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Low-Temperature Magnetic Properties of the Cage Compound $Pr_3Pd_{20}Ge_6$

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We have measured magnetization ($T \geq 80$ mK, $B \leq 9$ T) and specific heat ($T \geq 0.36$ K, $B \leq 12$ T) on the single-crystalline $Pr_3Pd_{20}Ge_6$. This compound crystallizes in the cubic $Cr_{23}C_6$-type structure with space group Fm3m, in which Pr ions occupy two inequivalent cubic sites 4a (O_h) and 8c (T_d), sitting at the center of "cages" formed by Pd and Ge ions. Inelastic neutron scattering [1] and high-field magnetization [2] suggest that the crystalline-electric-field (CEF) lowest level of the praseosymium 4f electrons is the quadrupole doublet Γ_3 for both the cites. In addition, the elastic constant $(c_{11} - c_{12})/2$ shows a steep softening with decreasing temperature, followed by a dip anomaly at ~ 0.26 K, suggesting the occurrence of quadrupole ordering [3]. We found magnetic susceptibility showing no tendency to saturate down to 80 mK, and multistep-like anomalies appearing in $M(B)$ below ~ 1 K [4]. No indication of the phase transition was detected in the measured B-T range. Overall features of the $M(B,T)$ curves and newly studied $C(B,T)$ data are basically explained in terms of a CEF model that assumes the lowest levels at the 8c and 4a sites to be magnetic (Γ_5) and non-magnetic (Γ_3), respectively. There are also significant deviations between the calculations and the experimental data with an energy scale of ~ 0.5 K, which suggest the presence of slight lattice distortion.

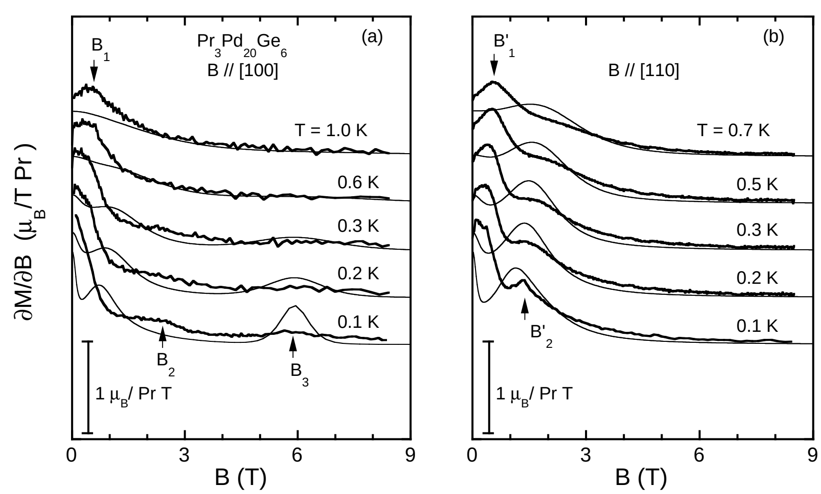

Figure 1: Temperature variations of differential susceptibility of $Pr_3Pd_{20}Ge_6$ for (a) $B \parallel [100]$ and (b) $B \parallel [110]$ (thick lines), compared with the CEF calculations (thin lines).

[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.