placement of the bridges breaks the symmetry in the array. Both the relative locations of wide and narrow bridges as well as the actual bridge widths affect the behaviour observed in this system. Bridges are located at the vertices in such a way that they encourage the formation of moment loops, which favours the formation of the long-range ordered state (Fig. 1c). Tuning the widths of the bridges changes the phase transition temperature. The authors observed a range of transition temperatures and, more importantly, transition temperatures both above and below the blocking temperature. The blocking temperature is where the magnetic moments stop fluctuating, so as the system is cooled down the magnetic moments will settle into whatever state they were in when the system went through the blocking temperature.

Using this modified artificial kagome ice, Hofhuis et al. were able for the first time to observe the long-range ordered state in kagome ice. Samples with different transition temperatures show the magnetic state throughout the phase transition. The symmetry breaking in the array fundamentally changes the way the system approaches the ordered state. In unbridged kagome ice, the charge on vertices is ordered before the spins. Because the bridges change the local interactions at the vertices, this modified system favours spin ordering before exhibiting charge ordering.

Hofhuis et al. carried out a careful analysis of temperature-dependent data in the samples that show long-range ordering. By comparing this data to Monte Carlo simulations, they were able to characterize the critical phenomena of this phase transition. They observed a clear splitting indicating the transition temperature to be 339 K.

The real space imaging of the long-range ordered state in kagome artificial spin ice, albeit a kagome artificial spin ice with modified symmetry, is an impressive accomplishment in itself. Equally exciting from this work are the thoughtful new tools the authors have used to achieve this feat. The idea of modifying local interactions without significantly altering the overall geometry of the array opens a world of new possibilities for designer artificial magnetic systems. The general properties of the array could be tuned to address any number of fundamental questions by judicious placement of the bridges. Varying the width of the bridges could serve as a controllable way to introduce disorder into the system.

The precision in the lithography used to pattern these systems is also a noteworthy advancement. The width of the bridges has to be controlled reliably with nanometre precision to observe the phase transition in this system. Combining this precision patterning process with the right geometric design would allow artificial spin ice to be used in applications such as reservoir computing[8]. ❐

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Competing interests

The author declares no competing interests.

CAVITY POLARITONS

Topological interface of light

Upon combining dissipative and nonlinear effects in a bipartite lattice of cavity polaritons, dissipatively stabilized bulk gap solitons emerge, which create a topological interface.

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Cavity polaritons are bosonic light–matter quasiparticles resulting from the strong coupling between quantum-well excitons and photons confined in a cavity[1]. Large optical nonlinearities — a result of the strong interactions between excitons — make cavity polaritons an attractive experimental way to probe interacting topological phases. Combining these strong nonlinearities with the inherent losses of photons, Nicolas Pernet and colleagues, writing in *Nature Physics*, have now studied a driven-dissipative version of the Su–Schrieffer–Heeger (SSH) model in a polariton lattice[2].

The SSH model[3] is one of the canonical examples in the field of topological phases of matter and describes a one-dimensional chain with alternating coupling constants resulting in two sublattices. In the topological phase, zero-energy states that are localized to the ends of the chain appear. The chiral symmetry of the model ensures that these end states are localized on only one of the sublattices. In their experiment, Pernet and colleagues went beyond this familiar picture by probing the nonlinear properties of such a system.

Solitons are localized wavepackets that do not spread. Topological gap solitons are one type of soliton that is created by defects induced by nonlinearity in a photonic topological insulator[4]. To realize such a gap soliton, Pernet and colleagues studied a chain of semiconductor pillars that realize the SSH model with a defect in the middle (Fig. 1a), resulting in a topological state in the linear regime.

Probing the interface defect with a quasiresonant pump laser allowed the team to access the nonlinear regime, evidenced by the observation of a hysteresis cycle in the transmitted intensity. In the high-intensity branch of the cycle, a topological gap soliton occurred, which had the same spatial profile as the linear topological interface state: the core is localized around the defect whereas the two exponentially decaying tails are sublattice-polarized (black line in Fig. 1b). As such, Pernet and colleagues realized a nonlinear topological gap soliton

