MUON SPIN DEPOLARIZATION IN Gd- AND $EuBa_2Cu_3Ox$

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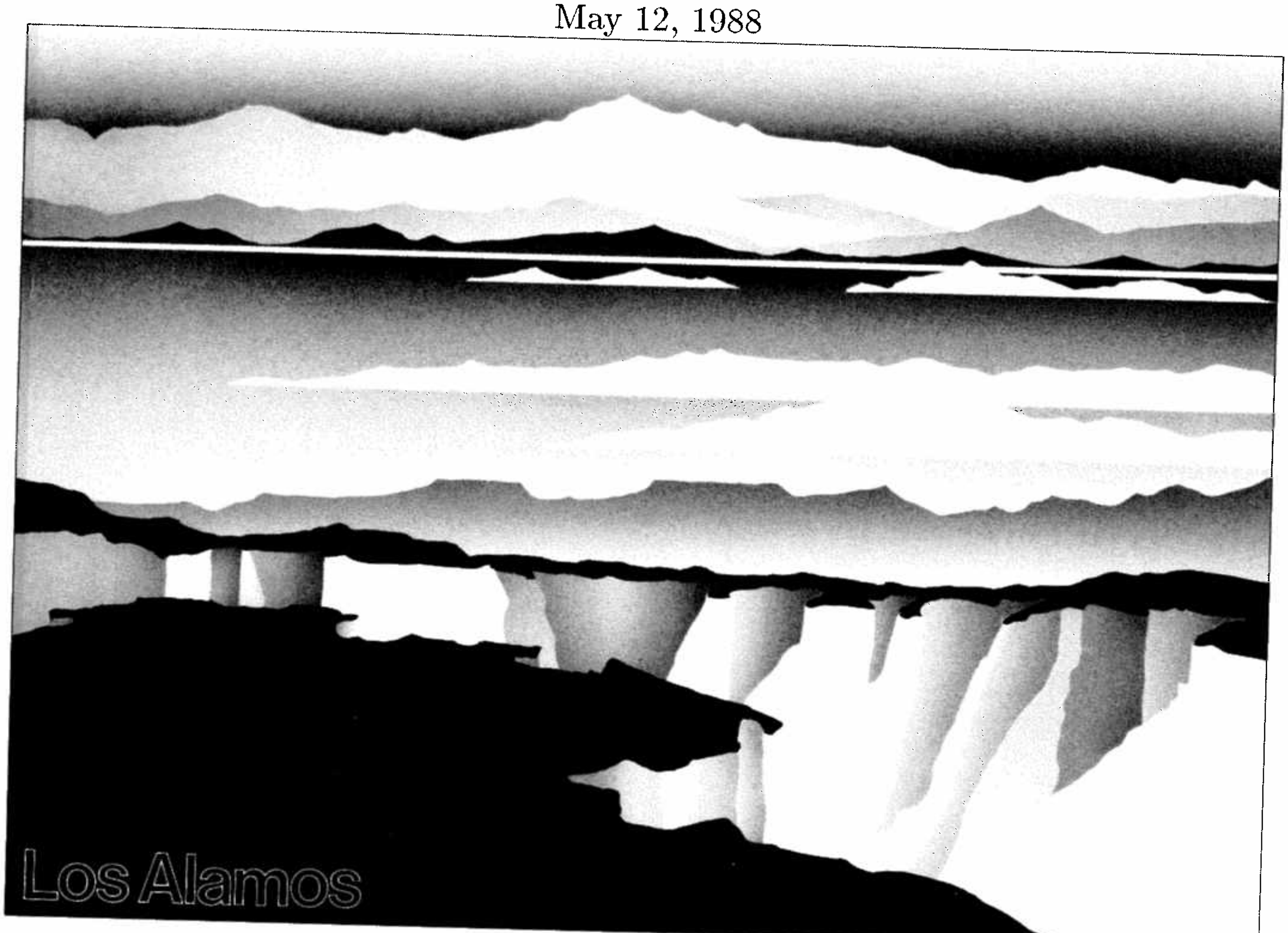

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MUON SPIN DEPOLARIZATION IN Gd- and $EuBa_2Cu_3O_x$

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Abstract Positive muon spin rotation (μSR) measurements on Gd- and $EuBa_2Cu_3O_x$ ($x \approx 7$) have been conducted in the temperature interval 4 - 300K. For each sample, muons stop both at grain boundaries and within the superconducting grains. Measured magnetic field penetration depths are 1550 and 1900Å for two specimens of $GdBa_2Cu_3O_x$, and 1350Å for $EuBa_2Cu_3O_x$.

