Nearly Isotropic Superconductivity in $(Ba,K)Fe_2As_2$

2009 NHMFL Science Highlight to NSF

DMR-Award 0654118

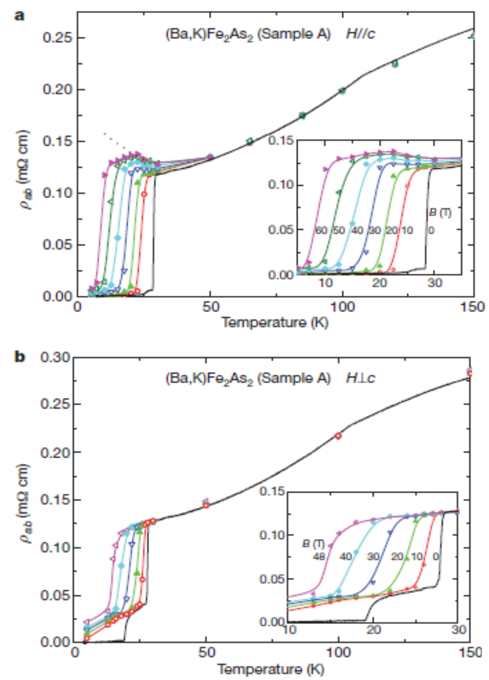
Pulsed Field Facility User Program

Superconductivity was recently observed in iron-arsenic-based compounds with a superconducting transition temperature (T_c) as high as 56 K, naturally raising comparisons with the high-T_c copper oxides. The copper oxides have layered crystal structures with quasi-two-dimensional electronic properties, which led to speculation that reduced dimensionality (that is, extreme anisotropy) is a necessary prerequisite for superconductivity at temperatures above 40 K.

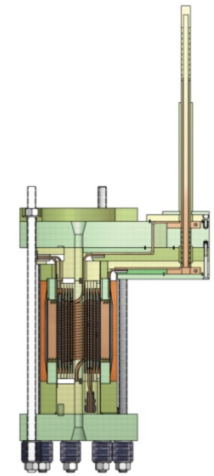
Early work on the iron-arsenic compounds seemed to support this view. Here we report measurements of the electrical resistivity in single crystals of $(Ba,K)Fe_2As_2$ in a magnetic field up to 60 T. We find that the superconducting properties are in fact quite isotropic, being rather independent of the direction of the applied magnetic fields at low temperature. Such behavior is strikingly different from all previously known layered superconductors, and indicates that reduced dimensionality in these compounds is not a prerequisite for "high-temperature" superconductivity.

We suggest that this situation arises because of the underlying electronic structure of the iron-arsenic compounds, which appears to be much more three dimensional than that of the copper oxides. Extrapolations of low-field single-crystal data incorrectly suggest a high anisotropy and a greatly exaggerated zero-temperature upper critical field.

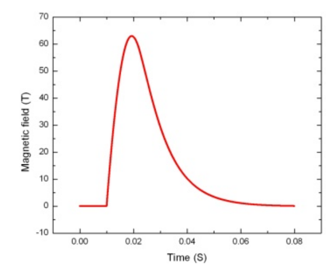
H.Q. Yuan, J. Singleton, F.F. Balakirev, S.A. Baily, G.F. Chen, J.L. Luo and N.L. Wang **NATURE, 457, pg 565, 29 January 2009.**



Electrical resistivity versus temperature at selected magnetic fields



Schematic of 65T pulsed magnet



Magnetic field pulse

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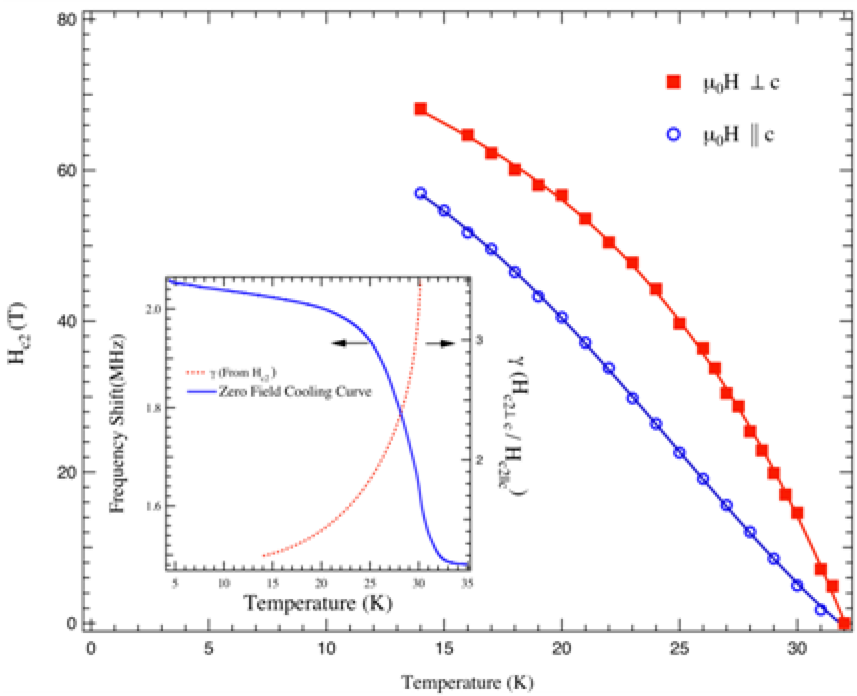

The upper critical field of $Ba_{0.55}$ $K_{0.45}$ Fe_2 As_2 measured in pulsed magnetic fields by the contactless conductivity method.

M. Altarawneh, K. Collar, C.H. Mielke, N. Ni, S.L. Bud'ko, P. C. Canfield
Phys. Rev B Rapid Comm., 78, 220505(R) (2008)

This class of superconductors has relatively high upper critical fields and transition temperatures that make them strong potential candidates for applications. The nearly isotropic nature of the superconductivity gives this class of materials an advantage when immersing the material in a non-static field.

These materials investigations involved multiple institutions as well as collaborations from around the world. Undergraduate (KC), Graduate (MA) and Postoctoral (HQY, SAB, and NN) took part in these experiments. A new experimental method was also developed while working on these experiments by graduate student M. Altarawneh.
(M. Altarawneh, C.H. Mielke and J.S. Brooks, Rev. Sci. Instrum, **80** 066104 (2009)).