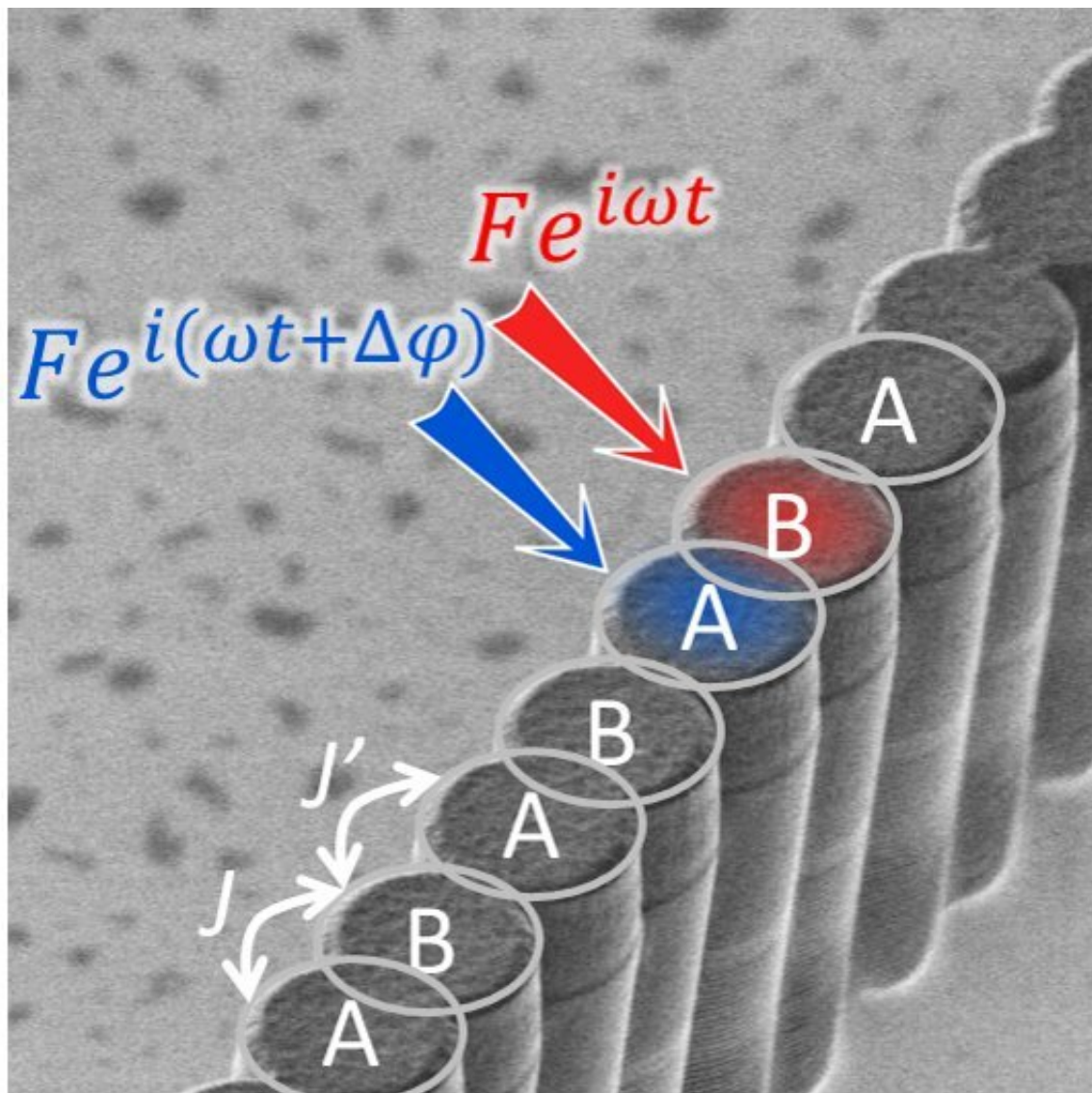


The formation of gap solitons in a 1D dissipative topological lattice

June 9 2022, by Ingrid Fadelli



Scanning electron microscopy image showing a chain of semiconductor cavities. The distance between the cavities is modulated, which gives rise to two different values of the coupling J and J' between adjacent cavities (represented

schematically by double white arrows). This modulation of the coupling provides the lattice with topological properties. Two cavities of the lattice are excited by two lasers of amplitude F , angular frequency and presenting a phase difference. Credit: C2N/CNRS.