Standard μSR techniques[1] were used to obtain positive muon (μ^+) Gaussian depolarization rates $\Lambda(T)$ for Eu- and $GdBa_2Cu_3O_x$ in a 1 kOe transverse field. Also, zero-field data were taken for the latter sample. Figures 1 and 2 show $\Lambda(T)$ and the corresponding muon precessional frequencies $\nu(T)$ for a well-characterized polycrystalline sample of $GdBa_2Cu_3O_x$. Two relaxation rates are observed for $T<T_c$, corresponding to two distinct muon stopping regions. From the $\nu(T)$ data we conclude that muons are thermalized in both normal and superconducting volumes of the sample. Further, the measured Fourier power and asymmetry data indicate that the superconducting to normal volume ratio is 5.6. We suggest that

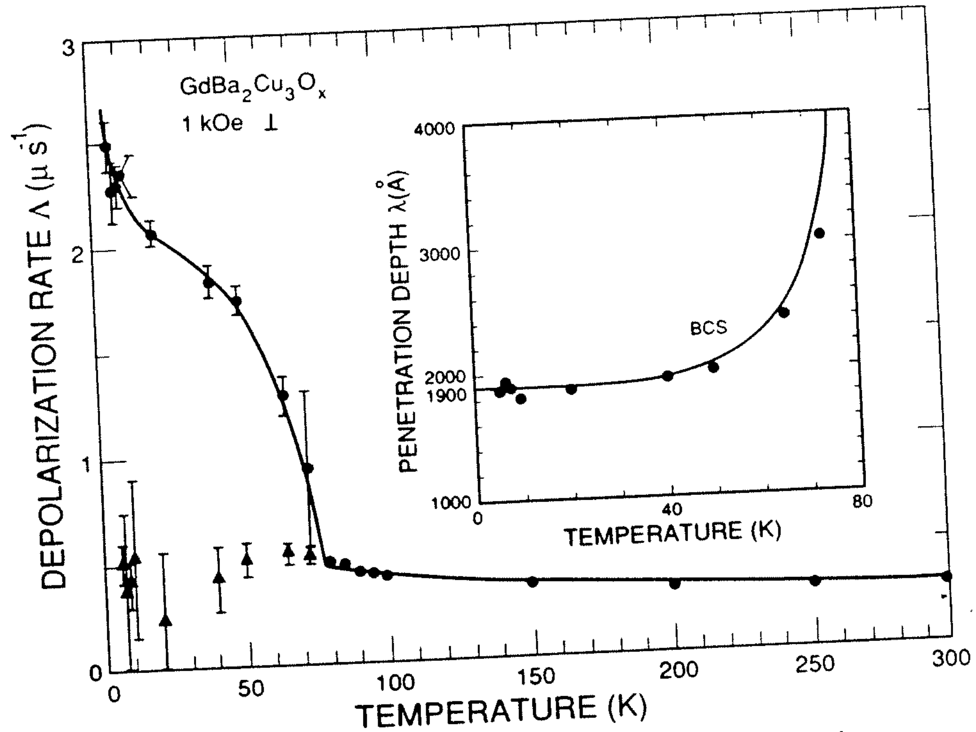

FIGURE 1. Muon Gaussian depolarization rates and penetration depth in GdBa$_2$Cu$_3$O$_x$.

