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EPR study of the dynamic spin susceptibility in heavily doped $YBa_2Cu_3O_{6+\delta}$

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Abstract

We report on measurements of the dynamic spin susceptibility of the CuO_2-planes on single crystals of $YBa_2Cu_3O_{6+\delta}$ using EPR techniques. Intrinsic EPR signals due to the existence of paramagnetic chain fragments (pcf) show a behaviour revealing the opening of a spin gap above the superconducting phase-transition temperature. This can be directly compared with the results as observed from neutron scattering and NMR experiments.

1. Introduction

The importance of antiferromagnetic (AFM) spin fluctuations for the normal and superconducting state properties of high-T_c cuprate superconductors is still unclear. In the superconducting samples of $YBa_2Cu_3O_{6+\delta}$, a spin pseudogap opens above T_c which appears to be strongly dependent on oxygenation. This has been demonstrated using inelastic neutron scattering (INS) [1,2] and nuclear magnetic resonance (NMR) techniques [3].

In this experimental paper we will show that the temperature dependence of the dynamic susceptibility in $YBa_2Cu_3O_{6+\delta}$ can also be studied by electron paramagnetic resonance (EPR) measurements. We have demonstrated previously that intrinsic EPR signals due to the existence of paramagnetic chain fragments (pcf) can be detected in $YBa_2Cu_3O_{6+\delta}$ single crystals for concentrations $0.7 \leq \delta \leq 0.9$ [4]. Similar results have been obtained earlier by other groups [5,6].

2. Experimental results

The EPR experiments were performed on almost 30 high quality single crystals of $YBa_2Cu_3O_{6+\delta}$ with different oxygen content δ. An intrinsic EPR signal could be detected for oxygen concentrations $0.7 \leq \delta \leq 0.9$ [4]. The maximum of the EPR absorption was located on the borderline from the orthorhombic phase II to the orthorhombic phase I [4] in accordance with numerical calculations [7]. Here we focus especially on the temperature dependence of the intensity of the absorption line, as well as on the T-dependences of the resonance field and of the line width.

Upon rotation of the c-axis from parallel to perpendicular with respect to the external magnetic field the resonance field of the well-defined EPR signals is shifted by almost 40 mT. Both , $g_{\parallel}$ and $g_{\perp}$ are almost temperature independent.

Fig. 1(a) shows the temperature dependence of the intensity of the absorption line which varies weakly in the temperature range considered. The most interesting result was the temperature dependence of the line width (Fig. 1b). As we will show, the strong increase in ΔH below 90 K provides experimental evidence on the opening of a spin gap in the heavily doped metallic

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