Topological photonics is a rapidly evolving area of research that focuses on the design of photonic lattices where the behavior of light is inspired from the physics of topological insulators. While most studies in this area presented photonic systems with linear topological properties, recent works have started paving the foundations of non-linear topological photonics.

Researchers at Université Paris-Saclay CNRS have recently reported the nonlinear response of a topological [lattice](#) implementing a driven-dissipative version of the Su-Schrieffer-Heeger model; a renowned elementary topological framework that describes particles hopping on a 1D lattice. The findings gathered by the team at Université Paris-Saclay CNRS, published in *Nature Physics*, show that coherent driving in topological lattices can be exploited, allowing physicists to stabilize new nonlinear phases.

"In 2017, our group [demonstrated the first topological laser using a 1D lattice of semiconductor resonator](#) very similar to the one used in our recent study," Sylvain Ravets and Jacqueline Bloch, two of the researchers who carried out the study, told Phys.org. "In this early work, however, we were using the linear topological properties of the system."

The recent study by Ravets, Bloch and their colleagues builds on their past research efforts, with the aim of extending their investigation to non-linear topological physics, which has so far mainly been explored in the context of conservative systems. In their experiments, the researchers

used a platform with a significant optical nonlinearity, which is subjected to continuous drive and dissipation.

"We used nanotechnologies to fabricate a 1D lattice of coupled non-linear resonators," Ravets and Bloch explained. "Each resonator consists of an optical cavity containing an active medium (a semiconductor quantum well), which provides the non-linearity. The coupling between neighboring cavities is staggered to implement the simplest topological model, known as the Su Schrieffer Heger model."

