Comment on "Spin Dynamics at Oxygen Sites in $YBa_2Cu_3O_7$"

Recently Hammel *et al.*[1] presented measurements of the nuclear relaxation rate $(1/T_1)$ in $YBa_2Cu_3O_7$. No coherence peak is observed in the superconducting state. In this Comment it is shown that an isotropic *s*-wave state can yield similar $1/T_1$ curves by including a large temperature-dependent pair-breaking rate $(1/\tau_{PB})$ and a large value for the ratio $2\Delta(0)/k_BT_c$.

The nuclear relaxation rate $(1/T_{1,S})$ in the superconducting state is given by[2]

$$\frac{1}{T_{1,S}}=\frac{1}{T_{1,N}}\int_0^\infty \frac{d\omega}{2T}\cosh^{-2}\left(\frac{\omega}{2T}\right)\left[\left(\mathrm{Re}\frac{u}{(u^2-1)^{1/2}}\right)^2+\left(\mathrm{Re}\frac{1}{(u^2-1)^{1/2}}\right)^2\right]. \quad (1)$$

The pair-breaking mechanism needed to smear out the coherence peak in $1/T_{1,S}$ is incorporated via $u=\tilde{\omega}/\tilde{\Delta}$, where $u=\omega/\Delta+\alpha u/(1-u^2)^{1/2}$ and $\alpha=1.0/2\tau_{PB}\Delta$. Evidence for a relatively large inelastic-scattering mechanism, possibly due to scattering from spin fluctuations, can be found in the large temperature-dependent resistivity just above T_c that is typical of the oxide superconductors. An additional feature in this calculation is a $1/\tau_{PB}$ that decreases below T_c, incorporating the removal of low-frequency quasiparticle states for inelastic scattering as Δ increases. A large temperature-independent $1/\tau_{PB}$ would result in too slow a decrease in $1/T_1$ as the temperature drops to zero. This observation may also be valid for proposals that an anisotropic *d*-wave state may explain the absence of the peak near T_c. Such a state may not fit the low-temperature $1/T_1$ data.[3] A large value for the ratio $2\Delta(0)/k_BT_c$ is also required in order to produce a rapid decrease with temperature in $1/T_{1,S}$ using Eq. (1). The usual BCS value of $2\Delta/k_BT_c=3.5$ produces a shoulder in $1/T_{1,S}$ between approximately $0.6T_c$ and $1.0T_c$ which is the remnant of the coherence peak.

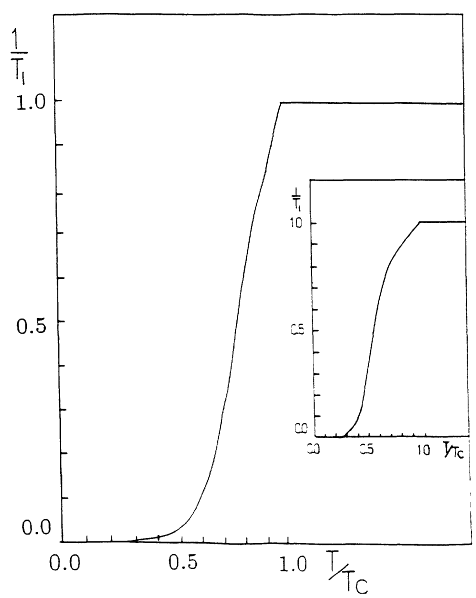

FIG. 1. The nuclear relaxation rate $1/T_{1,S}$ in units of the normal-state relaxation rate $1/T_{1,N}$ computed from Eq. (1).

Figure 1 is generated with $\Delta(T)=6.0T_c(1-T/T_c)^{0.5}$ and $1/\tau_{PB}=4T_c(T/T_c)^3$ in the superconducting state. The former would imply that $2\Delta(0)/k_BT_c=6.9$ if the BCS value of $\Delta(T)/\Delta(0)=1.74(1-T/T_c)^{0.5}$ is assumed, consistent with recent experiments.[4] The power-law temperature dependence used for $1/\tau_{PB}$ is a reasonable description of the freezing out of inelastic scattering upon entering the superconducting state.[5] The inset in Fig. 1 shows the relaxation rate for the same pair-breaking rate but with the BCS value of $2\Delta(0)/k_BT_c=3.5$. For the parameters corresponding to the main curve in Fig. 1, the coherence length $\xi_0=\hbar v_F/\pi\Delta(0)$ yields $\xi_0=15$ Å for $v_F=0.2\times10^8$ cm s^{-1} and $T_c=92$ K and the mean free path $l=v_F\tau_{PB}$ is approximately 42 Å at T_c, i.e., $l\geq\xi_0$.

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L. Coffey
Department of Physics
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

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