Quasiparticle Relaxation in a High-T_c Superconductor

Recent measurements by Eesley *et al.* [1] of transient reflectivity in superconducting $Tl_2Ba_2Ca_2Cu_3O_{10}$ were interpreted as evidence for order-parameter relaxation in the vicinity of T_c, which was analyzed in terms of BCS weak coupling for $\Delta(T)/\Delta(0)$. In this Comment we question this interpretation based on experimental evidence that laser pulse heating can mask the effect. Eesley *et al.* have shown [1] that the relaxation time τ_s in the superconducting state increases dramatically as T_c is approached; a similar increase was observed previously in $YBa_2Cu_3O_7$ [2,3] and in $Bi_2Sr_2Ca_2Cu_2O_{10}$ [3]. From a detailed temperature dependence at various power levels Eesley *et al.* inferred [1] that in the temperature range $(T_c-T)/T_c \leq 0.15$ the relaxation time varies as $\tau_s \propto T\Delta(T)^{-1}$ with a BCS-type $\Delta(T)/\Delta(0)$, similar to that in the usual low-temperature superconductors [4]. Because their relatively thick sample had a broad transition (onset at 120 K and zero resistance at 106 K), a clean divergence of τ_s was not observed at T_c; inhomogeneities were claimed to contribute to this slow rise in τ_s near T_c.

In this Comment we show that the divergence of τ_s near T_c in a clean thin film is extremely sharp at low laser intensities. We measured the induced reflectivity $\Delta R(t)$ at 625 mm with 60 fsec time resolution on $YBa_2Cu_3O_7$ films, 3000 Å thick with $T_c \simeq 89$ K and width of 2 K, expitaxially deposited by the uv laser ablation technique [2]. The samples were carefully handled and they were cooled only once through the phase transition; the average laser power was lower than 1 mW. For such a sample τ_s is proportional to the time $\tau_{1/2}$ it takes $\Delta R(t)$ to decay to half its initial value; we therefore show in Fig. 1 the behavior of $\tau_{1/2}$ as a function of temperature at various laser intensities. The onset of the divergence in $\tau_{1/2}$ shifts toward T_c as the intensity is reduced. Moreover, the *shape* of $\tau_{1/2}(T)$ changes at low illumination levels. The divergence of $\tau_{1/2}(T)$ is extremely sharp and sets in at $(T_c-T)/T_c \leq 0.025$ with our lowest intensity, contrary to the data presented in Ref. [1]. A similar effect of laser heating in $YBa_2Cu_3O_7$ was observed [5] in the gradual sharpening of the 340-cm^{-1} phonon softening with decreasing T below T_c, measured by Raman scattering, as the laser intensity was reduced. On the basis of the evidence presented above we therefore question the dependence of τ_s on T_c-T in Ref. [1] and their conclusion of $\tau_s \propto T\Delta(T)^{-1}$. Careful measurements at very low laser intensities have to be made on clean samples to verify this important relation. Moreover, if this relation were true, then our measurements shown in Fig. 1 indicate a much sharper $\Delta(T)/\Delta(0)$ than that expected for BCS; in fact, it is more in line with *strong coupling.*

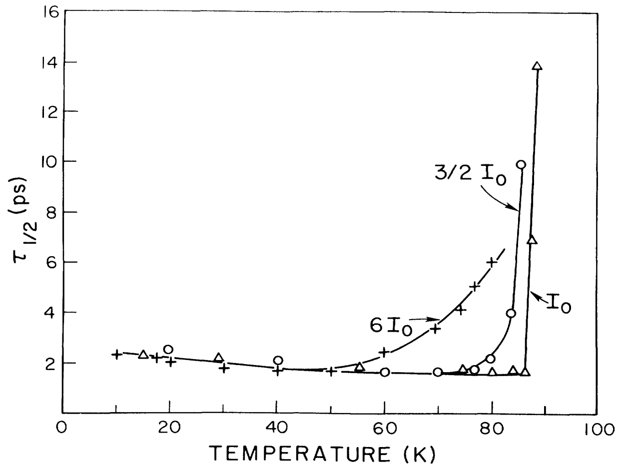

FIG. 1. Temperature dependence of quasiparticle relaxation time $\tau_{1/2}$ in $YBa_2Cu_3O_7$ at three different laser excitation intensities with $I_0 = 0.5\ \mu J\,cm^{-2}$ per pulse.

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