Optical sculpting and interactions between ballistic polariton condensates

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Host: Assistant Professor Timothy Liew

Abstract

Networks of interacting polariton condensates have been shown to offer a versatile platform for engineering and studying complex systems such as phase or spin-synchronized lattices [1, 2]. In this talk, we will present an in-depth experimental study of the nature of interaction, synchronization and coherence between spatially separated, non-trapped and ballistically expanding polariton condensates. We show that this driven-dissipative system differs from a conventional Josephson-junction of trapped condensates since the coupling is not mediated by a tunneling current but by radiative coupling inherently connected with finite time of particle transfer [3]. Synchronization of polariton condensates is observed for macroscopic distances (>100 μm) in systems of only two spatially separated condensates, as well as in 1D and 2D lattices of polariton condensates. We demonstrate that interactions in-between condensates can be optically controlled [4] and are described by delay-differential equations which makes networks of non-trapped polariton condensates a promising platform to study time-delay coupled systems [5], that arise in many areas of nature.

Using ordered arrangement of multiple lasers, we demonstrate our ability to synthesize various polariton crystal landscapes. Specifically, we investigate polyacetylene-like lattices (Su-Schrieffer-Heeger system) where laser engineered dimerised interactions allow us to observe period doubling of the crystal bands and multimodal condensation. When lattice defects are implanted flat-bands appear in the band structure with subsequent polariton condensation into solitonic solutions. Moreover, in periodic polygon structures, characterized by discrete rotational symmetry, we find modes supporting persistent circulating currents along the polygon edges. Lastly, we briefly discuss the prospect and challenges of using polariton condensate networks as neuromorphic hardware [6].

References:

Short Biography

Mr. Julian Töpfer completed his physics degree at the Karlsruher Institute of Technology (Germany) in 2017 and now pursues a PhD at the University of Southampton under the supervision of Prof. Pavlos Lagoudakis. Dr. Helgi Sigurdsson is a Research Fellow at the University of Southampton, School of Physics and Astronomy in the Hybrid Photonics group of Prof. Pavlos Lagoudakis. He specializes in theoretical studies involving strong light-matter physics with a strong focus on exciton-polariton condensates. He received his BSc in physics from the University of Iceland in 2012, and PhD in Research Physics at the Nanyang Technological University, Singapore in 2016 under the supervision of Prof. Ivan Shelykh.