Magnetic ordering in $YBa_2Cu_3O_6$

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The high-T_c cuprate oxide superconductor $YBa_2Cu_3O_{6+x}$ (YBCO) is a Mott insulator and its electromagnetic properties can be controlled by the oxygen content x. In the range $0 \leq x \leq 0.4$, YBCO is in the antiferromagnetic (AFM) ordered state below room temperature. The magnetic transition temperature T_N decreases with increasing x. As x increases further, the AFM ordered state disappears and the superconducting state appears at $x \geq 0.4$. Cu ions have localized d electrons in a $3d^9$ configuration.[1)] Thus, Cu ions control the magnetism of the YBCO system.

We characterized the magnetic susceptibility of single crystal YBCO with $x = 0$ that had been annealed at 580 ℃ in

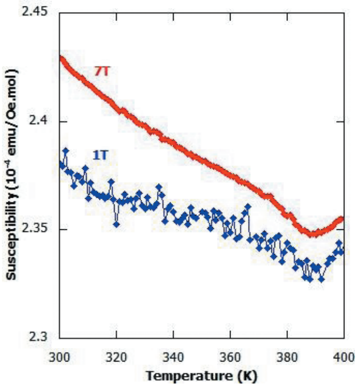

Fig. 1: Magnetic susceptibility of YBCO single crystals with x=0 measured under magnetic field of 1 and 7 T using SQUID.

Ar atmosphere using SQUID. T_N = 365 K is observed, but the magnetic transition is smeared out. This could be due to the inhomogeneous distribution of oxygen deficiency in the samples. In order to understand and clarify the magnetic ordering at the ground state of YBCO we used a muon spin rotation and relaxation (μSR) technique. The μSR experiment can detect the magnetic ordered state by the appearance of muon precession in a zero external field (ZF). Accordingly, the μSR experiment was performed in RAL (R486). A clear muon-spin precession was observed up to 279 K as shown in Fig. 2 (a). The observation of the muon-spin precession indicates clearly the appearance of a long-range magnetic ordered state in YBCO.[2,3)] Figure 2 (b) shows the slow damping of the non-oscillating signal above room temperature. This may be due to the fluctuating field or the nuclear dipole field that originates from the copper nuclei. Thus, we can say that the sample is in a paramagnetic state. A fast relaxing component was observed between 330 and 365 K

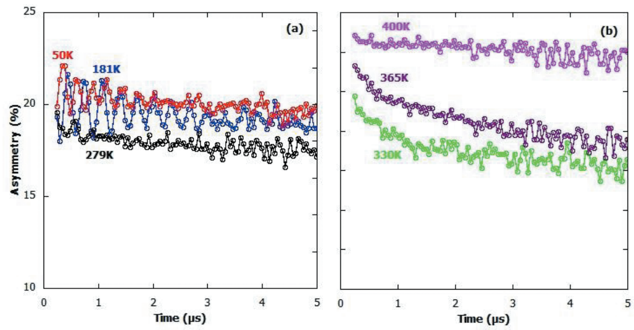

Fig. 2: ZF-μSR time spectra of YBCO single crystals with x=0 observed (a) below room temperature and (b) above room temperature.

and it increased with decreasing temperature. Therefore, T_N was se to 330 K from the current μSR experiment. The magnetic transition of μSR yields different results compared with the magnetic susceptibility measurement. We need more data points from the μSR point of view to elucidate macroscopic magnetic transition at high temperature.

References

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