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An "EPR" study of $YBa_2Cu_3O_7$ and related high-temperature superconductors**

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Abstract. Besides a $g \approx 2$ signal which disappears on cooling to the superconducting T_c, $YBa_2Cu_3O_7$ and related oxides show a near-zero-field signal in the superconducting state with certain unusual features attributable to a "superconducting glassy state".

Keywords. High-temperature superconductivity; $YBa_2Cu_3O_7$.

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High-temperature superconductors of the Y-Ba-Cu-O system with T_c in the 100 K range, discovered in the last few weeks (Ganguly *et al* 1987; Mohan Ram *et al* 1987; Rao *et al* 1987; Wu *et al* 1987) have created much expectation. These materials with characteristics of type II superconductors and high upper critical fields (> 50 T), are good candidates for "EPR" investigations, especially since EPR studies of bulk superconductors have not been reported extensively in the literature. In this communication, we make a preliminary report on some novel EPR results on the monophasic perovskites $YBa_2Cu_3O_7$ and $Y_{0.75}Lu_{0.25}Ba_2Cu_3O_7$ showing the onset of superconductivity above 100 K and zero-resistance well above 77 K.

The superconducting oxides were prepared by the solid state reaction of the component oxides in air at ~ 1200 K. The resulting oxides were tested for phasic purity by x-ray diffraction. The oxides were then annealed in flowing oxygen around ~ 1100 K. EPR experiments were carried out with a Varian E-109 spectrometer (X-band) on powdered samples.

$YBa_2Cu_3O_7$ shows an asymmetric signal at $g \approx 2$ at 300 K which becomes extremely broad in the superconducting state and cannot be detected (figure 1). More interesting is the observation of a signal near zero-field in the superconducting state (figure 2). This signal is very strong and narrow (compared to the $g \approx 2$ signal at 300 K). The lineshape of the signal is nearly Lorentzian, but asymmetric. The signal disappears on warming the sample to the superconducting transition temperature, accompanied by a phase reversal (see figure 2). The temperature variation of the intensity provides an order parameter of the transition.

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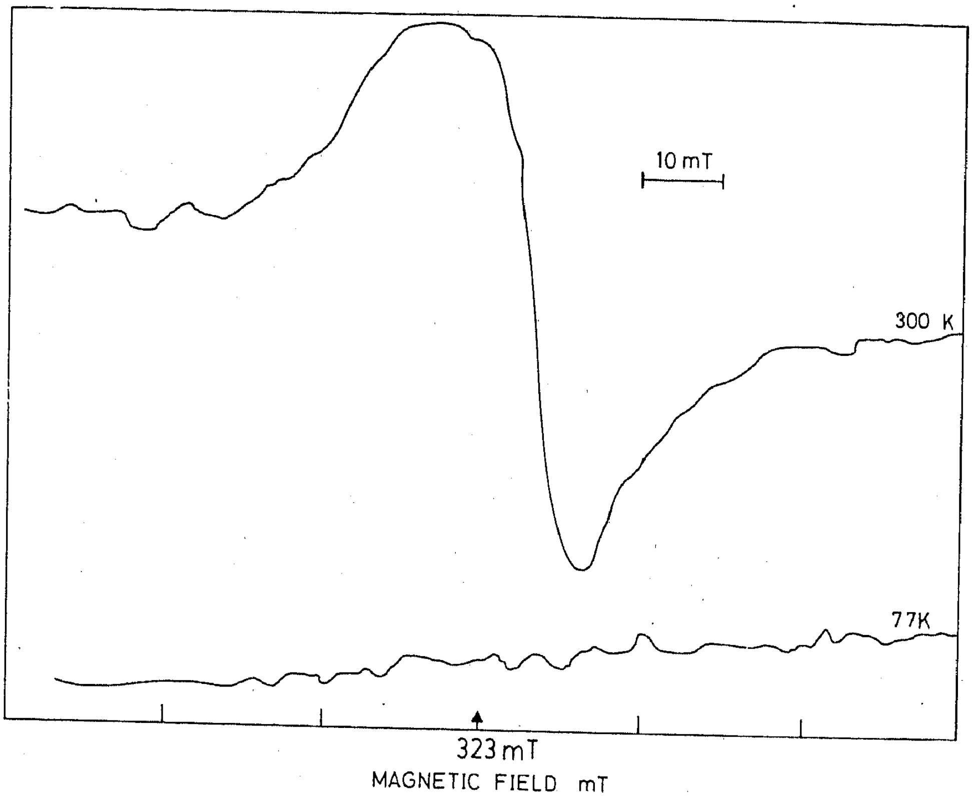

Figure 1. "EPR" of $YBa_2Cu_3O_7$ showing a $g \approx 2$ signal at room temperature; the signal is not detectable at 77 K.

