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μSR studies on filled skutterudite compounds II

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Filled skutterudite compounds shows much variety of the properties. We have carried out μSR measurements on some filled skutterudite compounds to elucidate the magnetic and the superconducting properties.

(1)Muon Knight shift in the superconducting phase of $PrOs_4Sb_{12}$

The unconventional superconductivity(SC) in $PrOs_4Sb_{12}$ has been attracting much attention. One of most important observation of the unconventional SC is the breaking of the time-reversal symmetry (TRSB) which revealed by our previous μSR measurement[1]. The Knight shift gives one more crucial information for the understanding of the symmetry of Cooper Pair. Thus, we measured the muon Knight shift in single crystalline sample of $PrOs_4Sb_{12}$. As a result, the muon Knight shift is preserve from above Tc to 20mK under the magnetic field of 3kG and 17kG. This fact suggests that the symmetry of the Cooper pair is spin-triplet state. This observation is consistent with NMR result[2].

(2)Substitution effect on unconventional superconductivity in $Pr_{1-x}La_xOs_4Sb_{12}$.

To confirm the role of a f-electron for the unconventional superconductivity, we performed μSR measurement on $Pr_{1-x}La_xOs_4Sb_{12}$ (x=0,0.4,1.0). In $LaOs_4Sb_{12}$, we observed temperature independent feature of zero-field relaxation rate above and below T_c. This fact indicate the absence of TRSB superconductivity in $LaOs_4Sb_{12}$ and provides convincing evidence for the 4f electrons playing an essential role for the realization of the TRSB superconductivity in $PrOs_4Sb_{12}$. In $Pr_{0.6}La_{0.4}Os_4Sb_{12}$, we observed weak internal field under zero magnetic field below T_c. The magnitude of the internal field is smaller than $PrOs_4Sb_{12}$.

(3)Nearly ferromagnetic state in AFe$_4$Sb$_{12}$(A=Sr,Ba,Ca)

The itinerant ferromagnetism in alkali-metal filled skutterudite AFe$_4$Sb$_{12}$(A=K,Na) exhibit the important role of 3d electrons in the physical property of filled skutterudite compounds. Recently, Matsuoka *et al* observed the ferromagnetic-like behavior in AFe$_4$Sb$_{12}$(A=Sr,Ba,Ca) from some bulk property measurements. To clarify the ferromagnetism, we carried out μSR measurement in spark plasma sintered and powdered samples of AFe$_4$Sb$_{12}$(A=Ba, Sr, Ca). We found that about 10% of the sample exhibit magnetism in A=Ba and Sr samples. We observed tiny increment of muon spin relaxation rate in A=Sr and Ca samples. This feature suggest that AFe$_4$Sb$_{12}$ stand nearly ferromagnetic state and ferromagnetism is induced around a few numbers of defect and/or deformation.

[1]Y.Aoki et al. Phys. Rev. Lett. **91**(2003)067003.
[2]H.Tou et al., 7b3 of this meeting.
[3]E.Matsuoka et al., 6b5 of this meeting.