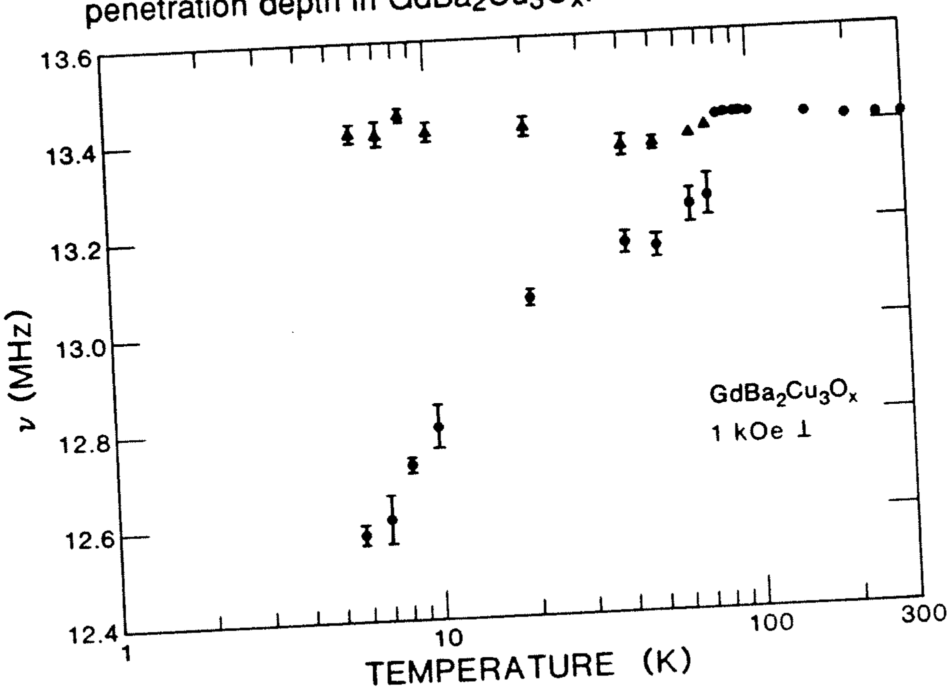

FIGURE 2. Muon frequencies in GdBa$_2$Cu$_3$O$_x$.

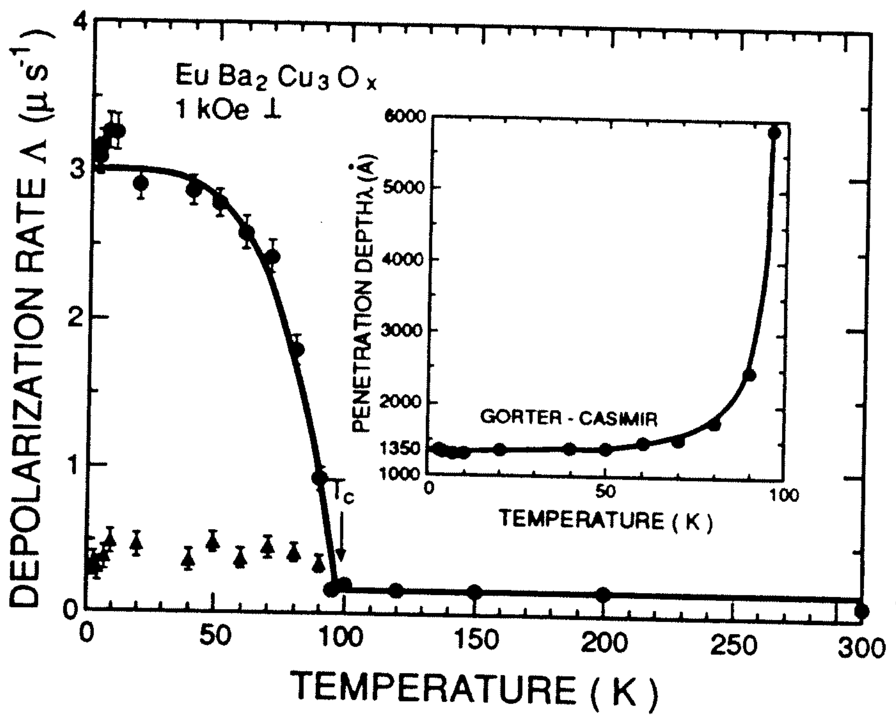

FIGURE 3. Muon Gaussian depolarization rates and penetration depth in $EuBa_2Cu_3O_x$.

