric potential lattice and smooth propagation of tail-free discrete breathers, Phys. Rev. Lett., 117, 014101 (2016).

[2] Y Doi, K Yoshimura, Construction of symmetric lattice for smooth mobility of discrete breathers, Nonlinearity, 33, 5142 (2020).

Experiments on Spatially Localized Vibrations in Magneto-mechanical Resonator Array

Masayuki Kimura
Setsunan University, Osaka, Japan

Spatially localized vibrations in nonlinear resonator arrays, which are called intrinsic localized modes (ILMs) or discrete breathers (DBs), have been observed in a variety of real physical systems such as, even in mechanical systems, nonlinearly coupled pendula [1,2], micro-mechanical cantilever arrays [3], and linearly coupled pendula [4]. We have also fabricated magneto-mechanical resonator arrays [5,6] to observe ILM/DB and to manipulate its position. The photos of the arrays are shown below. Recently, we have studied magnetically coupled two-degree-of-freedom resonators. In this presentation, experimental systems of the magneto-mechanical resonator arrays will be introduced with observation results, and recent progress on the two-degree-of-freedom resonator arrays will be shown.



Photos of the magneto-mechanical resonator arrays. Left: Linearly coupled cantilver array [5]. Right: Magnetically coupled cantilever array [6].

References

[1] FM Russell, Y Zolotaryuk, JC Eilbeck, and T Dauxois, Moving breathers in a chain of magnetic pendulums, Phys. Rev. B 55(10), 6304 (1997).
[2] Y Watanabe, T Nishida, Y Doi, and N Sugimoto, Experimental demonstration of excitation and propagation of intrinsic localized modes in a mass–spring chain, Phys. Lett. A 382 (30), 1957 (2018).
[3] M Sato, BE Hubbard, AJ Sievers, B Ilic, DA Czaplewski, and HG Craighead, Observation of Locked Intrinsic Localized Vibrational Modes in a Micromechanical Oscillator Array, Phys. Rev. Lett., 90, 44102 (2003).
[4] . Cuevas, LQ English, PG Kevrekidis, and M Anderson, Discrete Breathers in a Forced-Damped Array of Coupled Pendula: Modeling, Computation, and Experiment, Phys. Rev. Lett., 102, 224101 (2009).
[5] M Kimura and T Hikihara, Coupled Cantilever Array with Tunable On-site Nonlinearity and Observation of Localized Oscillations, Phys. Lett. A 373, 1257 (2009).
[6] M Kimura, Y Matsushita, and T Hikihara, A Study on Bifurcations and Structure of Phase Space Concerning Intrinsic Localized Modes in a Nonlinear Magneto-Mechanical Lattice, AIP Conference Proceedings 1474 (ISNA19), 55-58 (2012).

Acknowledgments: The beginning of this work was supervised by Prof. T. Hikihara (Kyoto University, Japan). This work is supported by JSPS Kakenhi No. 22760280, 25820164, 18K04020, and 21K03935. The author also acknowledges travel support from project MICINN PID2022-138321NB-C22.

Stabilization of laser and laser array emission by symmetric and asymmetric couplings from non Hermitian potentials

Ramon Herrero
Universitat Politècnica de Catalunya, Spain

Spatiotemporal instabilities in lasers and laser arrays induce temporally unstable and low spatial quality emission. Simultaneous intracavity modulations of refractive index and gain-loss lead to efficient stabilization mechanisms. The stabilization can be based on the suppression of the modulation instability, on the stabilization of specific stationary solutions or on field localization. The stabilization mechanism is shown in Vertical Cavity Semiconductor Emitting Lasers, Edge Emitting Lasers and arrays of Edge Emittig Laser.

Time-Varying and Dynamic Acoustic Metamaterials

Rubén Picó[1], Javier Redondo[1], Víctor J. Sánchez-Morcillo[1].
[1]Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Campus de Gandía.

Recent advances in metamaterials have dramatically extended the range of modern metamaterial properties [1]. Time-varying metamaterials are materials whose properties depend on the temporal variation of their physical parameters induced by an external source of energy [2]. We propose a temporal multilayer scheme of an unbounded string without dissipation consisting of a cascade of different speed media over time. Scattering coefficients are formulated with the transfer matrix method to predict the propagation of the waves in a spatially homogeneous time-varying one-dimensional elastic medium. The speed profile of a temporal multiple-layer string is dfefined by a discontinuity produced by a sudden switch of string speed from c_i to c_{i+1} characterized by the speed contrast γ_i= c_{i+1}/ci at the time T_i.

