Scale Invariance and Universality in a Cold Gas of Indirect Excitons

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Abstract

We address, theoretically, the puzzling similarity observed in the thermodynamic behavior of independent clouds of cold dipolar excitons in coupled semiconductor quantum wells. We argue that the condensation of self-trapped exciton gas starts at the same critical temperature in all traps due to the specific scaling rule. As a consequence of the reduced dimensionality of the system, the scaling parameters appear to be insensitive to disorder.

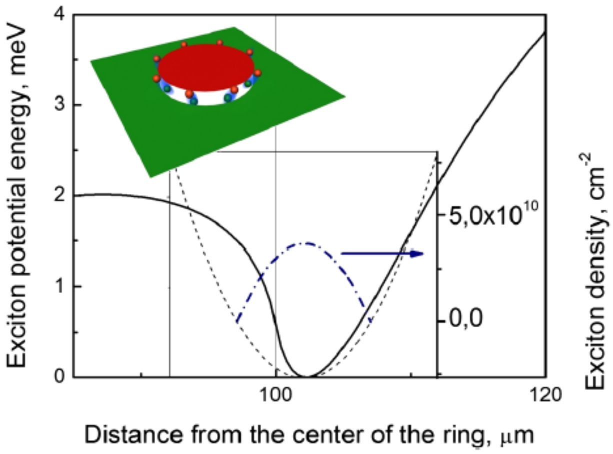

Fig. 1 Calculated potential profile for the radial motion of an indirect exciton in the vicinity of the ring (solid line) and the model harmonic trap (dashed line). The localization is due to the macroscopic charge separation (color inset on the left) which induces an in-plane electric field. The field tilts the exciton dipoles and thus reduces their potential energy. At low temperatures, excitons condense at the potential minimum located near the charge boundary. As a consequence of strong repulsive interactions, the density profile of the exciton condensate is very smooth and merely reproduces the shape of the trap (dotted-dashed line).

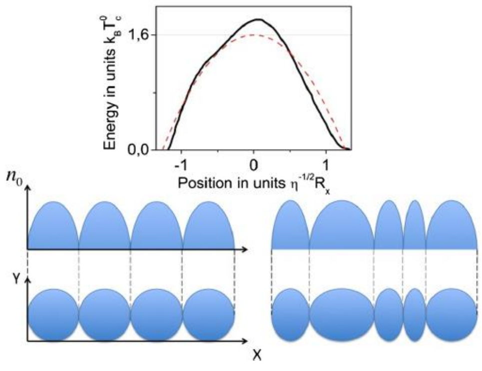

Fig. 2. The T=0 Thomas-Fermi result for the variation of exciton energy along the ring. The exciton resonance position measured in [1] from PL spectra is shown by the solid line. The Thomas-Fermi radius of the bead is measured to be R_x=20 μm.
(Bottom) The topological transformation of the condensate density conserving the total number of particles.
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[1] S. Yang, A.V. Mintsev, A.T. Hammack, L.V. Butov, and A.C. Gossard, Phys. Rev. B 75, 033311 (2007).