85% of stopped muons reside within the superconducting grains and that 15% occupy grain boundaries. Similar results are obtained from polycrystalline $EuBa_2Cu_3O_x$ as shown in Figs. 3 and 4, and also from a second sample of $GdBa_2Cu_3O_x$ (not shown).

The magnetic field penetration depth $\lambda(T)$ is related to the field inhomogeneity, and thus $\Lambda(T)$, by the expression

$$<|\Delta H|^2> = (B\phi/4\pi\lambda^2)[1+(4\pi^2\lambda^2B)/\phi]^{-1} = 2\Lambda^2/\gamma_\mu^2 \qquad (1)$$

where Λ is the μ^+ depolarization rate, γ_μ is the muon gyromagnetic ratio, λ is magnetic penetration depth, and ϕ is the flux quantum. By properly extrapolating the measured depolarization rates of Figs. 1 and 3 to zero Kelvin, and

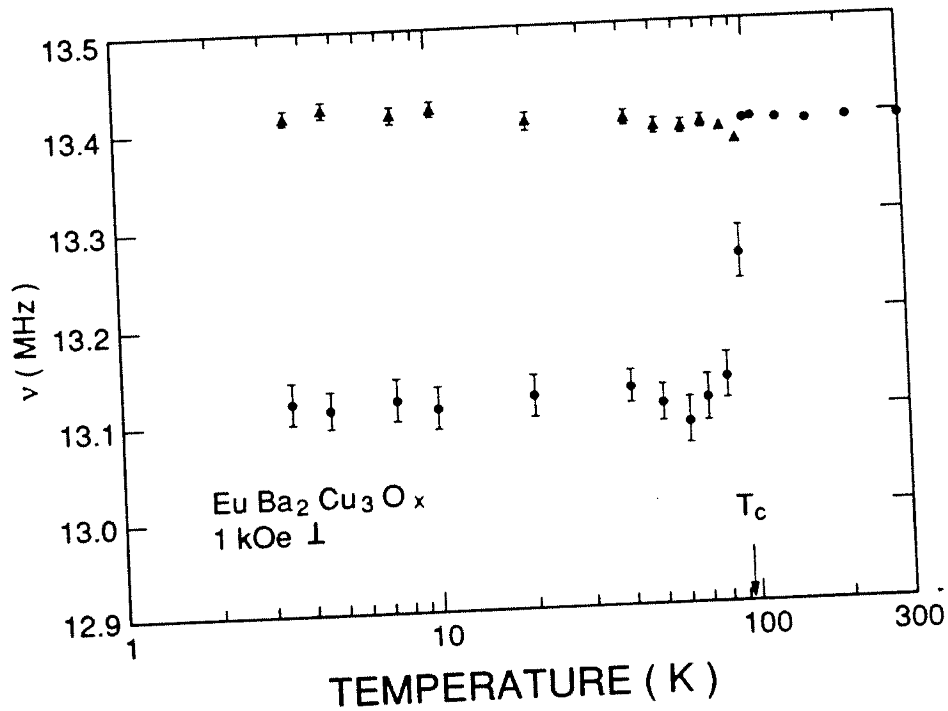

FIGURE 4. Muon frequencies in $EuBa_2Cu_3O_x$.

applying eq. (1), we find $\lambda(0)$ to be 1550 and 1900Å for two samples of $GdBa_2Cu_3O_x$, and 1350Å for $EuBa_2Cu_3O_x$. Moreover, we compute the temperature dependence of $\lambda(T)$ by assuming a phenomenological [2] expression $\lambda(T) = \lambda(0)[1 - (T/T_c)^4]^{-1/2}$ which we substitute into eq. (1), with the above measured values for $\lambda(0)$. These results are shown in the insets of Figs. 1 and 3. The solid lines represent the phenomenological expression calculated with the appropriate T_c's.

