Two component superfluid Bose-Einstein condensate of indirect excitons in two-layer Hall systems complementary filled

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We develop the model of interlayer coupling of electrons and holes in Landau levels complementary filled, $\nu_{top} + \nu_{bot} = 1$, in twin parallel Hall systems separated by an insulating barrier. Taking into account the opposite vertical polarizations of resulting indirect excitons we propose a two fluid model for related Bose-Einstein condensate of excitons. This model allows for optimization of repulsion of excitons in condensates resulting in their superfluidity. This repulsion needs a specific striping in k-space of carrier local density leading to an energy competition with the reentrant IQHE in striped structure in complex twin-layer Hall system. By application of the quantum Monte-Carlo simulation we have identified the phase diagram of the complex twin superfluid-IQHE system with respect to its filling scheme and the barrier thickness in both experimental configurations, counterflow or drag ones. We have achieved a consistence of the model with experimentally observed superfluid-IQHE phenomena in two measured systems: twin parallel Hall GaAs system separated by GaAlAs barrier and twin bilayer-graphene Hall system separated by hBN barrier. We have explained the puzzled observations of disappearance of the Hall response in drug configuration at (-1/2,-1/2) scheme of filling of twin bilayer-graphene system, the absence of the counterflow response of n=1 LLL states in bilayer-graphene, as well as we have achieved the quantitative consistence of the model phase diagram details with the experimental data (including energy activation values and the shape and positions of the transition curves).

Figures

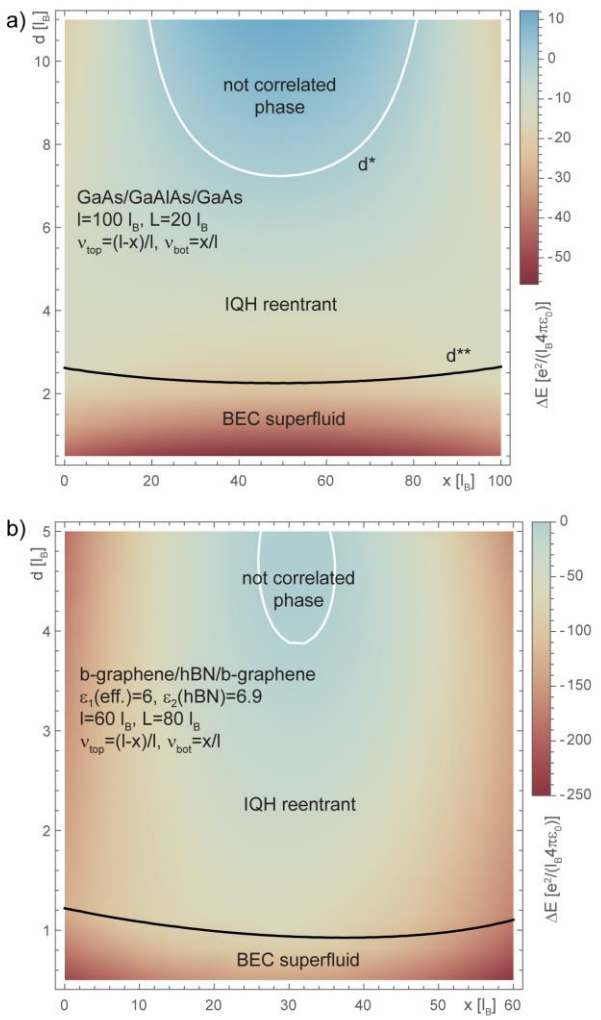

Figure 1: The phase diagram for the bilayer GaAs heterostructure (a) and b-graphene (b) at $\nu_{top}+\nu_{bot}=1$ displaying the energy competition between the reentrant IQH phase, superfluid BEC of interlayer excitons and not ordered phase; the energies of particular phases are determined by the MMC simulation.