Effects of Vortex Pinning on the Temperature Dependence of the Magnetic Field Distributions in Superconductors

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Abstract

The temperature and applied-magnetic-field dependence of the second moments of the magnetic-field distributions as measured by μSR for YBCO and BSCCO have been fit for four different intrinsic-field-distribution models (d-wave, 2-fluid, empirical, and BCS). It is found that if a pinning potential becomes important at about 20 K, all of the models can fit the data reasonably well. The fits and the associated fitting parameters are presented.

1. Introduction

THE pinning of vortices in superconductors can lead to either broadening or narrowing of the apparent field distribution as was pointed out by Brandt[1]. The extra degrees of freedom associated with this pinning allow one to obtain good fits for a variety of underlying field distributions. We present here the results of data analysis which includes the effect of pinning.

2. Data Analysis Techniques

WE used our μSR data for single crystals of $YBa_2Cu_3O_{7-\delta}$ (YBCO) and $Ba_2Sr_2CaCu_2O_8$ (BSCCO). For YBCO we first fit with a model using a London field distribution shape smeared with a gaussian. For BSCCO we fit with a back-to-back gaussian field distribution. Once having these we then extracted the second moments. For YBCO this used the second moment for a London model field distribution plus the gaussian second moment and then the background second moment was subtracted. For BSCCO the second moment of the back-to-back distribution had the background second moment subtracted. For the two-fluid model we used: $\lambda(0)^2/\lambda(T)^2 = 1 - (T/T_c)^4$, and for the empirical model: $\lambda(0)^2/\lambda(T)^2 = 1 - (T/T_c)^2$. We followed the description in Tinkham's book[2] for the BCS model. For the d-wave we used results of Amin et al. [3]for $\lambda(0)^2/\lambda(T)^2$, interpolating for the particular fields we used. We followed the general procedure of Fiory et al..[4]

3. Results

FITS to the data for the various models are shown below. The solid lines are the fitting function.

