

Ultrasonic dispersion associated with rattling in clathrate compound $\text{PrOs}_4\text{Sb}_{12}$

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We have measured the elastic constants in single crystals $\text{PrOs}_4\text{Sb}_{12}$. Elastic softening of $(C_{11} - C_{12})/2$ proportional to the reciprocal temperature $1/T$ above the superconducting transition $T_C = 1.85$ K is well described in terms of the quadrupole susceptibility for a non-Kramers doublet Γ_{23} . Furthermore, ultrasonic dispersion around 20-30 K has been observed in all elastic constants of C_{11} , $(C_{11} - C_{12})/2$ and $C_L = (C_{11} + C_{12} + 2C_{44})/2$ including Γ_{23} symmetry (as seen in C_L in figure), while in the case of C_{44} with Γ_5 symmetry in O_h notation ultrasonic dispersion is absent. This is contrast to the results of $\text{Ce}_3\text{Pd}_{20}\text{Ge}_6$ [1] and $\text{La}_3\text{Pd}_{20}\text{Ge}_6$ that reveals ultrasonic dispersion only in C_{44} with Γ_5 symmetry. This thermal activated type dispersion is attributed to the off-center rattling of Pr ion with Γ_{23} symmetry along [100] in cage consisting of Sb icosahedron. Very slow relaxation time $\tau_0 = 8.88 \times 10^{-11}$ sec and very small activation energy $E = 168$ K were determined in $\text{PrOs}_4\text{Sb}_{12}$.

We propose that the new type of degrees of freedom due to off-center ion in cage may play an important role in heavy fermion behavior and unconventional superconductivity in $\text{PrOs}_4\text{Sb}_{12}$.

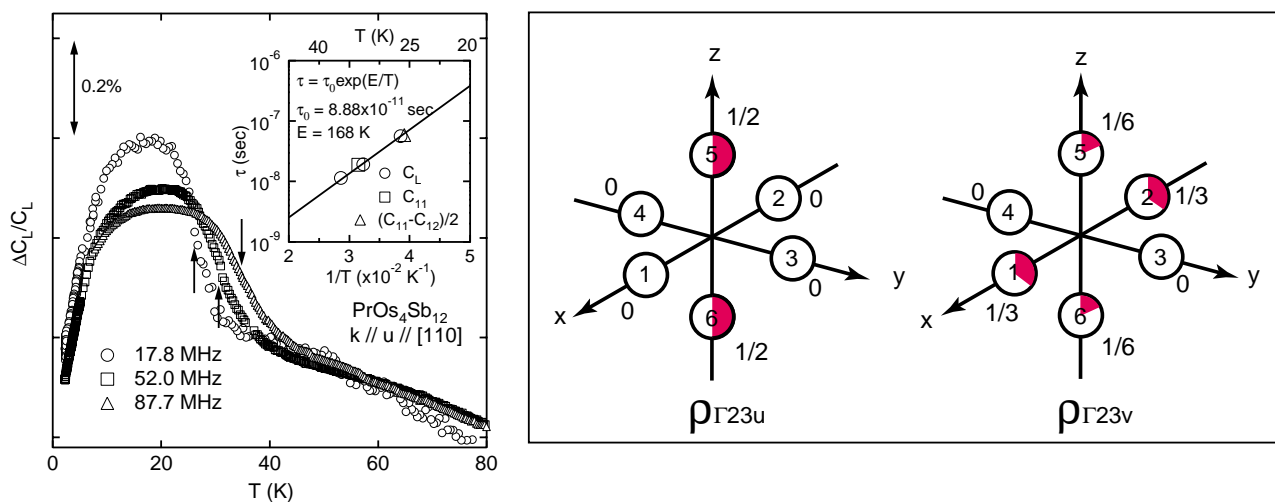


Figure 1: Ultrasonic dispersion in C_L (left) and schematic view of the Γ_{23} off-center mode (right) in $\text{PrOs}_4\text{Sb}_{12}$.

[1] Y. Nemoto, T. Yamaguchi, T. Horino, M. Akatsu, T. Yanagisawa, T. Goto, O. Suzuki, A. Dönni, and T. Komatsubara, Phys. Rev. B **68** (2003) 184109(R).