Engineering interactions in networks of polariton condensates and the prospect of neural architectures

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Exciton-polariton condensation has now been demonstrated as a flexible platform to study light-matter wave physics with transients in the order of picoseconds. Here, I will discuss the all-optical engineering of polariton condensate networks and the corresponding potential landscape of non-condensed exciton reservoirs induced by the nonresonant beams. We show that one can deterministically tune the interaction strength between different condensates by using another set of intruding nonresonant optical beams [1]. This allows switching of the phase arrangement between individual as well clusters of condensates (see Fig.1a,b). Such control enables us to study the physics of synchronous phases in large networks of nonlinear oscillators and intermediate regimes where chaotic trajectories reside.

I will present results on how the band structure of such all-optical lattice systems can be engineered to support polariton modes unique to the geometry in question. Of interest are polyacetylene-like lattices where the staggered interactions between condensates split the bands and a multimodal condensate appears. Implanting lattice defects leads to the appearance of *dark* and *bright* condensate defect states reminiscent of solitonic solutions. For polygon structures, characterized by discrete rotational symmetry, we find modes supporting persistent circulating currents along the polygon edges. Lastly I will discuss the prospect and challenges of using polariton condensate networks as neuromorphic hardware. Specifically, the advantage of time-delay interactions [2] over Josephson interactions between condensate nodes and how it suits a neural network strategy known as *Reservoir Computing* [3] (see Fig.1c).

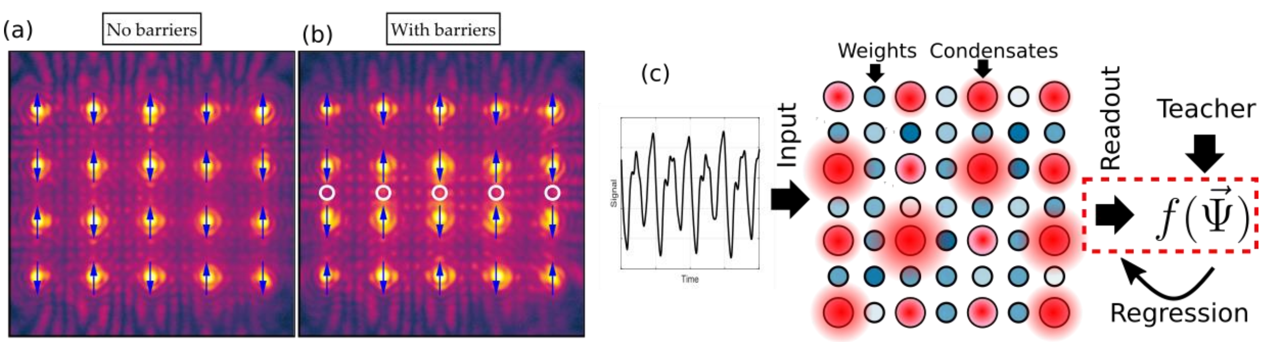

Fig. 1. A real space photoluminescence of a 4x4 polariton condensate lattice without (a) and with (b) nonresonant optical barriers [white circles] switching the parity of the upper and lower half denoted by the blue arrows. (c) Schematic of a reservoir computer where a resonant analogue signal is fed into a condensate network undergoing linear regression training in the same spirit as recurrent neural networks.

References

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