Berezinskii-Kosterlitz-Thouless Crossover for a Four-Component Superfluid of Dipolar excitons

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Indirect excitons confined in GaAs double quantum wells (DQW) constitute a model system to investigate the quantum phases accessible to dipolar gases. Indirect excitons result from the Coulomb attraction between spatially separated electrons and holes, a situation which is directly achieved by applying an electric field perpendicular to the plane of a DQW. In recent experiments we have reported signatures of quantum coherence and quantized vortices in the photoluminescence radiated by indirect excitons confined in a two-dimensional trap [1]. Here we show that in this geometry the excitons quantum phase transition obeys the Berezinskii-Kosterlitz-Thouless (BKT) mechanism, as expected theoretically. We show that the crossover occurs in a very unique way, due to strong dipolar interactions between excitons and to their underlying four-component spin-structure.

In our experiments, the BKT transition is accessed by unveiling the exciton equation of state, at thermal equilibrium, together with its scale invariance (Fig. 1). Using Monte-Carlo simulations we then quantify this behavior and localize the crossover. The critical temperature and density are thus confirmed quantitatively by analyzing the excitons quantum spatial coherence and the spatial distribution of density fluctuations. The latter analysis allows us to reveal the expected defect-driven (topological) nature of the excitonic superfluid transition at two-dimensions [2].

[1] R. Anankine et al. , Phys. Rev. Lett. **118**, 127402 (2017)

[2] S. Dang et al., submitted

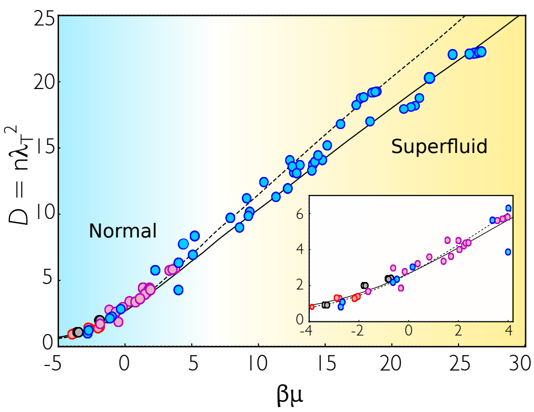

Figure 1: Phase space density D=$n\lambda_T^2$ as a function of the scaled chemical potential $\beta\mu = \mu/k_BT_b$ measured at T=0.33, 1.2, 2.5 and 3.5 K (blue, pink, black and red respectively).