Crescent states in charge-imbalanced polariton condensates

Authors: Artem Strashko[1], Francesca M. Marchetti[2], Allan H. MacDonald[3], Jonathan Keeling[4]
Institutions: 1. Center for Computational Quantum Physics, Flatiron Institute. 2. IFIMAC, Universidad Autonoma de Madrid. 3. University of Texas, Austin. 4. University of St Andrews.
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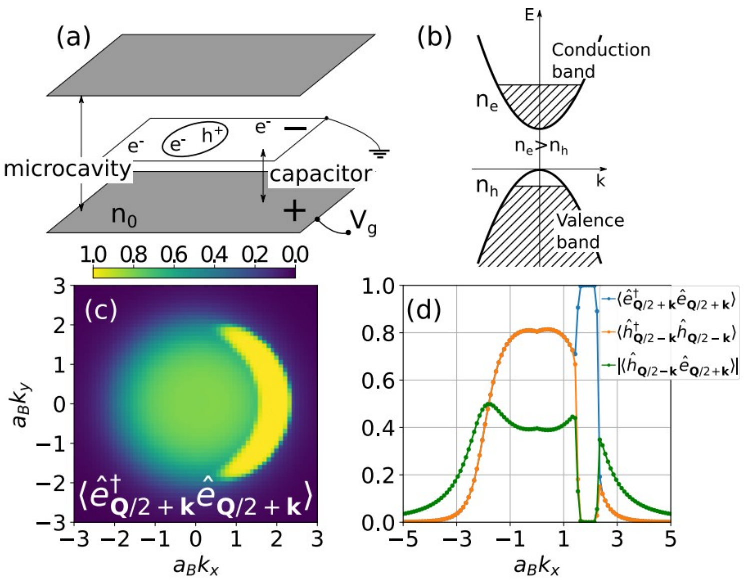
Abstract: We study two-dimensional charge-imbalanced electron-hole systems embedded in an optical microcavity. We find that strong coupling to photons favours states with pairing at zero or small centre of mass momentum, leading to a condensed state with spontaneously broken time-reversal and rotational symmetry, and unpaired carriers that occupy an anisotropic crescent-shaped sliver of momentum space.



(a,b) Cartoon of system: electronically doped quantum well strongly coupled to a microcavity. (c) Electron occupation in momentum space. Excess electrons occupy a crescent-shaped region. (d) Cross section at k_y=0, showing electron and hole occupations and coherence.

Project Description: The same kind of paired state of fermions arises in many contexts from superconductors, to superfluid He^3 and cold atoms, to excitonic insulators. When the fermions that are being paired have imbalanced densities or masses, a "Fulde-Ferrel-Larkin-Ovchinnikov (FFLO)" state is expected, with pairing at a finite centre of mass momentum. We study the fate of this pairing when imbalanced fermions are placed in an optical cavity, forming a polariton state. We find that in place of the FFLO state, a new *"crescent state"* is formed. This state has persistent counterflow of excitons and photons, and anisotropic transport properties.

Key Results, Conclusions:

- Coupling to photons suppresses pairing momentum in imbalanced condensate, favouring crescent state.
- On varying charge doping, sequence of transitions from isotropic state, to crescent state, to "breached pair" state, FFLO state, and ultimately unpaired normal state.
- Crescent state should show rectification of AC current, anisotropic transport, and optical SHG signatures.
- Phase diagram calculated via variational density matrix approach.

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