SUPERCONDUCTING ORDER ON DIFFERENT FERMI SURFACES IN MULTI-BAND SUPERCONDUCTORS

V.V. Barzykin (University of Tennessee, Physics and Astronomy); L.P. Gor'kov (FSU, NHMFL)

Introduction

We address the structure of the superconducting pairing in materials with a multi-band electronic spectrum. Although the theoretical problem is rather old, and some general understanding in frameworks of the BCS approach has already been achieved in the early `60s, the topic has recently become popular again in connection with the two-gap superconductivity found in MgB_2.The latter material has unexpectedly high transition temperature~39K, and is being actively studied in view of its practical importance. Notable, however, that most superconductors, including such strongly correlated systems, as heavy fermions and many organic superconductors, also belong to the multi-band class. Some, and among them the "115" $CeMIn_5$ heavy fermions, display a nodal (d-wave) superconductivity(SC) and non-Fermi liquid features in the normal state. Different experiments should allow to resolve the values of SC gaps on different Fermi surfaces and possible also shed some light on the role of correlation effects at formation of SC order parameters for electrons from different bands. In this connection, we discus some available experiments and suggest a few new ones. We concentrate on studying quasi-two dimensional superconductors, such as strongly anisotropic $CeCoIn_5$ or 2*H*-$NbSe_2$.

Results and Discussion

I. It was found in [1] that thermal conductivity in alloys $Ce_{1-x}La_xCoIn_5$ in the d-wave SC state displays a rapid decease with the x increase, as if one of participating Fermi surfaces were gapless. We have shown[2] that this behavior can be quantitatively explained assuming that one of Fermi surfaces has a smaller SC order parameter that is destroyed faster by defects, i.e., already by a small amount of La. A considerable larger d-wave SC gap on the other Fermi surface is responsible for the remaining contribution into the measured thermal conductivity.

II. Study of $CeCoIn_5$ in magnetic fields are mostly concentrated on the search for the inhomogeneous LOFF state at fields comparable with H_{c2}. We considered the same model of the two Q2D-Fermi surfaces with different superconducting gaps in the filed range well below H_{c2}, for any appearance of the LOFF state to be excluded. However, with its increase the magnetic field begins to destroy the smaller SC order. As the result, on this Fermi surface the energy spectrum becomes gapless, possesses a finite density of state(with the linear in T specific heat contribution); the meta-magnetic transition occurs at the crossover. For the d-wave SC ($CeCoIn_5$) the transition is usually of the second order. For the s-wave case (2*H*-$NbSe_2$) the transition bears the first order character[3].

Conclusions

Phenomena described above seem to be observable at magnetic fields $H \sim 0.1H_{c2}$.

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References

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