We consider the propagation of an initial transverse wave propagating in the string. Due to the change of speed at time T_i, two new waves are generated propagating in opposite directions, the later-forward wave “f” and the later-backward wave “b”. The process is reproduced in the following interfaces, generating new waves.By chain multiplication, we obtain the transfer matrix of any temporal multilayer string connecting the transverse field at any multistep configuration:

$$\begin{pmatrix} B_{i+1} \\ F_{i+1} \end{pmatrix} = \begin{pmatrix} f_{\gamma_{i+1},\tau_{i+1}} & b^{*}_{\gamma_i,\tau_i} \\ b_{\gamma_{i+1},\tau_{i+1}} & f^{*}_{\gamma_i,\tau_i} \end{pmatrix} \begin{pmatrix} B_i \\ F_i \end{pmatrix}$$

where *f* and *b* are the forward and the backward scattering coefficients at the *i*th temporal interface:

$$f_{\gamma_i,\tau_i} = \frac{\gamma_i \ + 1}{2\gamma_i} e^{-j\,\delta_{i,+}}$$

$$b_{\gamma_i,\tau_i} = \frac{\gamma_i \ - 1}{2\gamma_i} e^{-j\,\delta_{i,-}}$$

where $\delta_{i,\pm} = \tau_i \ (1 \pm \gamma_i)$ is the phase of each wave and $\tau_i \ = \omega \cdot T_i$ is a non-dimensional time related to the frequency of the wave ω.

References

[1] C Caloz and ZL Deck-Léger, Spacetime Metamaterials—Part I: General Concepts. IEEE Trans. Antennas Propag. 68, 1569–1582 (2020).

[2] Y Xiao, DN Maywar, and GP Agrawal, Reflection and transmission of electromagnetic waves at a temporal boundary. Opt. Lett. 39, 574 (2014).

Localized waves in highly nonlinear lattices: theory and experiments

Víctor J Sánchez-Morcillo[1] , Vitalyi Gusev[2], Noé Jiménez[3], and Rubén Picó[1]

[3] *Instituto de Investigación para la Gestión Integrada de Zonas Costeras (IGIC), Universitat Politècnica de Valencia, Paranimf 1, 46730 Gandia (Spain), victorsm@upv.es*
[2] *Le Mans Université, av. O. Messiaen, 72085, Le Mans (France), vitali.goussev@univ-lemans.fr*
[3]*Instituto de Instrumentación para Imagen Molecular (i3M), Universitat Politècnica de Valencia, Camino de Vera S/N, 46020 Valencia (Spain), nojigon@i3m.upv.es*

Summary: Wave propagation in a highly nonlinear system of coupled rotators is investigated. A discrete nonlinear wave equation is obtained, and the main characteristics of its propagating solutions are discussed. An experiment was designed to test the analytical predictions. Nonlinear signatures as amplitude-dependent dispersion, bistability and self-modulations, and strong localization are observed and discussed.

Highly nonlinear systems, including those where any linear response is absent (fully nonlinear systems) have been much less investigated than weakly nonlinear systems. Some known examples are granular media [1], or connected discs performing torsional motions [2]. In such systems, any arbitrarily small perturbation may lead to significant nonlinear effects. The absence of linear waves defines also the so-called *acoustic vacuum*, a medium where the speed of sound as defined by classical acoustics vanishes. Such systems are also known to support highly localized waves or *compactons*.

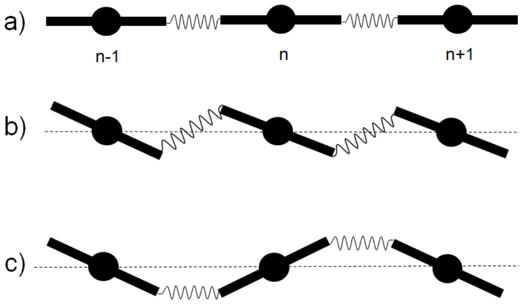


Figure 1 Three neighbour elements of the infinite rotator lattice. a) The lattice at rest, with rotating elements connected by unstressed springs.
b) Lattice excited with a symmetric mode k=π and
c) Lattice excited with the antisymmetric mode k=2π.

