COLLECTIVE OSCILLATIONS OF A TRAPPED EXCITON-POLARITON CONDENSATE

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Condensates of exciton-polaritons are nonequilibrium quantum fluids that exhibit an intriguing superfluid-like behavior [1], which, along with other collective properties, can be well understood by studying its elementary excitations. Recent experiments [2] measured the modified excitation spectrum but the near-zero momentum components, which are mostly affected by dissipation, were excluded. In this work, we observe collective oscillations, representing the low-energy excitations, of a high-density trapped condensate. Using an optically induced trap in the pulsed regime [3], we create condensates with long-lived sloshing that persist for the whole condensate lifetime, as shown in Figure 1. The longevity of the oscillation suggests that the damping due to friction from the normal (non-superfluid) component and the excitonic reservoir is minimal. The frequency of the oscillation, which is dominated by dipole modes, is around 10 GHz and chirps down as the density decays, confirming that the collective mode frequency depends on the mean-field energy. This work opens the way for probing and manipulating different oscillation modes which will shed light on unexplored properties of this weakly interacting system, such as the compressibility, hidden symmetry in two dimensions [4], and interaction of the first and second sounds.

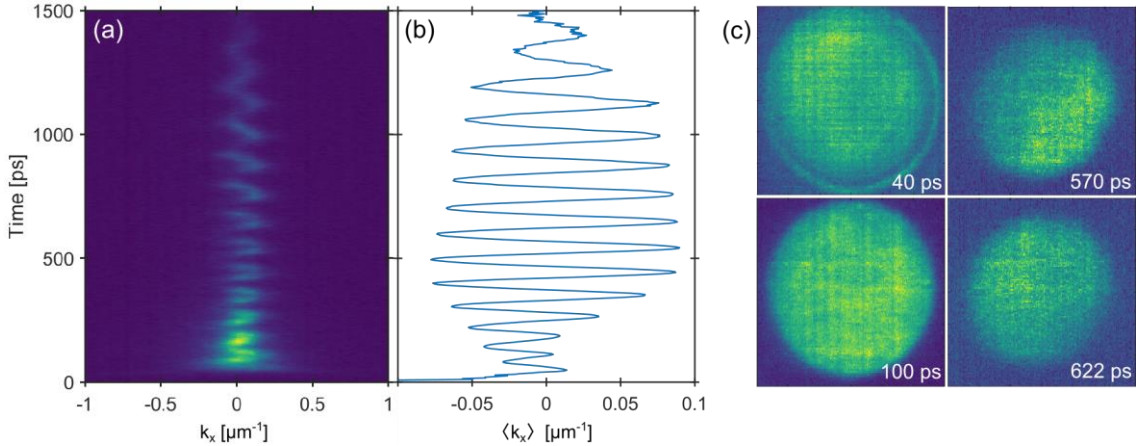

Fig. 1. Time-resolved (a) cross-section and (b) mean of the k-(momentum) space distribution of the sloshing condensate; (c) real space images of the condensate at different times.

References

[1] R. T. Juggins et al, *Nat. Comm*. **9**, 4062 (2018).
[2] M. Pieczarka *et al*., *arXiv:1905.10511*, 2019; P. Stepanov *et. al*., *arXiv:1810.12570v2*, 2018.
[3] E. Estrecho *et al*., *Phys. Rev. B,* **100**, 035306 (2019).
[4] L. P. Pitaevskii and A. Rosch, *Phys. Rev. A* **55**, R853(R) (1997).