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FFLO transition and non-Fermi-liquid in the 2D spin-imbalanced Fermi gas at zero temperature

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Abstract: The zero-temperature phase diagram "*population imbalance versus coupling strength"* of the transition to the superfluid state with finite momentum pairing (FFLO) for a two-dimensional Fermi gas is computed.

The object of this study is the two-dimensional Fermi gas at zero temperature with attractive contact interaction and spin population imbalance. Beyond the imbalance limit of Chandrasekhar and Clogston homogeneous superfluidity is destroyed but Fulde and Ferrell [1] and, independently, Larkin and Ovchinnikov [2] (FFLO) proposed in the 1960's that it could persist through pairing at a finite centre-of-mass momentum. We provide a comprehensive theoretical characterization of the FFLO transition in a two-dimensional (2D) spin imbalanced Fermi gas going beyond the historical mean-field characterization by adopting a diagrammatic *T*-matrix approach within two schemes: the non-self-consistent scheme and the partially self-consistent scheme.

The phase-diagram of the critical polarization versus coupling reveals significant differences between the two schemes (see Fig. 1 panel (a)) owing to the crucial role of self-consistency as argued within the Luttinger theorem. A marked effect of dimensionality is also found when compared to the three-dimensional (3D) phase- diagram [3].

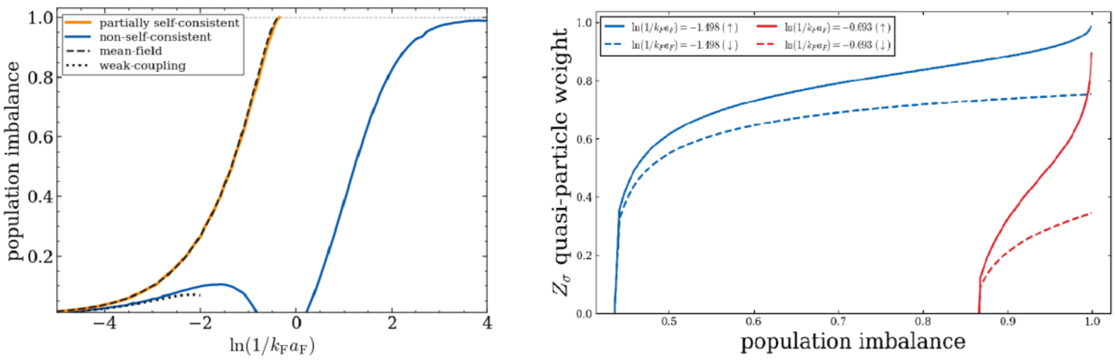

Fig. 1. Left Panel: phase diagram of population imbalance versus coupling strength at zero temperature of a 2D attractive Fermi gas within two computational schemes. Right Panel: quasi-particle weight for two representative coupling strengths as a function of the population imbalance approaching the two respective critical values.

At the critical polarization line, we examine the effect of quantum fluctuations on the quasi-particle scattering rate finding a non-Fermi-liquid behaviour with exponent 2/3 of the imaginary part of the self-energy on the Fermi surface (rather than the standard value of the Landau theory of 2), akin to that of nematic or charge density wave order in 2D quantum critical metals. However, the exponent is strongly dependent on the fermionic momentum being on the Fermi surface, above or below. This critical behaviour is drastically different to that of the 3D FFLO transition and represents an example of breakdown of the Hertz and Millis theory of quantum phase transitions [4,5].

References

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