Superfluid density and critical velocity near the fermionic Berezinskii-Kosterlitz-Thouless transition

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In this work we present our theoretical investigation of superfluidity in a strongly interacting Fermi gas confined to two dimensions at finite temperature [1]. Using a Gaussian pair fluctuation theory (GPF) in the superfluid phase, we calculate the superfluid density and determine the critical temperature and chemical potential at the Berezinskii-Kosterlitz-Thouless transition.

The theoretical description of pairing in a 2D interacting Fermi gas at finite temperature is a long-standing challenge due to strongly enhanced quantum and thermal fluctuations. We generalize the GPF theory for finite temperatures below the superfluid transition, solving a crucial technical problem of removing divergences in numerics [2]. This enables us to calculate the superfluid density, the key quantity in characterizing the BKT transition, beyond the mean-field and taking into account quantum fluctuations. Through a microscopic calculation of the critical velocity, beyond the phenomenological Landau quasi-particle picture, we predict the occurrence of a significant discontinuity in the critical velocity across the transition, associated with the universal jump in superfluid density [3], which, if observed experimentally, would provide an unambiguous proof of the fermionic BKT transition.

[1] B. C. Mulkerin, L. He, P. Dyke, C. J. Vale, X.-J. Liu, and H. Hu, ArXiv e-prints (2017), arXiv:1702.07091 [cond-mat.quant-gas].

[2] J. Tempere, S. N. Klimin, J. T. Devreese, and V. V. Moshchalkov, Phys. Rev. B **77**, 134502 (2008).

[3] J. M. Kosterlitz and D. J. Thouless, J. Phys. C **6**, 1181 (1973).