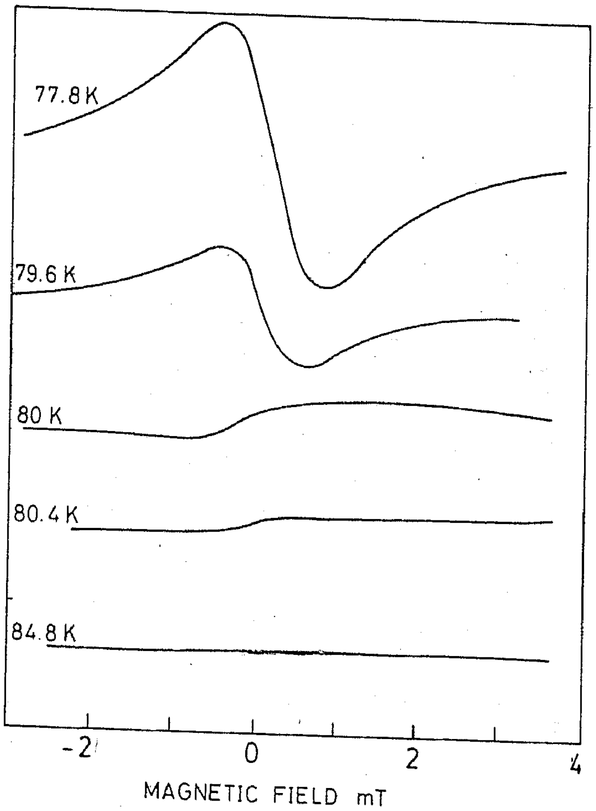

Figure 2. Near-zero-field signal of $YBa_2Cu_3O_7$ as a function of temperature.

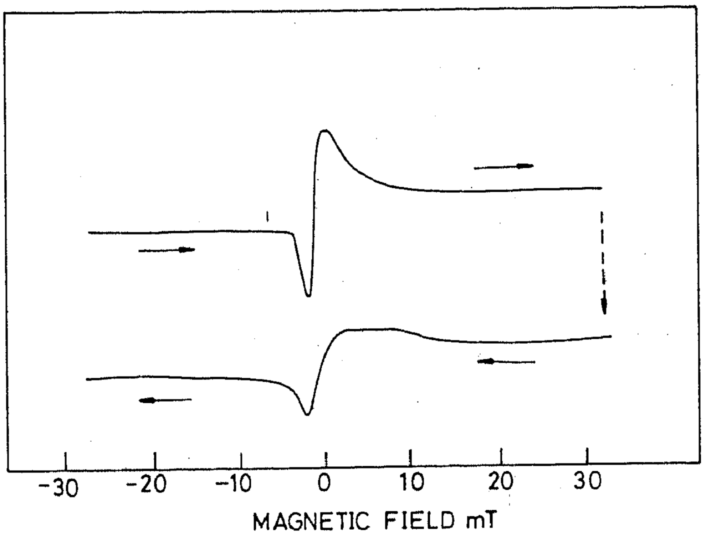

Figure 3. Lineshapes of the near-zero-field signal of $YBa_2Cu_3O_7$ in the forward and reverse field sweeps.

The lineshape of the near-zero-field signal shows pronounced differences in the forward and reverse sweep directions (figure 3). We have found a similar behaviour in the case of $Y_{0\cdot75}Lu_{0\cdot25}Ba_2Cu_3O_7$ which shows the signal in opposite phases in the forward and reverse sweep directions.

The observation of the near-zero-field signal as well as its unusual features can be broadly interpreted in terms of the presence of a triplet state or as due to collective excitations associated with antiferromagnetically coupled states. A more likely explanation however appears to be that based on the superconductive glass model (Ebner and Stroud 1985). This model predicts a maximum in static susceptibility close to zero field. The hysteresis effects in figure 3 are what would qualitatively be expected for a sample made up of a large number of superconducting grains of various sizes. The superconducting glassy state has been invoked by Müller *et al* (1987) to explain the magnetic properties of $La_{2-x}Ba_xCuO_4$.

Detailed "EPR" studies on these high-temperature oxide superconductors are in progress, especially to find out whether the zero-field signal is truly intrinsic to these materials.

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