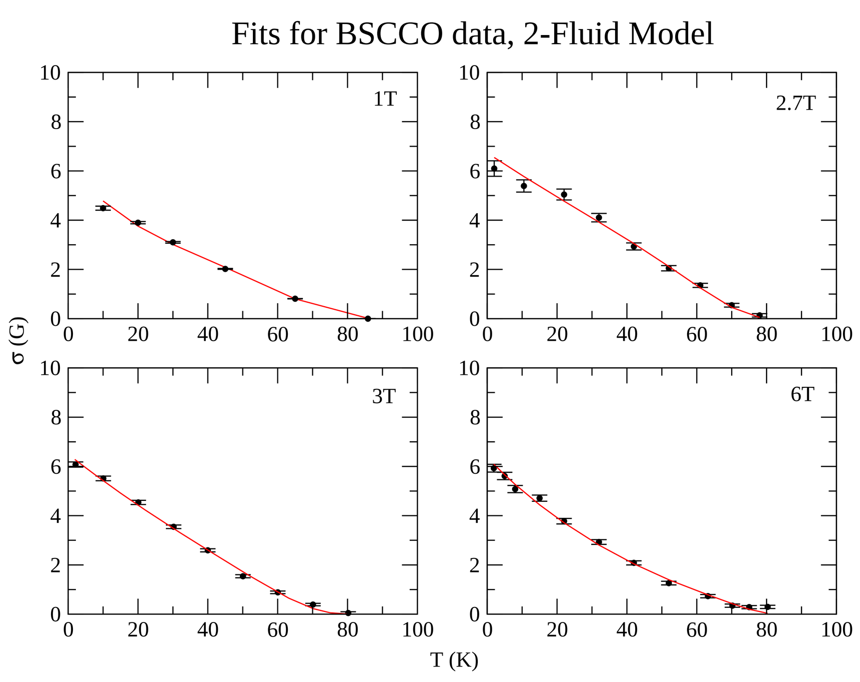

Figure 1: *2-Fluid fits for BSCCO*

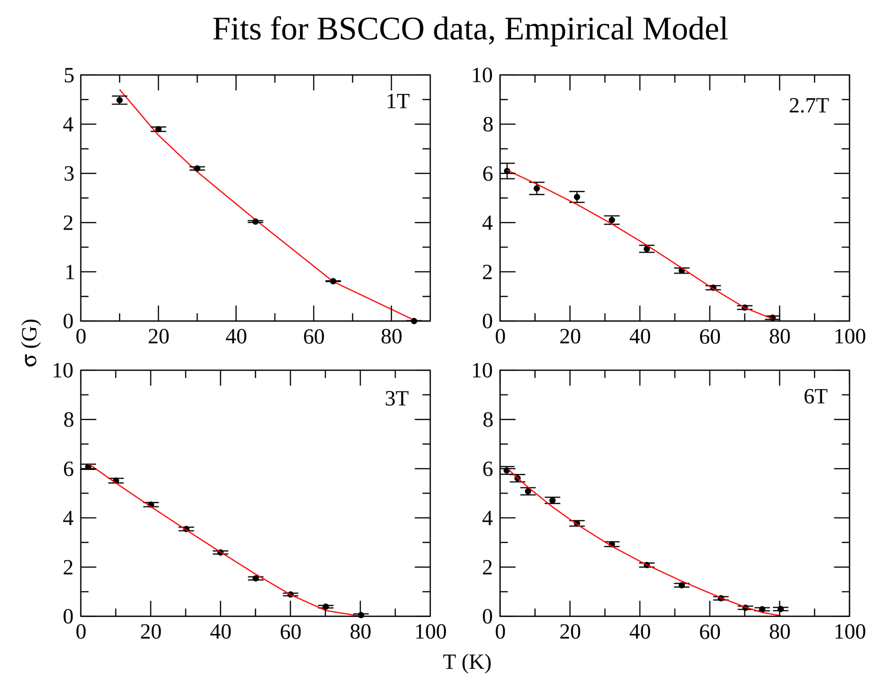

Figure 2: *Empirical fits for BSCCO*

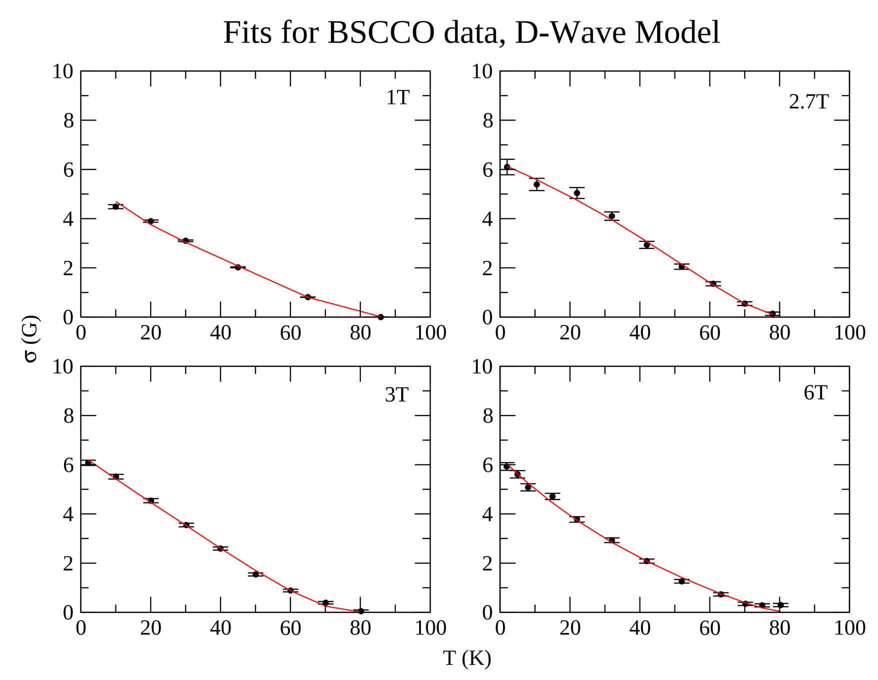

Figure 3: *d-wave fits for BSCCO*

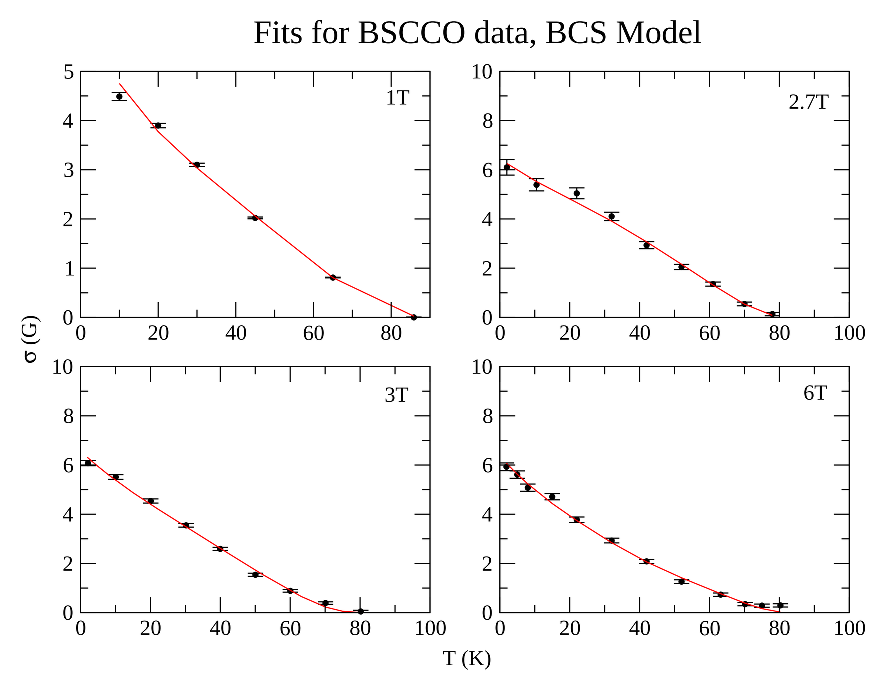

Figure 4: *Empirical fits for BSCCO*

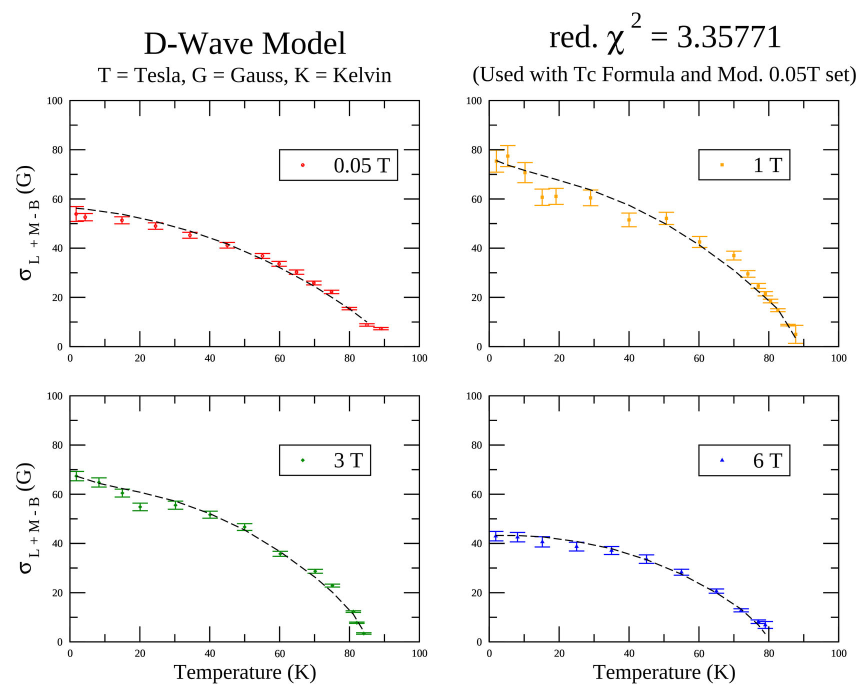

Figure 5: *d-wave fits to YBCO*

