Preformed pairs and quasicondensation in imbalanced Fermi gases in 2D

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In a two-dimensional Bose gas, superfluidity is suppressed through the Kosterlitz-Thouless mechanism, whereby vortex-antivortex pairs appear and break up above a critical temperature. The proliferation of free vortices and antivortices, destroying phase coherence, has been observed experimentally in a tightly confined atomic Bose gas. In this contribution, we focus on two-dimensional Fermi gases, where the formation of pairs is necessary to achieve superfluidity. Also for fermionic superfluids in two dimensions, superfluidity is suppressed by the Kosterlitz-Thouless mechanism. Additionally, when a population imbalance between the two pairing partners is present, pairing is frustrated. Also the binding energy of vortex-antivortex pairs is affected by population imbalance. We investigate the effect of imbalance on the superfluid phase diagram using path-integral techniques, where we include fluctuations beyond mean-field. This allows us to describe not only the temperature zero superfluid[1], but also provides a description for the non-superfluid phase with preformed pairs. This phase is distinct from the normal, unpaired Fermi gas, and relevant to the understanding of high-temperature superconductivity. We derive the properties of this phase through a calculation of the spectral function and the response properties, and show that collective modes can be used to probe this phase.

[1]see J.Tempere, S.N.Klimin, J.T. Devreese, Physical Review A **79**, 053637 (2009); S.N.Klimin, J. Tempere, J. Low Temp. Phys. **162**, 291 (2011).