We present a theoretical/experimental study of the dynamics of mechanical waves propagating in a highly nonlinear one-dimensional lattice consisting of rotating elements, with mass *m* and inertia moment *I*, coupled by linear springs (Fig. 1). The nonlinearity, of geometrical origin, is of cubic type. In the case of absence of pre-stress of the springs in the rest state (Fig. 1a), linear terms are absent and the system is purely nonlinear. The equation of motion for this lattice has been derived for a general geometry (for arbitrary spring-to- rotator length ratio), and its different limits have been explored.
The equation of motion for rotator *n* is defined by its angle φ_n. Wave propagation in this system is described by the nonlinear discrete equation

$$\ddot{\varphi}_n = -\left(\frac{1-\bar{\mu}^2}{12}\right)\left[\varphi_{n-1}^3 + 2a\varphi_n^3 + \varphi_{n+1}^3 + 3\varphi_n^2\left(\varphi_{n-1}+\varphi_{n+1}\right) + 3b\varphi_n\left(\varphi_{n-1}^2+\varphi_{n+1}^2\right)\right] \qquad (1)$$

where a, b and μ are geometrical parameters dependent on the spring length l_0 and radius of rotator R.
As the system described by Eq. (1) is highly nonlinear, it does not show linear dispersion at all, presenting what has been called an acoustic vacuum. Moreover, the obtained nonlinear dispersion is of optical phonon type, i.e. the wavelength increases with the frequency of the wave. Figure 2 shows the dispersion relation of the first harmonic (the wave at the excitation frequency). Note the presence of upper-lower bandgaps. Note also that, since the frequency in Fig. 2 is normalized to the amplitude of

excitation, this means that, for a given excitation frequency, the dispersion relation can be tuned by the excitation amplitude.

Analytical solutions for the amplitude of the fundamental wave and its third harmonic have been obtained in the rotating wave approximation. Other interesting feature of the system is that the amplitude of the third harmonic vanishes for a particular *k* mode, i.e. the system supports purely harmonic waves.

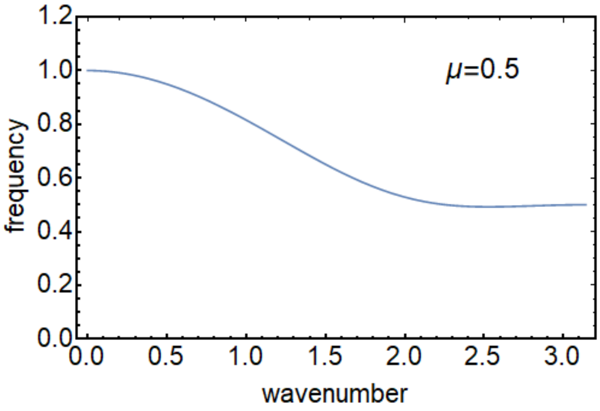


Figure 2 Dispersion relation for the case $l_0=R$ (μ=0.5). Frequency is normalized to the amplitude of the excitation, therefore waves can be propagating or evanescent depending on the initial amplitude.

Notably, we also obtain highly localized solutions (compacton-like), and study their existence conditions.

An experiment has been designed to check the main predictions of the theory. The system is excited at the boundary by driving harmonically the angle of the first rotator, and the motion of each rotator is tracked by video and processed to obtain the time evolution of the angles. Measurements show evidences of the nonlinear characteristics of the system, as the generation of harmonics, bistability and self-modulations, and the predicted amplitude-dependent transition from evanescent to propagating

