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VERY LONG SPATIAL AND TEMPORAL SPONTANEOUS COHERENCE OF 2D POLARITON CONDENSATES ACROSS THE PARAMETRIC THRESHOLD

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Since the demonstration of polariton nonequilibrium condensation in semiconductor microcavities [1], its coherence properties have been investigated both theoretically and experimentally [1-4]. In fact they are crucial to understand the differences and analogies of the polariton condensates compared to either standard lasers or equilibrium condensates. Here we report the behavior of such properties across the parametric threshold. Above threshold we have found an extremely large coherence length and long coherence time, lasting approximately six times more than those previously reported for similar cavities.

The experiments are performed in an OPO configuration, at $k=0$ of the lower polariton branch and zero detuning, on a $\lambda/2$ -AlAs microcavity with a 25 nm GaAs QW at its centre, and a Rabi splitting of ~ 4.2 meV. We use a monomode laser, to reduce fluctuations of the polariton population, and a relative large beam area ($\phi \sim 50$ μm) to obtain a true 2D condensate. Its coherence properties are measured with a Michelson interferometer.

A finite correlation length is measured at an energy $\delta E = -0.19$ meV from the parametric threshold, as shown in Fig. 1(A). Once the threshold is reached, by changing the detuning of the laser, the visibility extends across the entire condensate (Fig. 1(B)) as predicted in Ref. [2]; therefore a spatial coherence is observed along ~ 50 μm , which is, to the best of our knowledge, the largest value reported up to now for 2D microcavities.

The coherence time is also enhanced significantly when reaching the parametric threshold, showing an increase of more than one order of magnitude, starting from $\tau_C \sim 100$ ps at $\delta E = -0.19$ meV up to $\tau_C \sim 3$ ns at threshold. The highest value for the coherence time reported so far for GaAs microcavities amounts to ~ 500 ps [3], for 10 μm condensates, mostly limited by disorder. In our high-quality GaAs/AlAs microcavity, and using a larger spot, we validate the predictions of Ref. [4], showing that much longer coherence times can be achieved under low number fluctuations either by increasing the pump power or enlarging the size of the condensate.

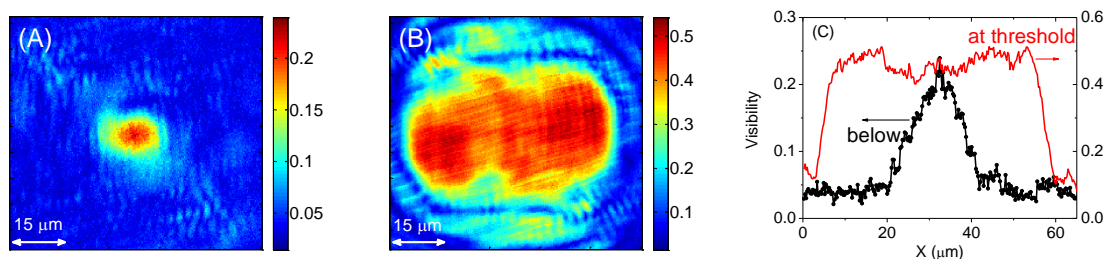


Fig.1: (A) Visibility map at $\delta E = -0.19$ meV from the signal state. (B) Visibility map at the OPO parametric threshold. (C) Comparison of horizontal visibility profiles below (dots) and above (line) threshold: while (A) and (B) emissions are comparable in size (50 μm) the visibility extension decreases strongly below threshold.

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