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Nonlinear Waves and Turbulence in Photonics 2022

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2 Abstracts

Labyrinthine patterns with permanent dynamics in a nematic liquid crystal light valve

Echeverria-Alar, Sebastian
University of Chile, Chile

Large-scale self-organization in different physical contexts produces labyrinthine patterns. This complex network of stripes is, in general, static. In this contribution, we show that in a nematic liquid crystal light valve experiment is possible to observe a labyrinthine pattern but with permanent motion. We characterize the dynamics by computing the maximum Lyapunov exponent and the power spectrum of the amplitude, and the phase of the 2D signal. Also, we propose a prototype Swift-Hohenberg equation that allows us to qualitatively explain the phenomenon.

Polarization-induced double-collapsed snaking in Kerr resonators

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We investigate the formation of vector solitons in weakly birefringent high-Q resonators. The presence of nonlinear polarization mode coupling in weakly birefringent high-Q resonators subject to a coherent optical injection allows stabilizing up to two families of vector dissipative solitons. Depending on dispersion properties of the system, these solitons can be either bright or dark[1,2,3]. A pair of coupled Lugiato–Lefever equations were used to investigate the dynamical properties of interacting laser fields confined in Kerr optical resonators. The normal dispersion regime is considered, and it is shown that two branches of dissipative solitons coexist and exhibit different peak powers and polarization properties. The input-output characteristics can possess either a bistable or a tristable homogeneous response. The coexistence of two branches of localized states is not possible in this dispersion regime without taking into account the polarization degrees of freedom. The stabilization mechanism of these localized states is attributed to a front locking mechanism, contrary to the case of anomalous dispersion where the underlying cause was modulational instability. Their bifurcation diagrams exhibit a heteroclinic snaking type of instability.

References:

[1] Etienne Averlant, Mustapha Tlidi, Krassimir Panajotov, and Lionel Weicker, Opt. Lett., 42, 2750-2753, (2017)

[2] B. Kostet, S. S. Gopalakrishnan, E. Averlant, Y. Soupart, K. Panajotov, and M. Tlidi, OSA Continuum, 4, 1564-1570, (2021)

[3] B. Kostet, Y. Soupart, K. Panajotov, and M. Tlidi, Phys. Rev. A, 104, 053530, (2021)

Permanent dislocation dynamics in a liquid crystal light valve induced by translational coupling

Pinto, David
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We explore the dynamics of a liquid crystal light valve with optical feedback. This feedback is translated thanks to a misalignment in the experiment. Exploring the translation parameter, instabilities to traveling or turbulent patterns are achieved. Surprisingly, there exists an intermediate state connecting these behaviors in space, characterized by a squared logarithmic law for dislocations accumulation in the translation direction. This state is predicted numerically by simulations and verified in the experiment. We show how these states are described by an inhomogeneous Ginzburg-Landau with advection, from which the dislocation distribution in space can be predicted. The general character of this equation allows the application of the theory to various nonlinear systems with broken reflection symmetry. Particularly, we show how the same law applies to vegetation patterns in sloped environments.

Higher order dispersion solitons: Families of exact solutions

Qiang, Long
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Solitons are pulses that balance nonlinear effects with the effect of dispersion. In the lowest order approximation, the (inverse) group velocity depends linearly on frequency. This quadratic dispersion often dominates higher orders of dispersion, which correspond to more complicated relations between group velocity and frequency. Recent studies have shown that solitons dominated by higher order dispersion effects give rise to a large family of possible soliton solutions. We study soliton solutions in formed in higher order dispersion systems, for example in our fibre laser that includes a spectral pulse shaper, and present families of exact analytic solutions.

How numerics add to the instabilities of the generalised nonlinear Schrödinger equation

Severing, Fenja
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Nonlinear dispersive waves can experience modulational instability as described by the nonlinear Schrödinger equation (NLSE). Solved numerically by the split-step method (SSM), not only physical instabilities occur, but also unwanted numerical ones. Previous work considers how to avoid the numerical instability of the NLSE.

Various setups in fibre optics are modelled by a generalised NLSE (GNLSE), for instance super continuum generation with input frequencies at zero dispersion wavelength. Here, we discuss a critical criterion for the correct spatial discretisation to avoid numerical instability in the context of the GNLSE. It can be seen that more accurate models featuring higher orders of dispersion come with a higher risk of including artefacts.

Inverse design of a flat dispersion Photonic Crystal cavity

Talenti, Francesco Rinaldo
Sapienza University of Rome, Italy

Contrarily to rings or disks, the resonances of Photonic Crystal (PhC) cavities are not naturally equally-spaced in the frequency domain. Here we present a technique to systematically design PhC resonators with a tailored disperion curve, with the objectives of developing an Optical Frequency Comb (OFC) PhC-based technology, miniaturization of parametric sources for quantum technologies and mode-locked lasers.

3 List of Speakers

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