Spontaneous emergence and tuning of phase coherence revivals within a quantum fluid

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Polaritons are quantum bosonic admixtures of excitons and photons, that have been shown to undergo the BEC phase transition and have been proposed as a platform for simulations of classical Hamiltonians [1]. The polariton architecture is advantageous for such endeavors, featuring extreme optical control and scalability enables straightforward realization of large scale lattices of interacting condensates limited mainly by the available optical power, while also featuring extremely efficient readout of the spin degree of freedom owing to the large number of particles populating the quantum degenerate condensation level. Additionally, we have recently demonstrated, that when the system is driven to the weak inter-particle interaction limit and interactions with the incoherent reservoir are suppressed, the coherence time of the polariton Bose gas increases to almost three orders of magnitude beyond the polariton lifetime of ~5ps, to the nanosecond range [2], underscoring the huge potential of the system should quantum effects be revealed, allowing individual spinor condensates to be treated as qubits [3]. Here we present and discuss initial experimental evidence towards the revealing of quantum coherence in spinor polariton BECs. It has been shown that in the optical trap configuration [4], the BEC tends to coalesce into one of its two spin eigenstates [5,6]. By spin polarizing the reservoir of particles (excitons) from which polaritons originate, combined with the macroscopic number of particles (N~2000) of the spinor condensate, we induce a local effective magnetic field on the system. The application of an effective field Ω will induce rotations of the spin state of the system around the Bloch sphere [3], while control of this field can serve as a means of coherent control of the BEC. By means of gated single shot delayed interferometric measurements of the condensate for the first time we uncover coherent rotations around the Bloch sphere that manifest as revivals of the first order normalized Glauber correlation function (g(1)(τ)) and demonstrate the extreme coherent control capabilities inherent in the system.

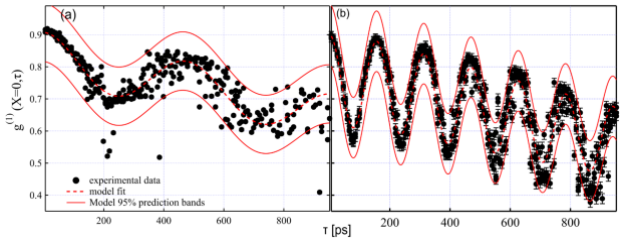

Fig. 1. Emergence of coherence revivals in a polariton BEC for increasing density. (a) For a condensate density around 1.5 times the threshold density we observe that the oscillation of the matter wave field accelerates and becomes more pronounced (b).

References

[1] N. G. Berloff, et al., Nature Materials 16, 1120 (2017).
[2] A. Askitopoulos, et al., (under review)
[3] T. Byrnes, K. Wen, and Y. Yamamoto, Phys. Rev. A 85, 040306 (2012).
[4] A. Askitopoulos, et al., Phys. Rev. B 88, 041308 (2013)
[5] A. Askitopoulos, et al., Phys. Rev. B 93, 205307 (2016).
[6] H. Ohadi, et al., Phys. Rev. X 5, 031002 (2015)