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Angle-Resolved Magnetization Measurements on Antiferroquadrupolar Ordering System $PrPb_3$

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$PrPb_3$ crystallizes in a simple $AuCu_3$-type cubic structure. Its CEF ground state is a Γ_3 non-Kramers doublet, which carries quadrupolar moments $O_2^0=(3J_z^2-\boldsymbol{J}^2)/2$ and $O_2^2=\sqrt{3}(J_x^2-J_y^2)/2$. One may therefore expect a quadrupolar ordering in $PrPb_3$. This compound actually exhibits a second-order transition at 0.4 K with a lambda-type anomaly in the specific heat, which is considered to be an antiferroquadrupolar (AFQ) ordering of Γ_3-type quadrupolar moments. Although extensive studies have been done on this system, the order parameter has not been established yet.

In this study, we examined the AFQ phase in $PrPb_3$ by angle-resolved measurements of T_Q, which we believe to better reflect the symmetry of the order parameter. For this purpose, we developed a low-temperature angle-resolved magnetization measurement system. Figure 1 shows the result for the (001) rotation plane. Interestingly, T_Q takes a v-shape minimum along the [110] direction. We have performed a mean-field analysis based on a simple two-sublattice model, and found that the result in Fig. 1 is incompatible with those obtained by assuming an isotropic AFQ interaction, and strongly suggests the existence of an anisotropic AFQ interaction that stabilizes the O_2^0 phase or its equivalents in all directions in a wide field range [1]. We believe the existence of anisotropic quadrupole interaction is new for simple cubic systems.

[1] T. Onimaru, T. Sakakibara, A. Harita, T. Tayama, D. Aoki and Y. Onuki: J. Phys. Soc. Jpn. **73** No.9 (2004), in press.

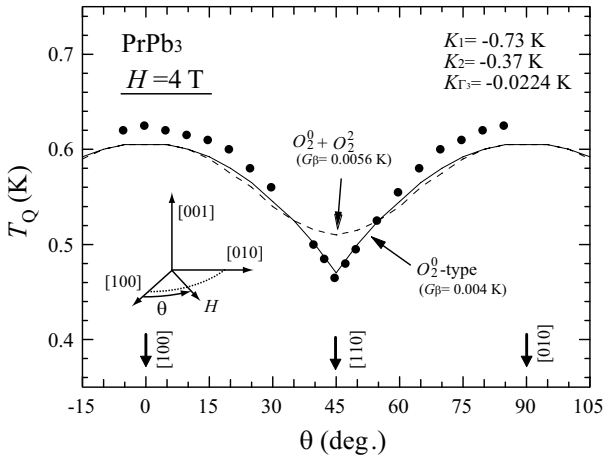

Figure 1: Field-angle dependence of the AFQ transition temperature T_Q in a field of 4 T rotated within the (001) plane. Dots are the experimental results. Solid (broken) line is the calculated result assuming anisotropic (isotropic) antiferroquadrupole interactions.