

# Field-induced phase transition in $\text{Pr}_3\text{Pd}_{20}\text{Ge}_6$

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$\text{Pr}_3\text{Pd}_{20}\text{Ge}_6$  crystallizes in the cubic  $\text{Cr}_{23}\text{C}_6$ -type structure (Fm3m) with two inequivalent Pr sites of 4a ( $\text{O}_h$ ) and 8c ( $\text{T}_d$ ). Inelastic neutron scattering [1] and high-field magnetization [2] suggested that the crystalline-electric-field (CEF) lowest level of the Pr 4f electrons is the non-magnetic  $\Gamma_3$  for both the sites. This scheme is however inconsistent with the  $T^{-1}$  variations of low- $T$  elastic constant  $c_{44}$  [3] and magnetic susceptibility, and we proposed that the magnetic  $\Gamma_5$  is alternatively the lowest level at the 8c site [4]. This CEF scheme qualitatively well reproduces the overall features of  $M(B, T)$ , but also shows a significant discrepancy that the calculated metamagnetic-like anomalies are rather sharper than the observations. This fact strongly suggests that the CEF levels are weakly split in this system. To obtain further information on the 4f states of  $\text{Pr}_3\text{Pd}_{20}\text{Ge}_6$ , we have measured specific heat for temperatures down to 0.36 K, in fields applied up to 12 T ( $\parallel$  [100], [110] and [001]). At zero field, the 4f contribution to the specific heat,  $C_{\text{mag}}$ , exhibits a sharp upturn as  $T$  is lowered below  $\sim 0.7$  K (Fig. 1(a)), which indicates the broken cubic symmetry, at least, in one of the Pr sites, as expected. We also found  $C_{\text{mag}}(T)$  to show a discontinuous change for  $B \parallel$  [100], as marked by open arrows in Fig. 1(a). The transition temperature  $T^*$  varies quasi-linearly with field, showing no tendency to have a finite  $T$  intercept (Fig. 1(b)). The observed features could qualitatively be understood in terms of the field-induced Jahn-Teller effect or quadrupole ordering in the  $\Gamma_5$  symmetry.

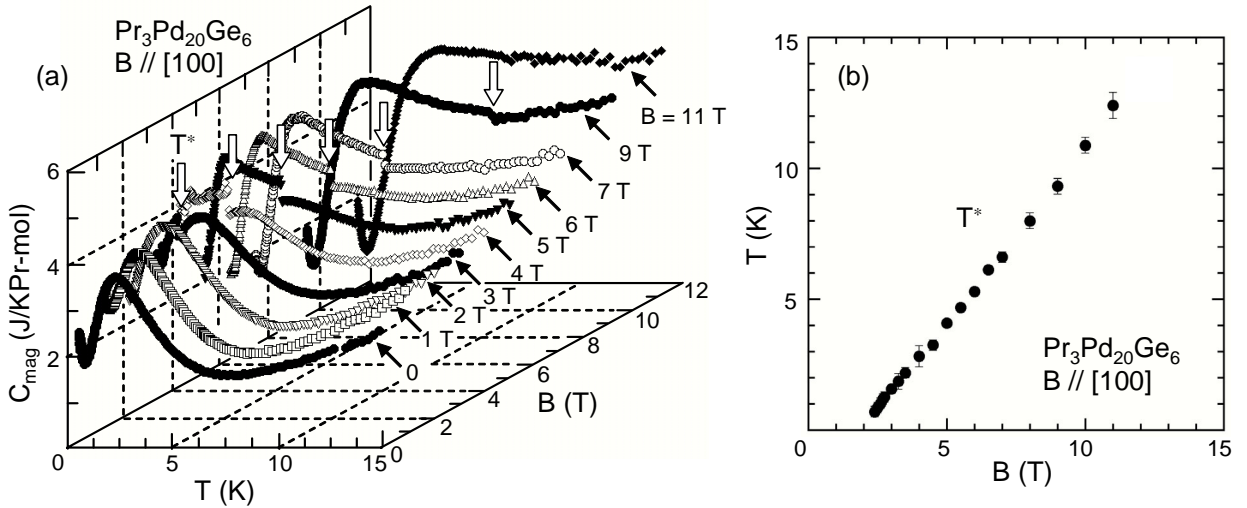


Figure 1: (a) Temperature variations of specific heat of  $\text{Pr}_3\text{Pd}_{20}\text{Ge}_6$  measured at various magnetic fields applied parallel to the [100] direction; in the plot  $C_{\text{mag}} \equiv C(\text{Pr}_3\text{Pd}_{20}\text{Ge}_6) - C(\text{La}_3\text{Pd}_{20}\text{Ge}_6)$  vs.  $T$ . (b) Transition temperature  $T^*$  plotted as a function of magnetic field.

[1] L. Keller *et al.*, Physica B **259-261** (1999) 336.

[2] M. Nakayama *et al.*, Physica B **281&282** (2000) 152.

[3] T. Horino *et al.*, Physica B **281&282** (2000) 576.

[4] H. Amitsuka *et al.*, J. Phys. Soc. Jpn. **71** (2002) 124.