1 - 11 Angle Dependence of d-wave Pairing Gap in Two Component Fermion System

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In a two component fermion system, the mismatched Fermi surfaces prevent the formation of Cooper pairs between the two spices near their average Fermi surface. Our previous work[1] has shown that the angle dependence of the non s-wave pairing gap can reduce the effect of the difference $\delta\mu$ between the Fermi surfaces of two spices in asymmetric nuclear matter. On the other hand, in the heavy fermion superconductors, such as CeCoIn5 pressured CeRhIn5 NpPd5Al2 and Tl-based cuprates, may have a couple of common features, for example, the d-wave pairing and a strong paramagnetic effect (the difference of the two Fermi surfaces $\delta\mu$). Therefore, the angle dependence of the pairing gap may have significant influence in these systems.

In this work, we discuss the d-wave pairing in two component fermion system generally. Two physical systems which have mismatched Fermi surfaces are considered: (i) Fixed chemical potential asymmetry $\delta\mu$ and (ii) Fixed fermion number asymmetry α. In case (i), the gapless quasiparticle excitation arises both in the usual Bardeen-Cooper-Schrieffer (BCS) and Sarma states due to the angle-dependent pairing gap, and these two kinds of states should be distinguished by the gap susceptibility κ_Δ rather than the constraint $\Delta < \delta\mu$ (as shown in Figs. 1 and 2). Meanwhile, the d-wave pairing can hold larger chemical potential asymmetry $\delta\mu$ than the s-wave pairing which is shown in Fig. 1[2].

In case (ii), the angle dependence of the d-wave pairing gap may reduce the effect due to the number asymmetry α of the two components, and enhance the superfluidity for large asymmetry at low temperature as discussed in Ref. [1]. This can be found in Fig. 3. In Fig. 3, the d-wave pairing holds larger gap value and smaller free energy than s-wave pairing.

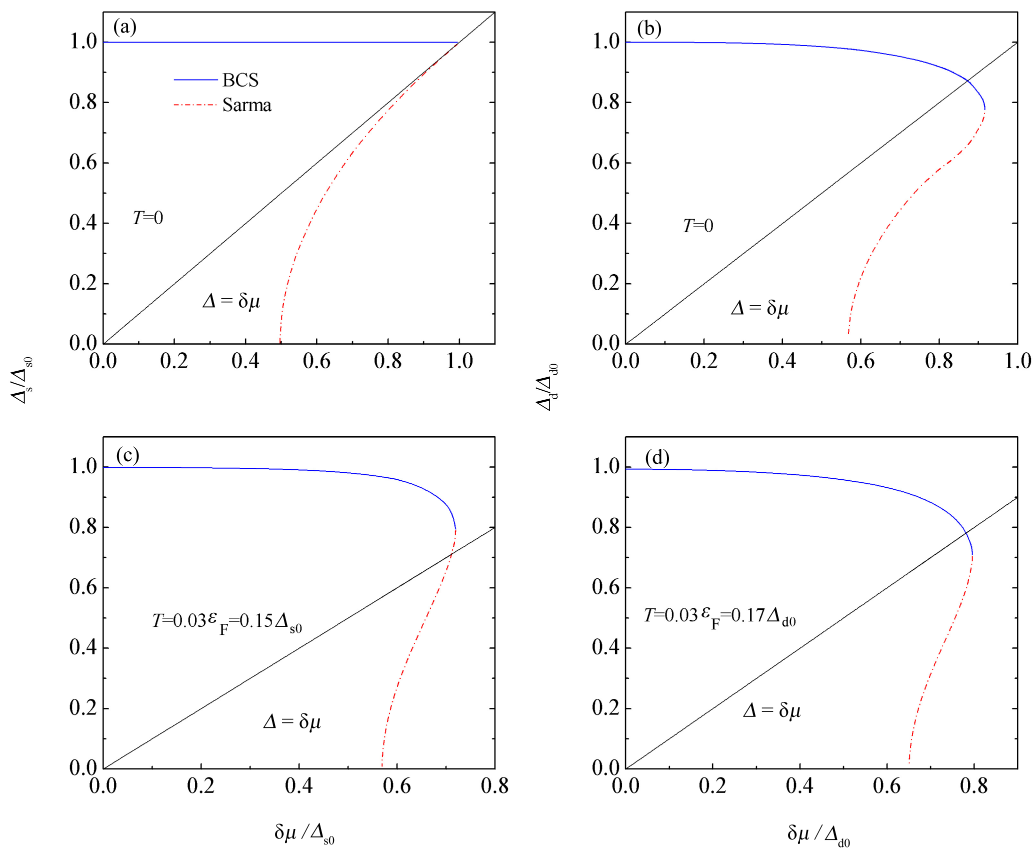

Fig. 1 (color online) The scaled pairing gaps Δ/Δ_0 as a function of the scaled chemical potential difference $\delta\mu/\Delta_0$. The left two and right two figures are related to the s-wave and d-wave pairing, respectively. The temperatures in the upper two and the lower two figures are set to be zero and finite temperature, respectively.