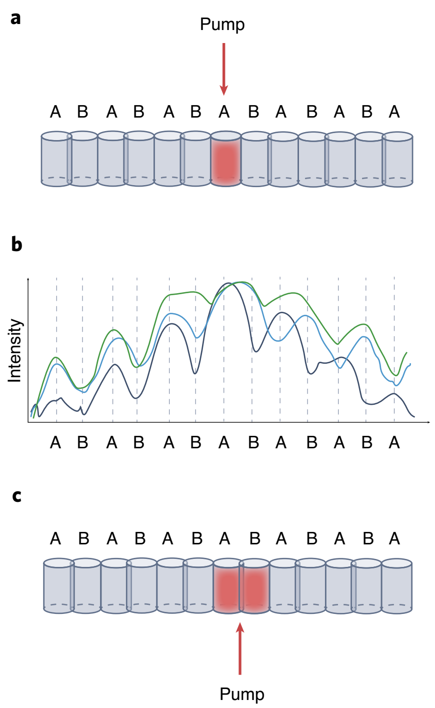

Fig. 1 | Soliton profiles on a SSH chain with pillar sublattices A and B. a, An SSH chain that contains a defect, which is optically pumped (red), supports a topological gap soliton. **b**, The topological gap soliton (black) is localized on the same sublattice as the defect, here the A sublattice. A similar spatial distribution of optical power along the chain occurs for a bulk gap soliton at low pump power (blue), but the bulk gap soliton loses some of its sublattice polarization for higher pump powers (green). **c**, Without a topological defect, optical pumping of an A,B site (red) results in a bulk gap soliton.

that bifurcated from the linear topological interface state.

Having established the existence of topological gap solitons in their sample, the team studied the bulk of the SSH chain without defects (Fig. 1c). Pumping a dimer in the middle of the chain with a pump frequency inside the topologically non-trivial SSH gap generated 'bulk gap' solitons, provided the laser power was above a certain threshold value. A second threshold exists at higher pump powers, above which the soliton core spreads to adjacent dimers in the SSH chain. These thresholds correspond to values for which the polariton field locally enters the nonlinear regime.

The spatial profile of these bulk gap solitons was similar to the localization of the topological gap solitons (blue and green lines in Fig. 1b). The soliton core was localized on each sublattice in the dimers, but the evanescent tails were strongly localized on one sublattice to the left of the core and on the other sublattice to its right. This behaviour of the tails is a consequence of the chiral symmetry of the SSH chain and cannot be observed for the soliton that appears in the topologically trivial gap at higher energies. These bulk gap solitons are robust against local defects on the sublattice on which the tail does not localize, as theoretically predicted for conservative systems[5].

Pernet and colleagues also investigated the presence of a non-Hermitian defect induced by non-resonant pumping of a sublattice site in a dimer next to the soliton core. If the defect is present on the sublattice to which the soliton tail localizes, the spatial symmetry with respect to the soliton core is broken, and the power spectrum becomes asymmetric. However, if this defect is present on the other sublattice, the threshold powers are the same as without a defect. The bulk gap soliton is therefore robust against this second type of defect.

Although the topological gap soliton in SSH chains with an interface and the bulk gap soliton in chains without one appear when driving the system to the nonlinear regime, Pernet and colleagues went one step further and investigated a new type of soliton that is stabilized by dissipation. This soliton is excited by driving the two pillars in a dimer with two separate laser beams that have the same amplitude on both sublattices but a different phase. By tuning this phase difference, different regimes can be accessed.

The most interesting case appears when the phase difference is close to but not equal to the maximum value. In this case, a bulk soliton occurs that is localized to only one sublattice with an exponential tail in only half of the SSH chain. The spatial profile of the soliton thus looks very similar to that of a zero-energy end state existing at the end of a topologically non-trivial SSH chain.

The sublattice polarized dissipative soliton has no counterpart in undriven or conserved systems, and its presence has remarkable consequences. Because the soliton core is localized to only one site in the driven dimer, a local potential barrier is created. The lattice is effectively split into two SSH chains, one with a weak link at the end and one with a strong link at the end, separating a topologically non-trivial and a topologically trivial chain. Calculations suggest the emergence of a topological state at the effective interface separating the two chains. Pernet and colleagues thus successfully created a topological interface of light.

Pernet and colleagues' work establishes polariton lattices as another suitable means for exploring non-Hermitian topology. In particular, the natural presence of nonlinear effects allows the study of interactive physics that has so far received little attention. A promising prospect is the effects of nonlinear physics on non-Hermitian exotic phenomena such as exceptional points and the non-Hermitian skin effect.

Moreover, this work is relevant in the context of quantum fluids of light[6], where one research direction focuses on discovering exotic collective phenomena in polaritonic systems induced by a balance between drive and dissipation. The dissipatively stabilized solitons observed by Pernet and colleagues show that such exotic many-body phases can be induced by coherent driving. ❐

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