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Local field measurements in $PrOs_4Sb_{12}$ — summary and future issues —

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The unconventional superconducting nature in $PrOs_4Sb_{12}$ has attracted much interest. Among them, we have performed local magnetization measurements by micro-Hall probe and visualization of local field induction by magneto-optical technique.

Figure 1 shows local magnetization hysteresis curves in $PrOs_4Sb_{12}$, measured by a 30×30 μm^2 Hall probe along one of the principal axes. A remarkable dip structure is observed in each hysteresis loop near the central magnetization peak field H_{cp} [1]. A quite similar anomaly is also observed in Sr_2RuO_4 [2]. The anomaly is characteristic of superconductors with broken time-reversal symmetry, and is considered to be an evidence for the underlying degenerate domains.

Using an array of Hall probes with each active area of 5×5 μm^2 spaced every 15 μm, spatial distribution of local magnetization anomaly is characterized. Local magnetization hystereses measured by three different elements of the Hall probe array revealed remarkable spatial dependence of the anomaly. Additionaly, we have observed that the data become less reproducible (Fig. 2). A remarkable dip structure appears occasionally, although it does not always appear even at the same temperature. These results suggest that the source of the local magnetization anomaly, i.e. the domain structure, develops inhomogeneously with the scale comparable to the size of the Hall probes.

Double transitions in $PrOs_4Sb_{12}$ have been studied carefully as representative phenomena of the exotic superconductivity in this material. Nevertheless, as was pointed out by Measson *et al.*, these transitions have also been observed even in macroscopic magnetization, which gives significant doubt on the intrinsic nature of the phenomena. Fig. 3 shows the local magnetic susceptibility at two different points as a function of temperature. At one point, the superconducting diamagnetism increases rapidly below $T_{c1} \simeq 1.85$ K, while that at the other point grows only below $T_{c2} \simeq 1.68$ K. The results mean that two intrinsic phases which give different T_c are stabilized in the crystal.

Very recently, we have observed paramagnetic Miessner effect like signal in the temperature dependence of local magnetization, which is probably dependent on the point of the sample surface. The signal may have some relation with the spontaneous moment observed in μSR experiments.

[1] S. Kasahara *et al.*, Physica C **426-431**, (2005) 381.
[2] T. Tamegai *et al.*, Physica B **284-288**, (2000) 543.

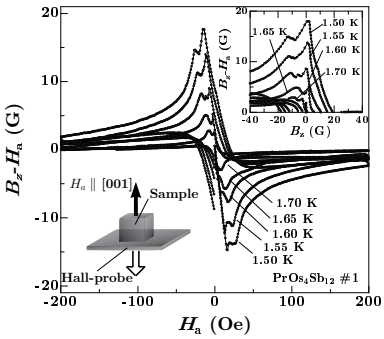

Figure 1: Local magnetization hysteresis curves in $PrOs_4Sb_{12}$ for the [001] axis measured by a Hall probe with an active area of 30×30 μm^2.

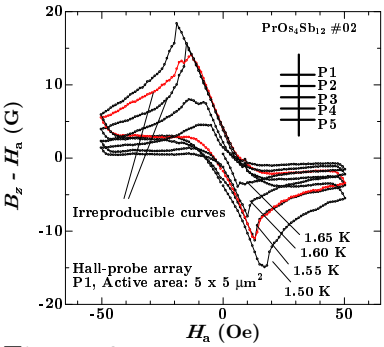

Figure 2: Local magnetization hysteresis curves in $PrOs_4Sb_{12}$ for an active area, P1, of the Hall-probe array.

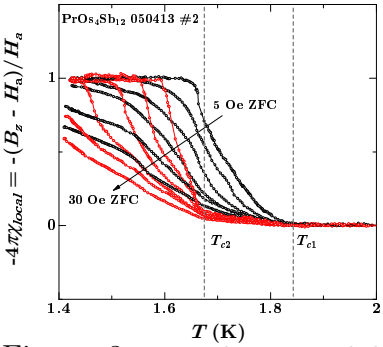

Figure 3: Local susceptibility for two different point of the sample.