Networks of liquid light

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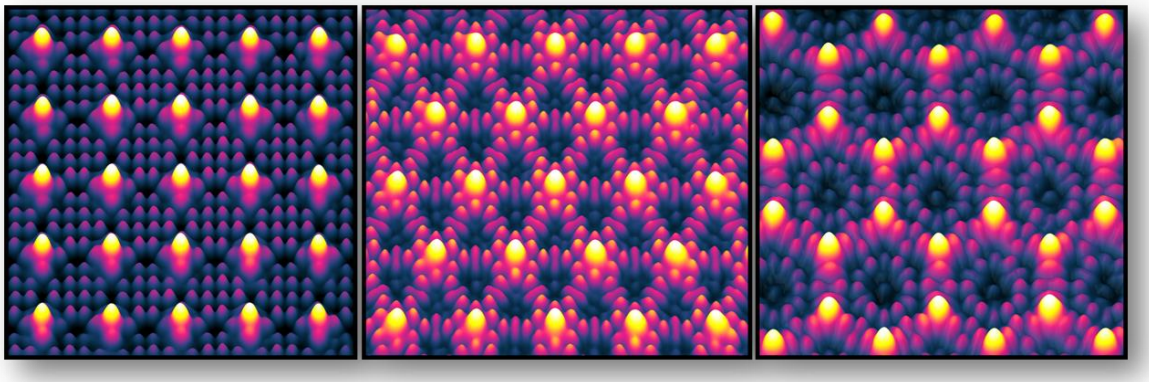
Recent years have seen a surge of advancements in optical manipulation over bosonic light-matter quasiparticles known as exciton-polaritons in semiconductor microcavities. These particles appear under strong-coupling conditions between cavity photons and embedded quantum-well excitons. Characterised by very high interaction strengths, nonlinearities, and picosecond timescales, these coherent light sources provide an exciting testbed to explore room-temperature nonequilibrium Bose-Einstein condensation in the optical regime.

In this talk, I will present results on all-optically engineered macroscopic networks of connected exciton-polariton condensates, which permit studies on fundamental emergent behaviours in complex nonequilibrium dynamical systems while subject to a drive and bosonic final-state stimulation. I will explain how a uniquely polaritonic feature gives rise to so-called “ballistic condensates” which, when spatially coupled, form a bosonic condensed matter analog of time-delay coupled oscillators that are ubiquitous in nature. I will present experimental and theoretical results on large-scale condensate networks displaying aforementioned emergent behaviors, including: spontaneous synchronization with unprecedented long-range spatial and temporal correlations [1,2], geometric frustration and formation of persistent superfluid currents [3], non-invasive optical control of the network coupling weights [4], synthesis of artificial lattices for studies of non-Hermitian topological physics [5], flatbands [6], and vortex frustration [7].



[1] Töpfer et al., Communication Physics **3**, 2 (2020).
[2] Töpfer et al., Optica **8**, 106 (2021).
[3] Cookson et al., Nature Communications **12**, 2120 (2021).
[4] Alyatkin et al., Physical Review Letters **124**, 207402 (2020).
[5] Pickup et al., Nature Communications **11**, 4431 (2020).
[6] Alyatkin et al., Nature Communications **12**, 5571 (2021).
[7] Alyatkin et al., arXiv:2207.01850 (2022).