Zero-field μ^+ exponential relaxation rates and asymmetries for $GdBa_2Cu_3O_x$ are shown in Fig. 5. With decreasing temperature there is a drop in asymmetry and concomitant increase in Λ near T_c. Enhanced field inhomogeneity can explain the increase in Λ, but not the

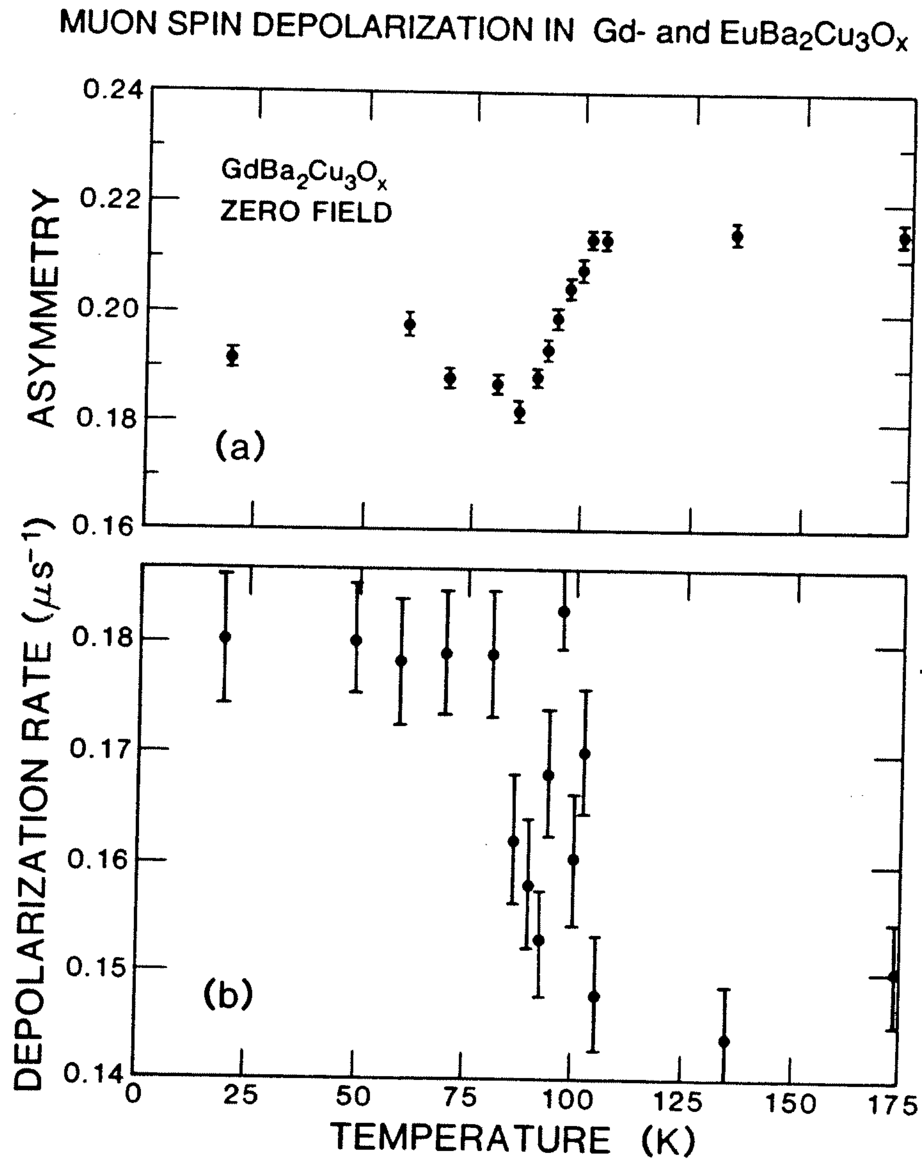

FIGURE 5. Muon exponential depolarization rates and asymmetries in $GdBa_2Cu_3O_x$ taken in zero field.

decrease in asymmetry; thus we offer no explanation for this puzzling result.

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REFERENCES

1. S. F. J. Cox, J. Phys. C, **20**, 3187 (1987).
2. P. D. De Gennes, *Superconductivity of Metals and Alloys* (Benjamin, New York, 1966), p. 26.