References

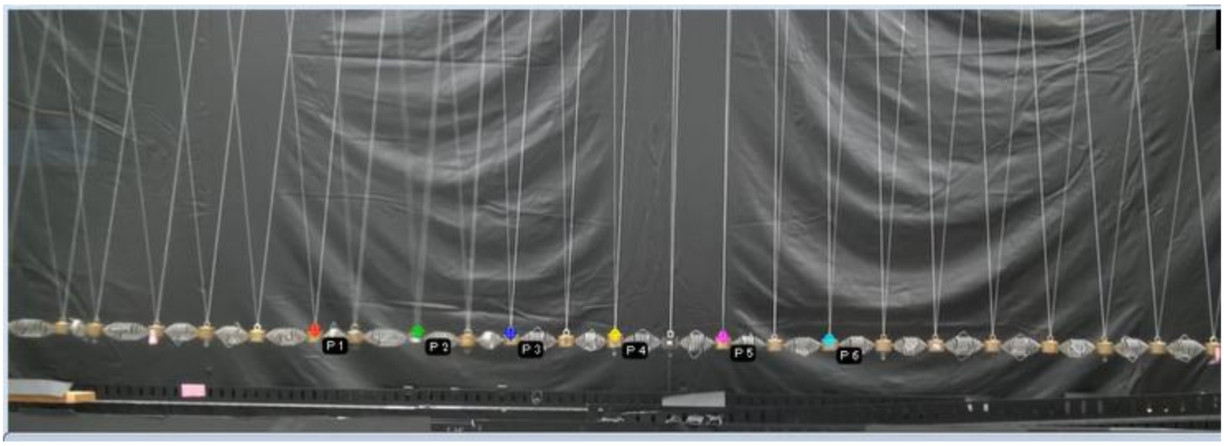
[1] V Nesterenko, Dynamics of heterogeneous materials, Springer (2001).
[2] OV Rudenko and EV Solodov, *Acoust. Phys.*__57__, 51-58 (2011).
[3] YS Kivshar, *Phys Rev. E.*__48__, R43 (1993).
[4] P Rosenau, Phys. Rev. Lett. **73**, 1737 (1994).

Acknowledgments: VSM acknowledge support from the projects PID2019-109175GB-C22 and PID2022-138321NB-C22

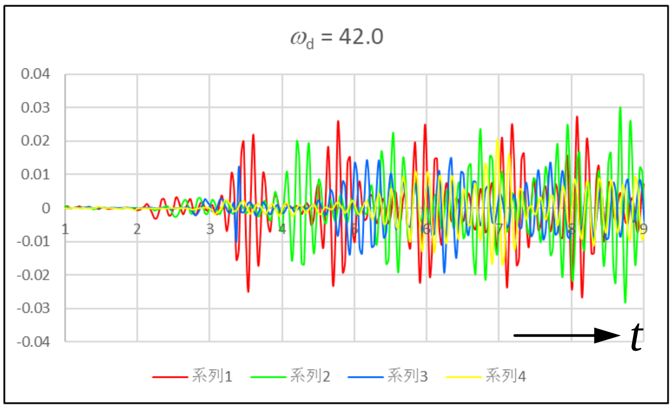
Measuring velocity of supratransmission in a mass-spring chain

Yosuke Watanabe
Setsunan University, Osaka, Japan

Propagation velocity of nonlinear localized oscillations in a mass-spring chain is measured. The chain emulates the Fermi-Pasta-Ulam one of beta type and sinusoidal driving with large amplitude and high frequency at the one end may excite the propagating localized oscillations [1], the supratransmission [2,3]. The propagating velocity appears to be nearly constant throughout the propagation.



Snapshot of the propagation of nonlinear localized oscillation in the mass-spring chain. In the movie some oscilllators are marked with color points to be tracked.



Tracking results of the propagations of localized oscillations, in which color coding coincides with the figure shown above.

References

[1] Y Watanabe, et al.,Phys. Lett. A 382 (2018) 1957-1961.
[2] R Khomeriki, et al., Phys. Rev. E 70 (2004) 066626.
[3] F Geniet and J Leon, Phys. Rev. Lett. 89, 13 (2002) 134102.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number 23K03582.

PHD STUDENTS SESSION:

Unidirectional mode coupling in non-Hermitian waveguides

Nayeem Akhter
Universitat Politècnica de Catalonya

We propose an all-optical control of the mode dynamics in multimode waveguides, by simultaneous modulation of the refractive index and of the gain/loss coefficient. The induced unidirectional mode-coupling, yields to the enhancement or reduction of the excitation of higher order transverse modes, depending on the modulation parameters. In the latter case, the all-optical mode-cleaning is observed, resulting in an almost single-mode spatially coherent output. While coupling towards higher order modes, enhances pulsing and, eventually, leads to supercontinuum generation. We analytically predict the effect on a coupled mode theory for 1D waveguides, which is numerically proven solving the wave propagation equation. The proposal is generalized to the more involved case of 2D waveguides for different geometries. We expect these results to pave the way towards novel no-Hermitian photonics applications.

