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Angle-resolved magnetization/specific-heat measurements on strongly correlated f electron compounds

T. Sakakibara, H. Aoki, T. Onimaru and T. Tayama

Institute for Solid State Physics, University of Tokyo,
Kashiwa, Chiba 277-8581, Japan

We have developed angle-resolved magnetization and specific-heat measurement techniques for investigation of anisotropic f electron systems such as quadrupolar ordering and anisotropic superconductivity. Here we present some new results on an antiferro-quadrupolar (AFQ) ordering compound $PrPb_3$ and a d-wave superconductor $CeCoIn_5$.

The cubic compound $PrPb_3$ has a Γ_3 doublet ground state and is considered to show an AFQ ordering below T_Q=0.4 K. In a simple model, the OP in a magnetic field is either O_2^0 ($H \parallel [001]$) or O_2^2 ($H \parallel [110]$) types, depending on the field direction. In order to confirm this point, we have been investigating the anisotropic phase diagram of $PrPb_3$ by the angle-resolved magnetization measurement. Preliminary results for H rotating in the (001) plane are shown in Fig1a. The transition temperature $T_Q(H,\theta)$ is found to change smoothly, implying no discontinuous change of the OP within this plane. The [001]→[111]→[110] rotation experiment will be done soon.

$CeCoIn_5$ is an anisotropic superconductor with line nodes in the gap. Recent thermal conductivity measurement in rotating field has reported a fourfold gap symmetry in the ab-plane possibly of $d_{x^2-y^2}$ type. We have examined this issue by means of the specific heat measurement in rotating field. The field-orientation dependence of the specific heat $C(H,\theta)$ with H rotating in the ab-plane exhibits a clear fourfold angular oscillation in the superconducting mixed state (Fig.1b), directly proving the zero-energy density-of-state oscillation arising from the gap nodal structure of d-wave superconductivity [1]. Direction of the minima in $C(H,\theta)$ ([100]), however, points to a d_{xy} gap symmetry in this system.

The work has been done in collaboration with D. Aoki, Y. Haga, H. Shishido, R. Settai and Y. Onuki.

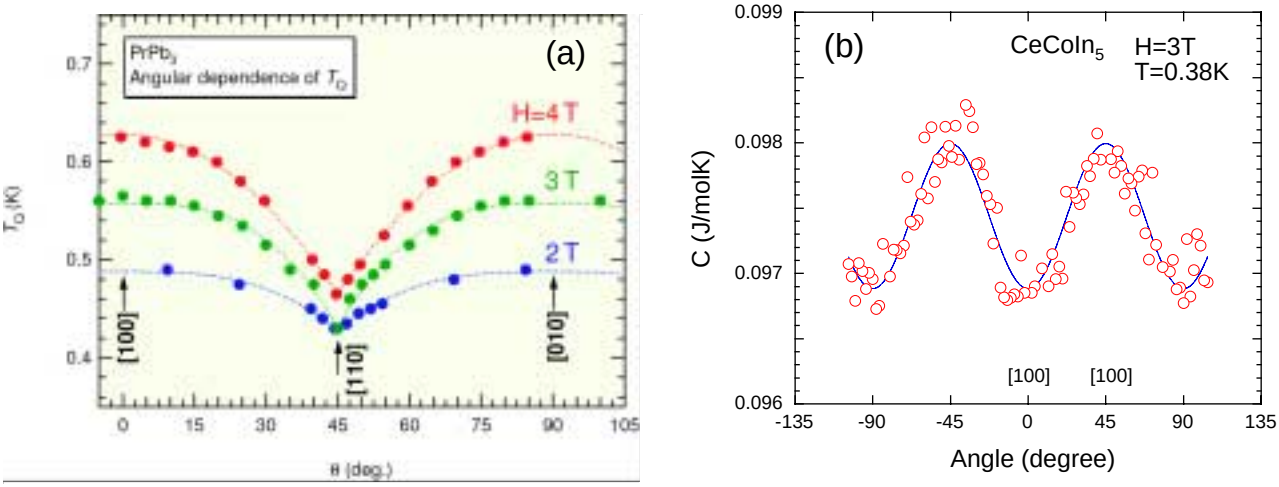

Figure 1: (a) Field-angle variation of the AFQ transition temperature in $PrPb_3$ with H rotating in the (001) plane. (b) Field-angle variation of the specific heat of $CeCoIn_5$ with H rotating in the ab-plane.

[1] H. Aoki *et al.*, preprint.