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Microscopic study of superconducting characteristics on $(Pr_{1-x}La_x)Os_4Sb_{12}$: ^{121,123}Sb-NQR

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We report on superconducting (SC) characteristics for $PrOs_4Sb_{12}$ and $(Pr_{1-x}La_x)Os_4Sb_{12}$ (x = 0.05, 0.2) via the measurements of nuclear spin-lattice relaxation rate $1/T_1$ and NQR spectrum of Sb nuclear. Our previous work has revealed that the $1/T_1$ in $PrOs_4Sb_{12}$ shows neither a coherence peak just below T_c = 1.85 K nor a T^3 like behavior that used to be observed for unconventional heavy-fermion (HF) superconductors with the line-node gap [1]. Likewise, the La substituted samples exhibit no coherence peak just below T_c. This result demonstrates that $PrOs_4Sb_{12}$ is not a simple anisotropic *s*-wave superconductor where the non-magnetic impurity scattering makes a coherence peak increase due to the averaging effect of any anisotropic gap structure. The $1/T_1(T)$ for $PrOs_4Sb_{12}$ undergoes an exponential decrease in the range T=0.6 K($0.32T_c$) $-T_c$ = 1.89 K, indicative of a gap opening over the Fermi surfaces at a high temperature regime. This seems to be inconsistent with the angle-resolve thermal conductivity measurements that suggested the presence of point-node gap under a magnetic field [2]. At a temperature regime lower than 0.6 K, it is unexpected that the T variation in $1/T_1$ is unusual depending on the sample quality and the La substitution which enhance $1/T_1$ significantly. Remarkably, the latter leads to $1/T_1$ = constant behavior below $T \sim 0.6$ K.

Fig.1 displays $1/T_1(T)$ for two different type of the samples of $PrOs_4Sb_{12}$, which exhibits the exponential decrease in the range T=0.6 K($0.32T_c$) - T_c = 1.89 K, and $1/T_1$ = constant below $T \sim 0.6$ K. This result suggests that a possible *new phase* may exist below $T \sim 0.6$ K. On the other hand, it should be noticed that the La substitution, *which breaks up a coherency of $4f^2$ derived heavy-fermion state*, is almost nothing to do with reducing T_c up to 20% La doping. This is an underlying issue that should be relevant with the nature of SC order-parameter symmetry. In any case, the SC characteristics of "non-conventional" superconductor $PrOs_4Sb_{12}$ are far from comprehensive understanding at present stage. We will present the results from the microscopic measurements on this novel SC compound.

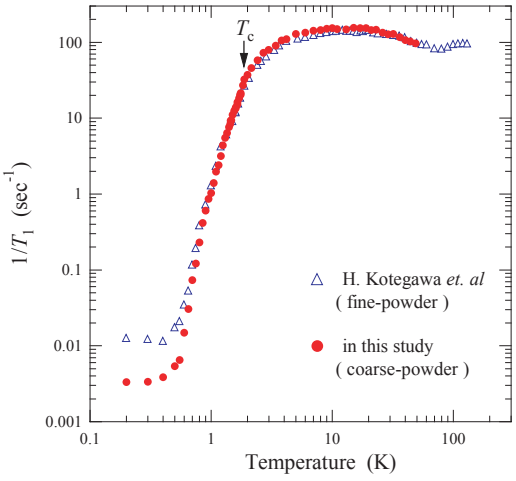

Figure 1: Temperature dependence of $1/T_1$ for the two samples of $PrOs_4Sb_{12}$.

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