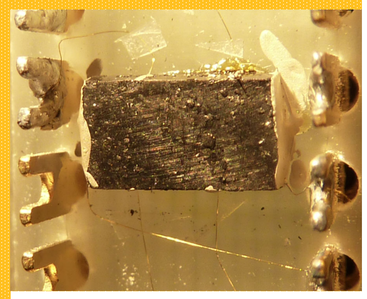
Magneto-transport properties and thermally activated flux flow $Ba(Fe_{0.95}Ni_{0.05})_2As_2$ and $Ba(Fe_{0.94}Ni_{0.06})_2As_2$ superconductors

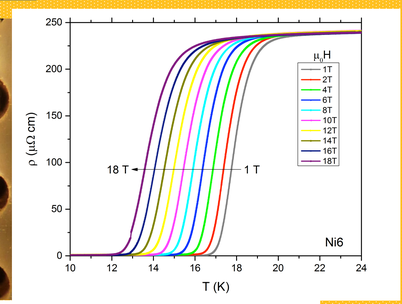
Martin Nikolo[1], Xiaoyan Shi[2], Jianyi Jiang[3], Jeremy Weiss[3], and Eric Hellstrom[3]

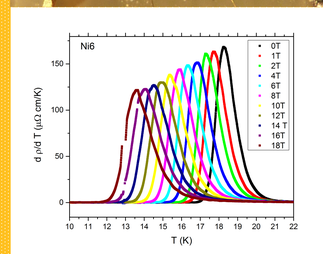
[1]Department of Physics, Saint Louis University, St. Louis, MO 63103, USA. [2]National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310, USA
[3]Applied Superconductivity Center, National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310, USA

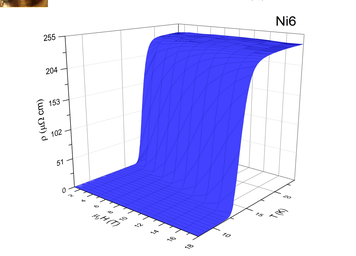
Measurement



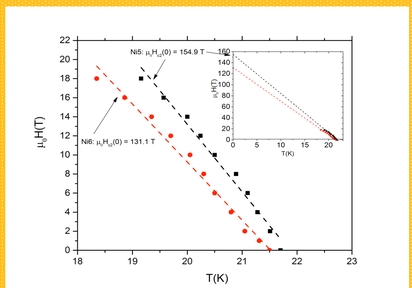
Resistivity vs. temperature in fields 0-18 T







Upper critical field



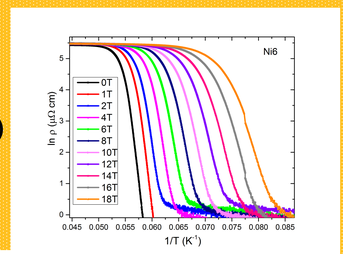
There is an onset of weak pinning at T_x (TAFF off) in low fields. As we move vertically across the *T-H* phase curve, staying above T_x, the weak pinning strength decreases to zero as the field increases from 0 T to 18 T and we get an unpinned vortex fluid.

Analysis

The Anderson-Kim Arrhenius TAFF model

$$\rho = \rho_0 \exp(-U(T,H)/k_B T)$$

$$\frac{d\ln\rho}{d(1/T)} = -U/k_B$$

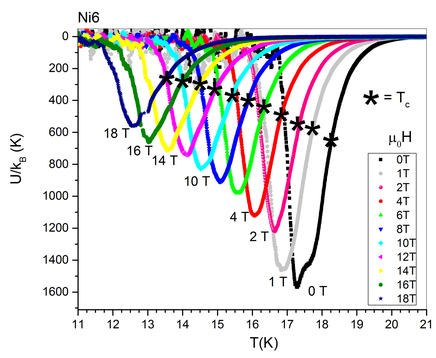


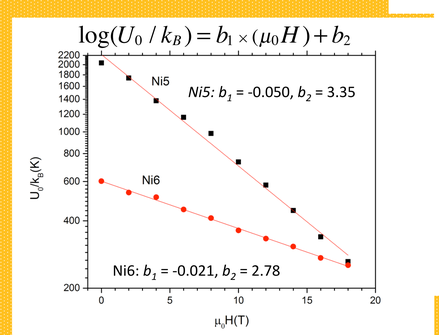
Modified Anderson model

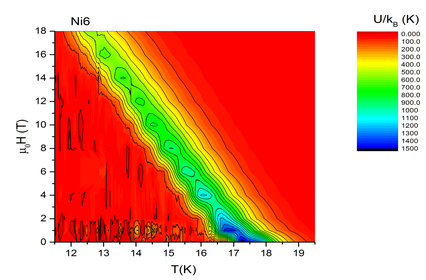
$$\frac{d\ln\rho}{d(1/T)} = -\frac{U_0^2}{k_B^2}\left(\frac{1}{T}\right)$$

