Two-dimensional optical trap producing exciton-polariton Bose-Einstein condensates in microcavity structures

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Exciton-polaritons are quasiparticles formed as a result of strong coupling between excitons in a quantum well and photons in an optical microcavity. Because they are particles with bosonic properties, they can form Bose-Einstein condensate. Due to the short lifetime and strong interaction with non-condensed polaritons and excitons, they are considered to be in a nonequilibrium state. The nonequilibrium character can be reduced by spatial separation of the condensate from the non-condensed particles i.e. excitonic reservoir. This can be performed by a ring-shaped potential that confines polaritons in its centre [1, 2]. Exciton-polaritons created beneath the excitation laser flow outside the spot to the inside of the ring and exhibit properties more similar to the equilibrium state [3].

In our work we demonstrate a method to shape the laser beam into a ring of variable diameter and steep edges. The ring-shaped beam was obtained using two axicons [4] and the diameter of the ring was changed from 2 to 6.5 μm. Special care was taken to keep the whole optical system very compact. The semiconductor microcavity containing semimagnetic quantum wells was excited by non-resonant optical pumping generated in this way.

Exciton-polariton condensates were obtained both on the ring perimeter and inside the ring, as shown in the Figure. All condensates demonstrate typical threshold-like behaviour with non-linear emission intensity increase, linewidth narrowing and energy blueshift. Even though the condensates are strongly localized in photonic potential minima, we have demonstrated that it is possible to populate the potential minima away from the excitation. Our work opens now the possibility to study the properties of localized condensates close to equilibrium in semimagnetic semiconductor samples.

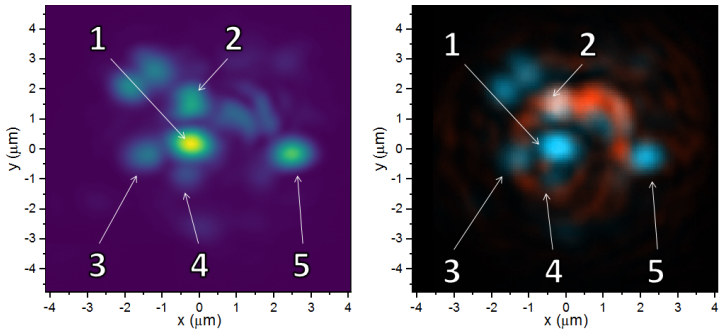

Figure. Left panel: the emission from exciton-polariton condensates in real space. Right panel: the same image with the condensate emission marked in blue and ring shape potential generated by the laser in red. Condensates 1 and 5 are separated from the reservoir, the condensates 2 - 4 are spatially overlapped with it.

[1] A. Askitopoulos et al., Physical Review B, **88**, 041308(R) (2013). [2] E. Estrecho et al., arXiv:1809.00757v2 (2019). [3] Y. sun et al., Phys. Rev. Lett. 118, 016602 (2017) [4] Q. Yong et al., Chinese Physics Letters **21** (2004).