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Engineering Quantum Circuits in a Polariton Condensate

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Abstract:

Microcavity exciton-polaritons are quasiparticles that result from the hybridisation of excitons (bound electron hole pairs) and light confined inside semicon-ductor microcavities. At low enough densities, they behave as bosons according to Bose-Einstein statistics, but they have finite lifetimes and have to be continuously repopulated. Resent experiments investigated polariton condensation and the phenomena associated with it, such as pattern formation, quantised vortices and solitons, increased coherence and cross- over to regular lasing.
Polariton condensates have a number of features that put them aside from other condensates: (1) they are nonequilibrium systems capable of pattern forming; (2) polaritons condense at relatively high (even room) temperatures due to very small effective masses; (3) polaritons leak out of the cavity in the form of photon emission carrying all information related to their density, frequency, phase, spacial and temporal coherence, so completely characterising the condensate inside the cavity (4) polaritons have po-larisation degree of freedom that are affected and, therefore, can be manipulated by magnetic fields; (5) one can easily engineer any external landscape and vary pumping in space and time; (6) polariton condensates form quantized vortices in response to slight changes in the environment: when flow exceeds critical velocities, when fluxes interact, when trapped in harmonic potentials, when pumping powers exceed a threshold for pattern

forming instabilities, when magnetic field exceeds a threshold etc. In my talk I discuss mathematical modelling of the dynamical behaviour of polariton condensates and recent experimental findings on condensates pumped in localised space positions to generate new type of quantum circuits.

When polaritons condense they flow away from the pumping spot due to polariton-polariton interactions and repulsive interactions with hot reservoir excitons. The outflow of polaritons interact with polaritons created by other pumping positions resulting in phase difference locking between condensates or to a relative dynamical motion between the spots [1, 2]. By controlling the geometry of pumping spots and the parameters of the pump it is possible to create and control the quantum circuits consisting of many condensates [3, 4].

References

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