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How to identify the gap structure in unconventional superconductors

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Among various known unconventional superconductors, such as UPt_3, $CeCoIn_5$, YNi_2B_2C or $PrOs_4Sb_{12}$ there are only a few whose pairing symmetry is firmly established. It is often the case that various bulk thermodynamic quantities, such as specific heat, thermal conductivity, nuclear relaxation time exhibit mutually contradicted power law behaviors. We are needed definitely more effective or additional measurements to identify the gap structure, which consists of the spin and orbital parts. Here we propose several new experiments to remedy this situation based on microscopic quasi-classical calculations to describe the vortex state in type II superconductors:

(1) Angle resolved specific heat experiment[1]

The Sommerfeld coefficient γ depends on the field direction relative to the gap node. Thus under field rotation γ exhibits a characteristic oscillation pattern. By analyzing its pattern and oscillation amplitude we can show that we extract useful information on the nodal position, the gap topology and also the Fermi velocity anisotropy.

(2) Field dependence of $\gamma(H)$[2, 3]

It is well known that $\gamma(H) \propto \sqrt{H}$ behavior is associated with the nodal gap structure while $\gamma(H) \propto H$ in an isotropic gap superconductor. We demonstrate that by analyzing carefully $\gamma(H)$ behavior bridging these two extremes, we can obtain useful information on the degree of the gap anisotropy.

(3) Angle resolved magnetization

Angle-dependent magnetization for both longitudinal and transverse (torque) directions also exhibits characteristic oscillation patterns, reflecting the gap structure. Thus these measurements are potentially important in identifying nodal position.

(4) Vortex sheet structure[4]

We have shown that the vortex sheet is stable where half quantum vortices are aligned in a row for pairing function with two components. Recently in Sr_2RuO_4 vortex sheet like structure is observed[5].

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