MAR15-2014-020851

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Novel Materials & Multi-scale Analysis of the Superconducting State in Iron Based Superconductors[1]

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The understanding of the fundamental nature of a material's superconducting state is of crucial importance, if superconductors are to fulfill their promise for widespread use in energy-related needs. Our research applies multi-scale characterization techniques to study and probe the nuclear, electronic, and magnetic details of single crystals. The importance of such broad investigative work is demonstrated in our recent publication on praseodymium-doped $BaFe_2As_2$ for which non-uniform local distortions through isolated Pr atoms do not provide percolation path superconductivity [1]. For $CaFe_2As_2$, it is found that large Fermi-surface reconstruction in the non-magnetic phase causes a non-superconducting ground state [2], while different crystalline domains with varying lattice parameters are identified [3]. For Cu-doped $BaFe_2As_2$ it is found that orthorhombic distortion below T_s leads to magnetically ordered state of FeAs planes, hence no superconductivity [4]. Studies of this nature can yield groundbreaking results by demonstrating that many parameters can compete in a bulk material and even be spatially and electronically non-homogenous on nanometers.

[1] Phys. Rev. Lett. 112 (2014), 047005;
[2] Phys. Rev. Lett. 112 (2014), 186401;
[3] Sci. Reports 4 (2014), 4120;
[4] Phys. Rev. Lett. 113 (2014), 117001.

[1]This work was primarily supported by the U. S. Department of Energy, Office of Science, Basic Energy Sciences, Materials Science and Engineering Division.