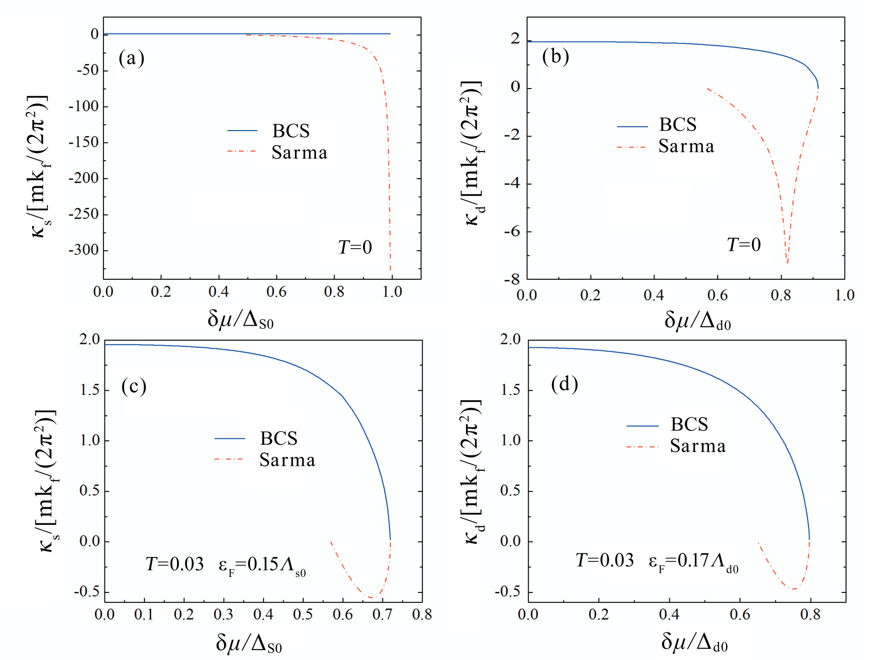

Fig. 2 (color online) The scaled gap susceptibility versus the scaled chemical potential difference. The left two and right two figures are related to the s-wave and d-wave pairing, respectively. The temperatures in the upper two and the lower two figures are set to be zero and finite temperatures, respectively.

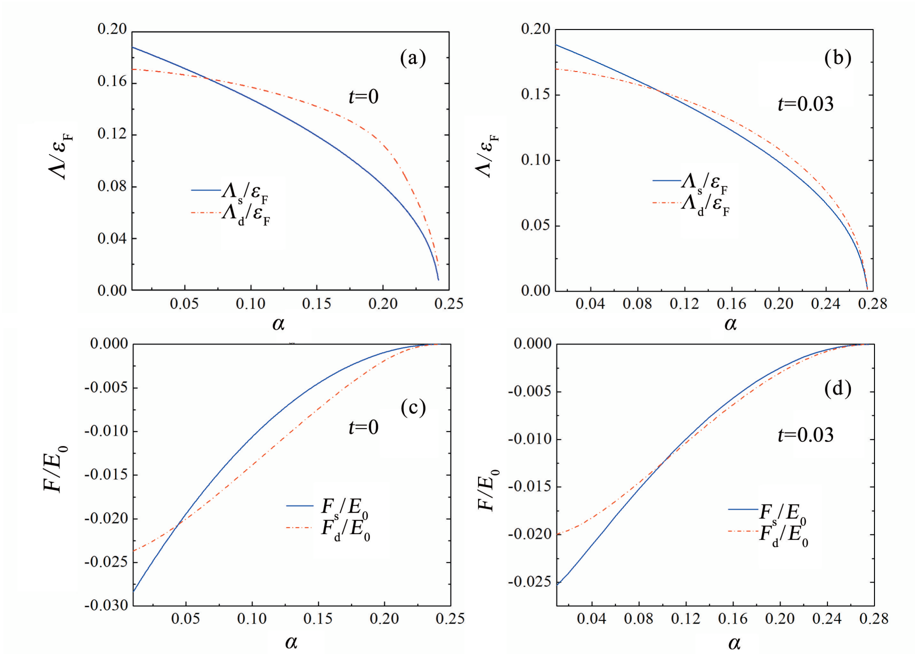

Fig. 3 (color online) The scaled pairing gap and the scaled difference of the free energy of the normal and superconductiong state versus the number density asymmetry α for the s-wave and d-wave pairing. The temperatures in left two and right two figures are set to be zero and finite temperatures, respectively. The blue solid and red dash-dotted lines are related to the s-wave and d-wave pairing, respectively.

References

[1] Xinle Shang, Wei Zuo, Phys. Rev, 88(2013)025806.

[2] Wei Wang, Xinle Shang, Mod. Phys. Lett. B, 29(2015)1550011.