Quantum Fluids of Light in a Chip

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In this seminar, we explore the burgeoning field of strong light-matter interactions, particularly when photons are confined in semiconductors, giving rise to a unique quasiparticle – the polariton. This hybrid state, combining photons and electronic excited states, exhibits remarkable properties, evolving into a coherent state known as Bose-Einstein condensate, akin to cold atoms. Beyond the potential for all-optical devices with advantages in energy consumption, dissipation-less operation, and high clock frequencies, [1] polaritons have revealed fascinating macroscopic quantum phenomena, including superfluidity, [2] quantized circulation, [3,4] and parametric effects, to cite a few. More recently it has been shown that these fluids also excel in neuromorphic computation, opening doors for hardware implementation of artificial neural networks. [5,6]

The seminar will spotlight the dynamic aspects of a quantum flow of polaritons, revealing their potential as a platform for studying complex phenomena difficult to simulate in classical systems. A particular focus will be on turbulence in a quantum system, which, beyond its fundamental interest, can serve as an ideal test bed for the study of two-dimensional classical turbulent flow. [7] By simultaneously mapping flow velocity and density in space, we gain insights into the ultrafast dynamics of thousands of vortex states. [8] Additionally, the seminar will explore the exciting possibility of optically creating a Josephson junction and observing flux onset in an annular condensate, reminiscent of superconducting Josephson junctions.

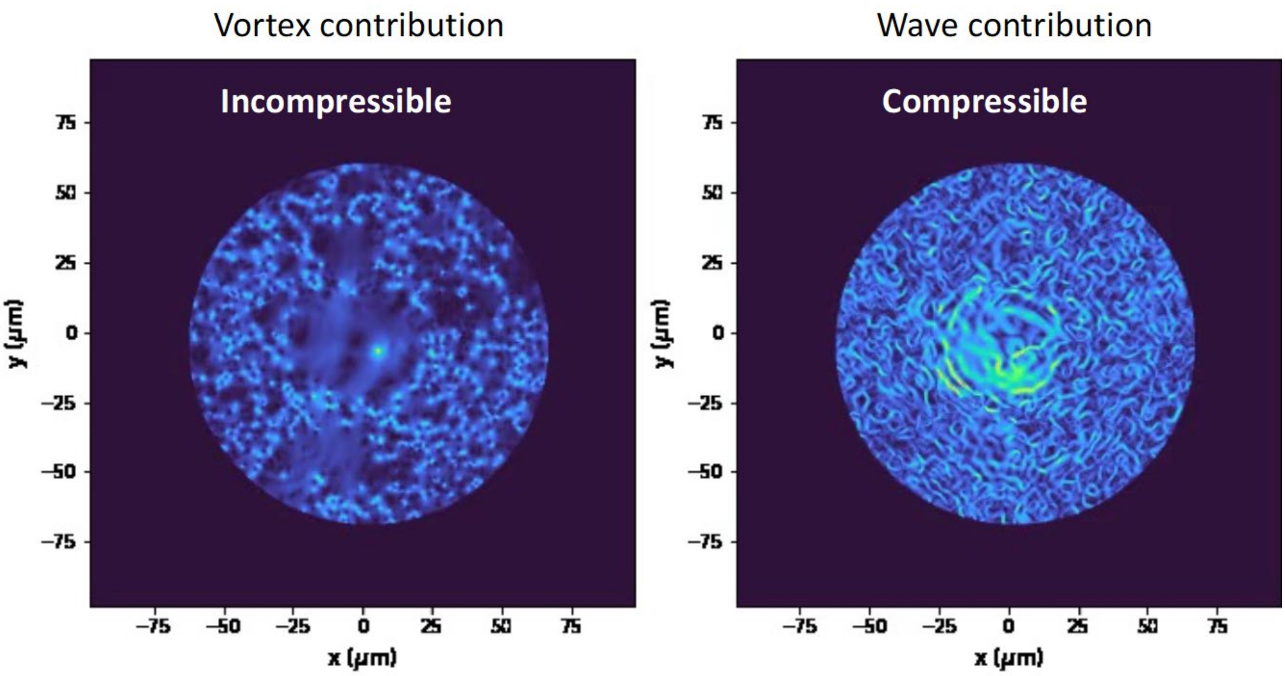

Figure: Incompressible and compressible superfluid velocity decomposition of a turbulent polariton fluid

References

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[4] R. Panico, *et al*., Dynamics of a Vortex Lattice in an Expanding Polariton Quantum Fluid, *Phys. Rev. Lett*. 127, 047401 (2021).

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[8] R. Panico, et al. Conformal invariance of 2D quantum turbulence in an exciton–polariton fluid of light, *Appl. Phys. Rev.* 10, 041418 (2023).