Probing Tan's contact in an exciton-polariton Bose-Einstein condensate

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The short-range behaviour of the many-body wavefunction of a quantum system with contact interactions is manifested in the momentum occupation distribution $N(k)$ as a power-law decay $\sim k^{-4}$ at large wavevectors. The asymptotic value $\lim_{k\to\infty} k^4 N(k) = C$ is referred to as "the contact" and has been linked to numerous universal thermodynamic relations in seminal papers of S.Tan [1]. The value of the contact has been successfully measured in fermionic gases at the unitary limit [2,3]. Similar studies are much more challenging in the case of bosonic quantum gases [4], where three-body Efimov resonances appear when approaching the unitary limit. Recently, the contact has been measured in a weakly interacting Bose-Einstein condensate (BEC), and significant deviations from theoretical predictions have been found [5].

Exciton polaritons are composite bosons resulting from the strong coupling between excitons and photons in a semiconductor microcavity. These quasiparticles can condense into a driven-dissipative BEC and form a macroscopically coherent many-body quantum state. We have recently observed experimental evidence of quantum depletion in a high-density exciton-polariton BEC [6], by probing the photoluminescence of the negative energy Bogoliubov excitation branch (so-called ghost branch – GB). Analysis of the asymptotic behaviour of momentum distribution in the GB allows for the extraction of the Tan's contact for various exciton-photon detunings, i.e. for different polariton-polariton interaction strengths and an excitonic fraction of the exciton-polariton quasiparticle, see exemplary data in Fig. 1. The obtained values of the contact show deviations from the theoretical predictions based on the local density approximation and Bogoliubov theory, which treats the exciton-polariton as a structure-less boson characterised by an experimentally measured contact interaction strength. We discuss the influence of the composite nature of exciton-polaritons on the short-range behaviour of the condensate wavefunction and possibility to connect the extracted Tan's contact to thermodynamical properties of exciton-polariton condensate.

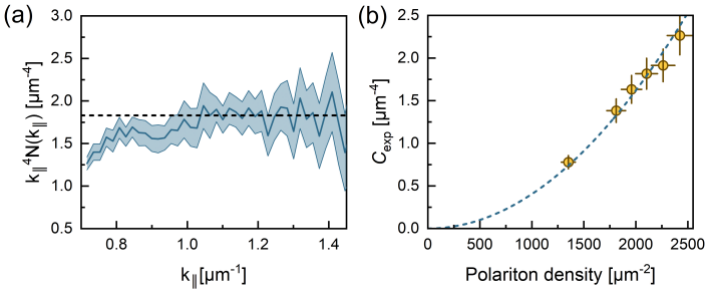

Fig. 1 (a) Measured dependence $k^4 N(k)$ for extraction of the contact. (b) Tan's contact as a function of polariton density fitted with a quadratic function.

References

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