Field Dependent NMR Study of Glassy Spin Freezing in $Ba(Fe_{1-x}Co_x)_2As_2$

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Introduction

The Iron-based superconductors exhibit rich phase diagrams that include magnetism, superconductivity, and both Fermi and non-Fermi liquid metallic phases. Upon Cobalt doping, the stripe spin density wave (SDW) phase of $BaFe_2As_2$ is suppressed and superconductivity (SC) emerges at temperatures up to 23 K for $x \approx 0.07$. For $0.03 < x < 0.06$ the energy scales of the SDW order and SC are comparable and interaction occurs in the form of coexistence and competition of order parameters. Moreover, recent NMR [1] and neutron scattering [2] results have identified a phase of short-range cluster spin glass behavior which may be intimately linked to the competition of SC and SDW in this class of materials and possibly related to nematic fluctuations [3].

Experimental

We measured the spin-lattice relaxation rate T_1^{-1} of ^{75}As at the central transition (I_z = +½ to -½) by saturation recovery with $H \perp c$-axis at 30.4 T at four different doping levels for x = 0.058 using the high-homogeneity resistive magnet in Cell 2 at the DC field center. A Helium flow cryostat was used to control temperature.

Results and Discussion

The data show strong field dependence over a decade of applied field values from 3.5 T to 30.4 T. This field dependence is the result of glassy behavior, which was previously inferred from stretched exponential relaxation behavior and signal wipeout in Co-doped samples. [1] Glassy dynamics has also been observed in the 1111 Iron-based compounds [4] and $Ba(Fe_{1-x}Ni_x)_2As_2$ [2]**.** The spin lattice relaxation rate at the peak $T_1^{-1}{}_{max}$ is a linear function of the inverse of the applied field H_0^{-1}. The suppression of the relaxation rate with applied field and the large distribution of relaxation rates (β<1) drive home the conclusion of glassy dynamics in Co-doped $BaFe_2As_2$.

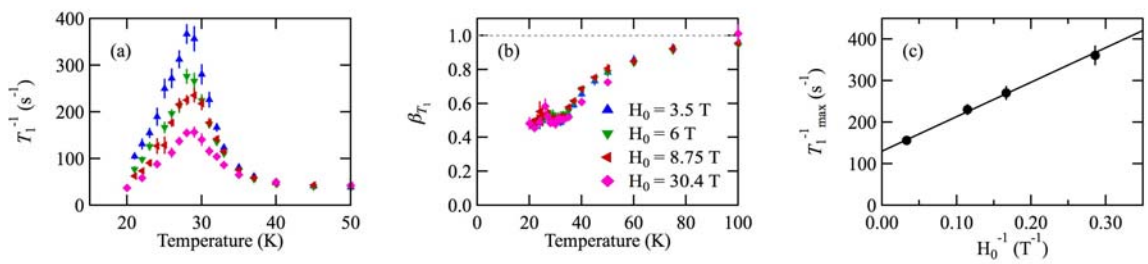

Fig. 1: (a) Spin-lattice relaxation rate T_1^{-1} versus temperature of ^{75}As in $Ba(Fe_{1-x}Co_x)_2As_2$ with $H \perp c$-axis for x = 0.058. (b) Stretching exponent β versus temperature. (c) Maximum spin-lattice relaxation rate $T_1^{-1}{}_{max}$ vs temperature.

Conclusions

Field dependence of spin-lattice relaxation indicating glassy behavior was observed over a decade of applied fields in a single crystal of in $Ba(Fe_{1-x}Co_x)_2As_2$ for x = 0.058 with $H \perp c$-axis. This inhomogeneous behavior appears to be a general feature in a variety of iron-based superconductors and must be understood if the interaction of the spin density wave and superconducting ground states is to be properly described. Furthermore, a connection between the observed glassy behavior and normal state nematic fluctuations is likely.

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References

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