Master 2 “Photonics, Complex and Quantum Systems (PhoCQS)”: Research Training 2023-2024

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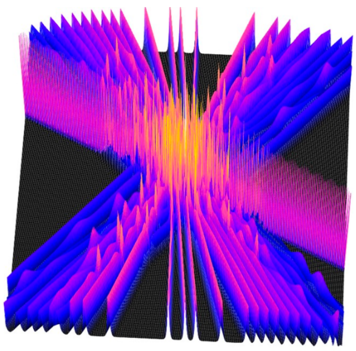
Topic: Nonlinear Dynamics of complex Systems

Soliton gas in a nonlinear electrical line

Recently, a new theme in turbulence theory has emerged in connection with the dynamics of strongly nonlinear random waves propagating in conservative systems described by integrable equations such as the Korteweg-de Vries (KdV) and 1D nonlinear Schrodinger (NLS) equations. This kind of random wave motion in nonlinear conservative systems, dubbed *integrable turbulence*, was first explored at PhLAM and has garnered considerable interest from both theoretical and experimental viewpoints.

Localized nonlinear solitary waves, termed solitons in the context of integrable systems, are a ubiquitous and fundamental feature of nonlinear dispersive wave propagation. Solitons exhibit particle-like properties such as elastic, pairwise interactions accompanied by certain phase/position shifts and have been extensively studied both theoretically and experimentally. The particle-like properties of solitons suggest some natural questions pertaining to the field of statistical mechanics, e.g. one can consider a *soliton gas* as an infinite ensemble of interacting solitons characterised by random amplitude and phase distributions.

The goal of this internship is to build an electrical line in which wave propagation is described at the leading order by the focusing 1D-NLS equation. Once the electrical line will be characterized in terms of propagation/interaction of individual solitons, it will be used to investigate some statistical properties of large random soliton ensembles that will be compared with predictions from the kinetic theory of soliton gas.



Space-time plot showing a soliton gas in a physical system described by the focusing 1D-NLS equation