Symmetry Induced Condensate of Pairs of Intervalley Excitons

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2D and 3D TMD materials can support intervalley excitons characterized by long life time, which implies a possibility of their condensation. The point group symmetry dictates that such a condensate is multi-component. A critical role is played by the internal Josephson effect which is of higher order and, thus, is leading to mixing pairs of excitons from the time-reversed valleys. Simplistic argument based on the mean field method predicts pairing effect controlled by the number of the components. However, finite temperature Monte Carlo simulations show that such pairing occurs only in 2D, while in 3D the transition between normal and condensed phases is of strong Ist order. Fig.1 presents the phase diagram in 2D. The transition turns out to be of the BKT-type [1]. Options for detecting excitonic pairing are discussed.

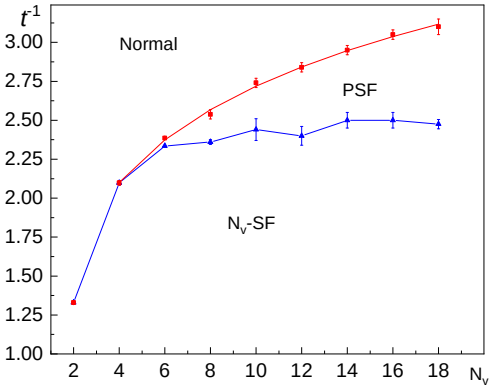

Figure 1: Finite temperature phase diagram of the 2D material with N_v-species of the intervaley excitons. The vertical axis shows the inverse excitonic condensate bare stiffness (times temperature). Normal labels incoherent thermal state; PSF denotes the condensate of pairs; N_v-SF stands for N_v component condensate

Due to the quantum to classical maping criteria, the finite temperature 2D system must cross over to D=2+1 system upon approaching zero temperature. Thus, it is expected that the line of the BKT transitions will end by the tricritical point signaling the emergence of the Ist order quantum transition between normal and the N_v-component condensate. Thus, the pairing effect should exist only at finite temperatures. It is induced by intricate thermal collective fluctuations rather than by direct attractive forces between excitons. This prediction is to be tested by Quantum Monte Carlo Simulations.

References

[1] A Alkady and A Kuklov, Phys. Rev. B **112**, 054507 (2025)