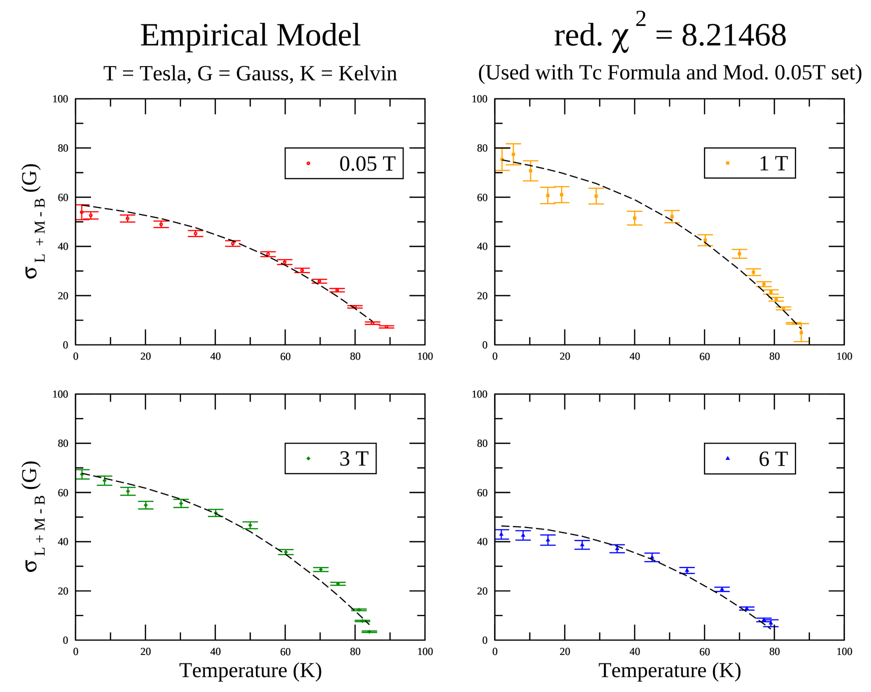

Figure 6: *Fits to YBCO with the empirical model*

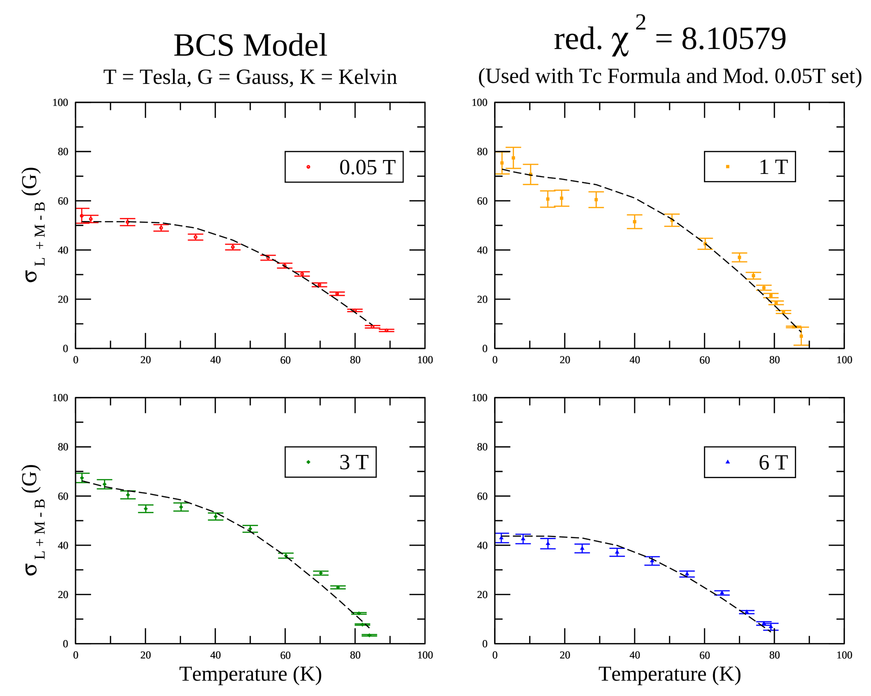

Figure 7: *Fits to YBCO with BCS model*

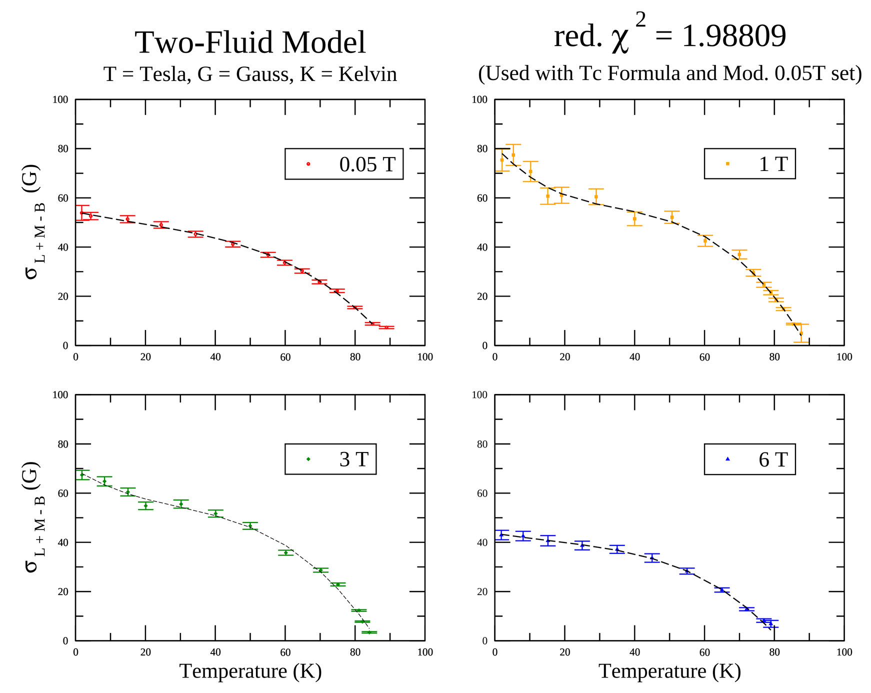

Figure 8: *Fits to YBCO with the two fluid model*

4. Conclusions

FROM the figures one can see data are reasonably well fit. The BSCCO data require a very large degree of pancake disorder to fit. One could argue that there is hardly any order at all. The YBCO data have indications of a kink around 20 K. This can be fit reasonably well with a trapping-induced increase in the second moment which sets in at about that temperature. The 2-fluid model has the lowest χ^2. However, more complex pinning behavior has not been considered.

References

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