Hybridisation of the different scenarios leading to spatial localisation: hybrid frequency combs in non-Hermitian Kerr Cavities.

Salim Benadouda Ivars

This study introduces a novel scenario for the formation of dissipative localised structures in nonlinear systems. Traditionally, soliton formation relays on the existence of at least two different potentially stable stationary states: either two uniform states (flat), or a uniform and a patterned state. Each formation scenario holds unique features, which can be typically found in optical cavities with either normal and anomalous dispersion, respectively. However, we show how the introduction of a periodic non-Hermitian modulation in Kerr cavities induces a hybridisation of these two established mechanisms, resulting in a new scenario that combines properties of both. As a consequence, the basal stationary states exhibit dual behavior, where a state can act as either flat or patterned under the same parameters. This phenomenon arises from the stabilization of periodic solutions comprising trains of dark solitons, which are unstable in the unmodulated case.

These findings expand the fundamental understanding of localised structures in nonlinear science, introducing a new paradigm for their formation. Beyond a fundamental scope, the work holds significant implications, especially for frequency comb generation, as the hybridisation blends anomalous and normal dispersion properties within a normal dispersive cavity. This allows for the stabilisation of new of new families of frequency combs associated to stable solitons, molecules, and patterns. Additionally, it leads to an unexpected and reversible mechanisms for real-time comb manipulation and control.

Simulation methods for the study of time-varying acoustic systems

Jaime Galiana-Nieves[1], Javier Redondo[1], Víctor J. Sánchez-Morcillo[1], Rubén Picó[1].
[1]Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Campus de Gandía.

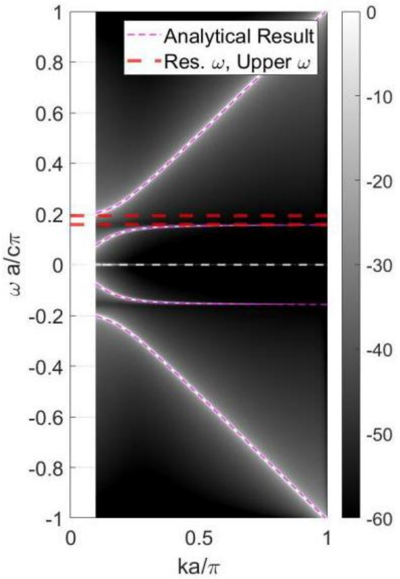
In the last years, the study of time-varying materials by means of simulations is gaining interest. In this work we focus on the FDTD method for the simulation of time-dependent models. Due to the complexity of implementing moving systems using this method, different techniques have been studied to approximate the solution of these systems.

Firstly, boundary conditions have been implemented as FIR filters obtained from the acoustic admittance calculated using the transfer matrix method. In this way, the response of the system at each time instant can be calculated and applied at a single point.

Secondly, FDTD has been combined with the Inmersed Boundary Method (IBM) for the simulation of time-varying systems.

Finally, an implementation has been implemented from analytical expressions of a static Helmholtz resonator. Once the system has been validated, we will proceed to the implementation of the same system, but time-variant.

Figure: Dispersion relation of an static Helmholtz resonator obtained from the analytical expression (purple) and the results from the FDTD simulations (white).



References

[1] D Zhao, CA Barrow, AS Morgans, and . Carrote, Acoustic Damping of a Helmholtz Resonator with an Oscilating Volume, *AIAA Journal*, 47, 7, 2009.
[2] E Riva, MIN Rosa, Y Guo, and M Ruzzene, Adiabatic sound transport in acoustic waveguides with time-varying Helmholtz resonators, *Frontiers in Acoustics*, 2023.
[3] AG Hayrapetyan, KK Grigoryan, RG Petrosyan, and S Fritzsche, Propagation of sound waves through a spatially homogeneous but smoothly time-dependent medium, *Ann. Phys*., 333, 47-65, 2013