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MAGNETIC ORDERING IN THE HIGH T_c SUPERCONDUCTOR $\text{Eu}_{0.1}\text{Gd}_{0.9}\text{Ba}_2\text{Cu}_3\text{O}_x$ [†]

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Superconducting transition temperatures T_c near 95 K have been found for a number of $\text{R Ba}_2\text{Cu}_3\text{O}_x$ systems, where R includes most of the rare earths /1/. Even magnetic ions such as Gd^{3+} have little effect on T_c . Heat capacity measurements of $\text{GdBa}_2\text{Cu}_3\text{O}_x$ show a λ -like feature at 2.24 K thought to be associated with magnetic ordering, and superconductivity persists below this temperature /2/.

We have made ^{151}Eu Mossbauer Effect (ME) measurements on $\text{EuBa}_2\text{Cu}_3\text{O}_x$ at temperatures down to 1.3 K. The isomer shift in $\text{EuBa}_2\text{Cu}_3\text{O}_x$ clearly shows the Eu to be in the 3+ state, and the absence of any hyperfine field shows it to be non-magnetic at all temperatures studied.

For $\text{Eu}_{0.1}\text{Gd}_{0.9}\text{Ba}_2\text{Cu}_3\text{O}_x$ we find a transferred hyperfine field at the Eu-sites developing below 2.1 K. These results are shown in Fig. 1 from data fitted with a magnetic Hamiltonian for the unresolved hyperfine spectra. The curve shown is a Brillouin fit to the data assuming $g = 2$ and a moment of $7\mu_B$ for Gd^{3+} . The fit gives a saturation hyperfine field of 2.9(3) T and a magnetic ordering temperature T_N of 2.09(11) K. The temperature of the peak in the heat capacity for $\text{Eu}_{0.1}\text{Gd}_{0.9}\text{Ba}_2\text{Cu}_3\text{O}_7$ was determined to be 1.95(5)K.

The measurements show that $\text{Eu}_{0.1}\text{Gd}_{0.9}\text{Ba}_2\text{Cu}_3\text{O}_x$ becomes magnetically ordered below 2.1 K with the temperature dependence expected for spontaneous ordering of Gd^{3+} ions. The magnitude of the hyperfine field transferred to the ^{151}Eu sites is roughly that expected from the dipole field from the Gd^{3+} neighbors; the Eu retains its Eu^{3+} nonmagnetic character. The ordering temperature T_N and the heat capacity peak are of common origin. Superconductivity masks the presence of magnetic ordering in magnetic susceptibility measurements, but a long extrapolation of the high temperature susceptibility /2/ of $\text{GdBa}_2\text{Cu}_3\text{O}_7$ gives $T_0 \sim -4.8$ K. Below 2.1 K, magnetism and superconductivity coexist.

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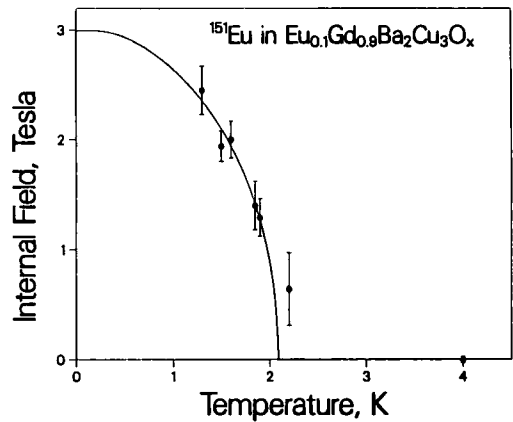


Fig. 1. Transferred hyperfine field at ^{151}Eu sites as a function of temperature.