Density induced BCS-Bose evolution in gated two-dimensional superconductors: The role of the interaction range in the Berezinskii-Kosterlitz-Thouless transition

C. A. R. Sá de Melo

School of Physics, Georgia Institute of Technology, Atlanta

The evolution from Bardeen-Cooper-Schrieffer (BCS) to Bose superconductivity versus carrier density (n) in two-dimensional (2D) gated superconductors is discussed and the fundamental role that the interaction range plays in the Berezinskii-Kosterlitz-Thouless transition is addressed. [1] The density dependence of the critical temperature (T_c), superfluid density, order parameter, chemical potential and pair size are investigated. The most important finding is that it is essential to include classical and quantum phase fluctuations, as well as finite-ranged interactions to explain the non-monotonic behavior of T_c versus n and to guarantee that the upper bound on T_c is not exceeded in 2D superconductors, as experimentally observed in Li_xZrNCl [Science 372, **190** (2021)], a lithium intercalated layered nitride, and in magic-angle twisted trilayer graphene [Nature **590**, 249 (2021)]. Furthermore, it is shown that from measurements of T_c and the order parameter, the effective mass of charge carriers and their interaction strength and range can be extracted.

[1] "Density induced BCS-Bose evolution in gated two-dimensional superconductors: The Berezinskii-Kosterlitz-Thouless transition as a function of carrier density", Tingting Shi, Wei Zhang, and C. A. R. Sá de Melo, arXiv:2106.10010v1 (2021).