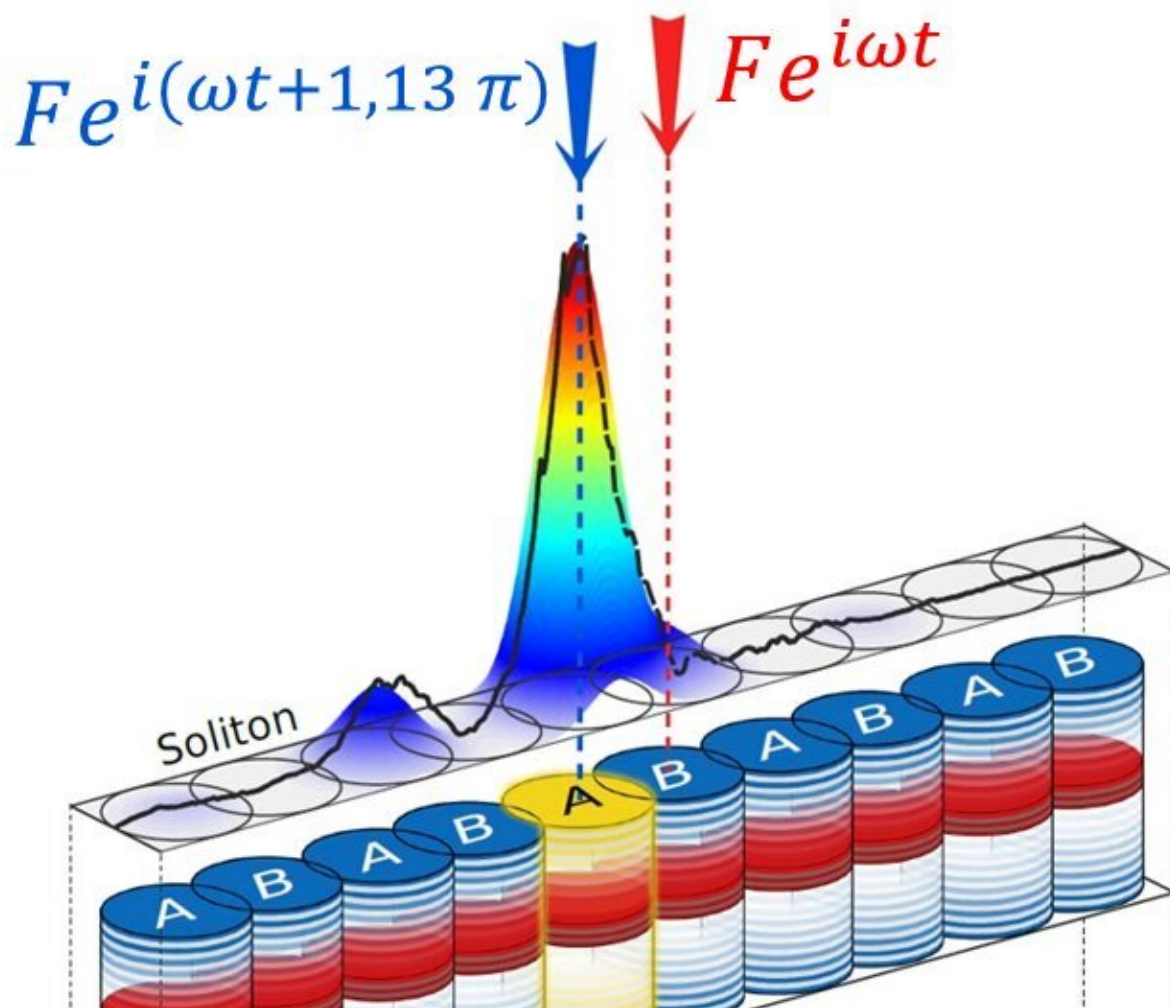


Illustration of the novel family of dissipative gap solitons discovered by the

researchers for the measured intensity profile of such soliton is shown at the top of the figure. The intensity is very strong on one single site, thus leading to the spectral detuning of this site with respect to the rest of the chain. The chain is thus effectively broken, and an edge state appears in the excitation spectrum, as shown at the bottom of the figure. Credit: C2N/CNRS.

To trigger a non-linear response in their 1D lattice, Ravets, Bloch and their colleagues shone one or two [laser beams](#) on specific parts of the lattice. Subsequently, they monitored the transmitted intensity as a function of the input laser power.

"A particularly relevant knob that we used in our experiment is the relative phase between the excitation beams, which provides a new level of control that had not been considered so far," Ravets and Bloch said.

The experiments carried out by the researchers yielded novel and interesting results. Specifically, the team uncovered the formation of new gap soliton families, which are stabilized by the resonant excitation. These gap solitons do not exist in conservative systems, such as coupled waveguides operating in propagative geometries.

"These solitons have the same profile as a topological edge state, and actually induce the appearance of a topological edge state for excitations on top of the nonlinear steady state. We like to call this ability to control the system through the engineering of the laser excitation scheme 'drive engineering,'" Ravets and Bloch said.

The recent study by Ravets, Bloch and their colleagues highlights the possibility of exploiting coherent driving to stabilize nonlinear phases in topological photonic systems. In the future, the experimental methods outlined in their paper could be used to control the topology of 1D

photonic systems and could also be extended to 2D systems.

"In our next study, we plan to extend these ideas to photonic topological insulators in 2D lattices where our aim will be to demonstrate the ability to optically control the topology of a non-linear photonic lattice through the engineering of the drive and dissipation," Ravets and Bloch added.

More information: Nicolas Pernet et al, Gap solitons in a one-dimensional driven-dissipative topological lattice, *Nature Physics* (2022). DOI: [10.1038/s41567-022-01599-8](https://doi.org/10.1038/s41567-022-01599-8)

© 2022 Science X Network

Citation: The formation of gap solitons in a 1D dissipative topological lattice (2022, June 9) retrieved 26 June 2024 from <https://phys.org/news/2022-06-formation-gap-solitons-1d-dissipative.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.