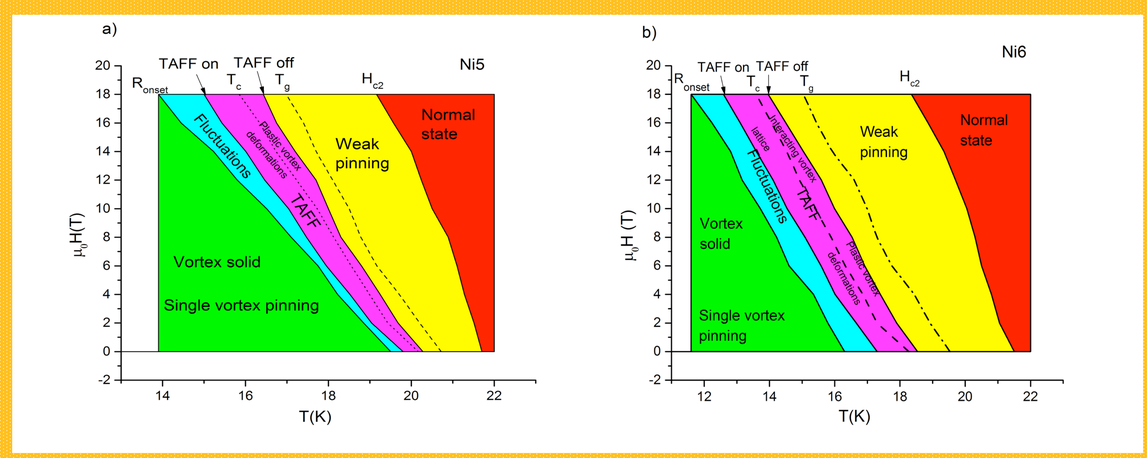
$$\rho = \rho_0 \exp\left(-\frac{U_0^2}{2k_B^2 T^2}\right)$$

Slope of $d\ln\rho/d(1/T)$ gives U_0^2/k_B^2



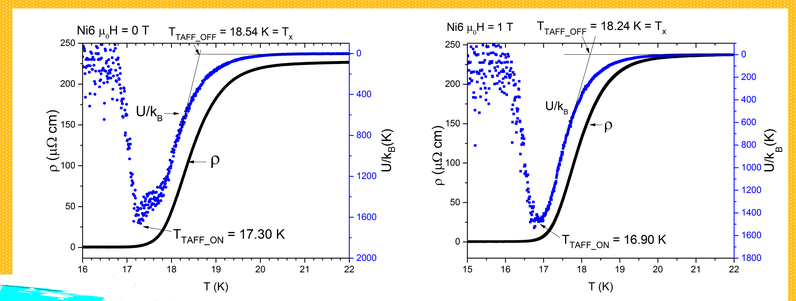


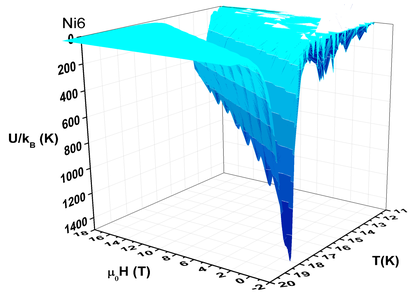


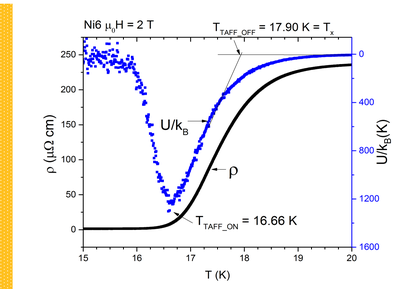


Results

Pinning potential energy and resistivity vs. temperature for 0, 1, and 2 T







The TAFF boundary forms a narrow deep valley of decreasing depth across the *T-H* plane as *H* is increasing. It is about 0.4 to 1.7 K wide.

The onset of fluctuations is seen as the resistivity shows the first signs of an increase but this initial rise does not fit the Arrhenius TAFF model for we do not get a clearly defined slope that defines the activation energy *U*.

Just below T_x, we see the onset of weak pinning that turns to no pinning as we approach H_{c2}. This is not an abrupt first-order transition, but a continuous one where weak pinning and no pinning regimes coexist. In other words, the vortex fluid phase is a fully disordered phase, which is not separated from the normal phase by a true phase transition —they really are the same phase and are connected by a smooth crossover.

Conclusion

We determine the flux flow activation energies of $Ba(Fe_{0.95}Ni_{0.05})_2As_2$ and $Ba(Fe_{0.94}Ni_{0.06})_2As_2$ bulk superconductors as a function of magnetic field and temperature.

We determine the upper critical field and the *H-T* phase diagram with particular emphasis on the limitations of the Anderson-Kim TAFF regime.