Weak Disorder and Modulational Instability in Polariton Condensates.

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Microcavity defects lead to a disordered photonic potential landscape [1], which may undesirably affect the spatial distribution, propagation, and spatial coherence of exciton-polariton condensates, and may pin vortices [1, 2, 3]. As such, cavity disorder is often avoided in experiments and it's effects remain relatively under-studied.

Non-resonantly pumped polariton condensates have previously been shown to be modulationally unstable near threshold [5] due to self focusing non-linearities arising from interactions with an underlying excitonic reservoir. We propose that a disordered potential may seed an initial spatial profile which is reinforced by the modulational instability of the state, localising condensates to densities at which polariton blue-shift far exceeds the magnitude of the seed potential. Results for a ring shaped pump corroborate this idea, under this scheme polaritons propagate away from the excitonic reservoir and condense at the ring's centre, hence no self focusing and a more homogeneous emission.

We use a high Q-factor, long polariton lifetime (~ 100ps) GaAs/AlGaAs planar microcavity (as in [4]) with a high density of strain-induced cross-hatched dislocations along the crystal axes. This is excited non-resonantly with 100fs pulses centred at 709nm. When Pumping with a large (FWHM = 140μm) Gaussian spot, the condensate's shape is consistent over many pulses, with emission and propagation mostly confined along the axes of the disorder. This pattern persists far above threshold, albeit with more spatially homogenous emission, and is mirrored with a similar modulation in the condensate's spatial $g^{(1)}$ function. Spectrally narrow emission at a given k-vector below threshold indicates that the magnitude of the disordered potential is below 0.1meV, smaller than polariton blue-shift (~ 0.5meV) at large pump powers. In contrast, when pumping in a structured ring shape, a homogenous condensate is observed even at low polariton blue-shifts, which remains consistent as the cavity is translated and different disorder is sampled.

In the case of Gaussian pumping, more homogenous emission at high powers suggests a possible phase transition from a spatially modulated, disorder-affected state, to a homogeneous one. Analogous to the first-order dissipative phase transition seen in previous work [5].

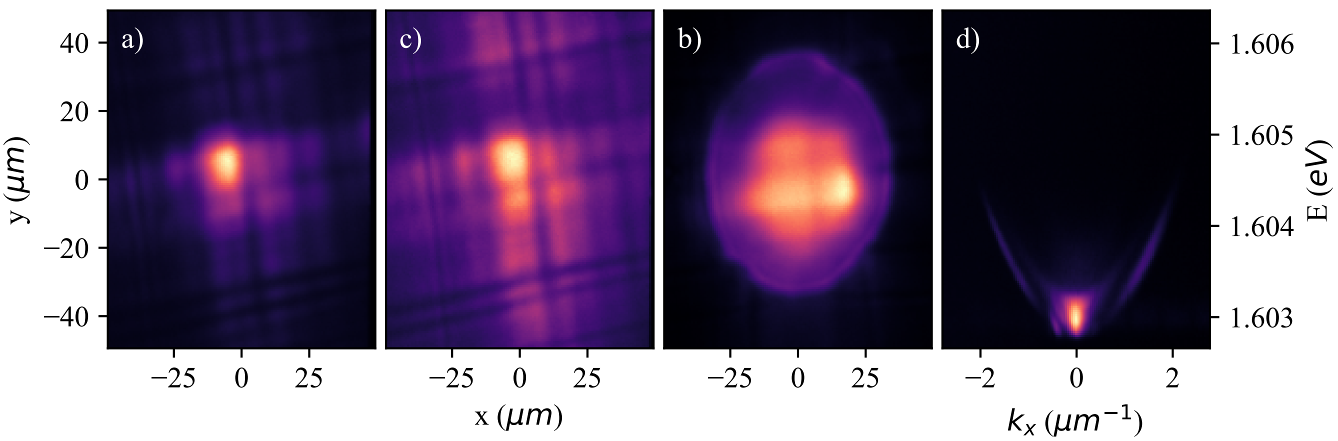

Figure 1: a,b) Real space emission of a polariton condensate at 2× and 4× threshold power under a 150μm FWHM Gaussian pump profile. c) Real space emission with 60μm diameter ring pump profile at threshold and d) it's corresponding dispersion (logarithmic scale).

References

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