Disorder study of scale-invariant resistivity in a high-temperature superconductor

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Introduction

The normal state of high-temperature superconductors has challenged conventional understanding of metals for decades. It is often suggested that the prevailing description of electrons in solids is unable to describe the behavior of these materials. Most recently, we have shown that the resistivity of an iron-based superconductor is scale-invariant between magnetic field and temperature [1]. In this systematic disorder study, we constrain the possible mechanism for the universal transport behavior.

Experimental

Transport devices of an iron-based high-temperature superconductor $BaFe_2(As_{1-x}P_x)_2$ were systematically damaged with alpha particles; the relevant metric characterizing the disorder level is the zero-temperature limiting resistivity (also called residual resistivity). Transport measurements were then carried out in pulsed magnetic fields.

Results and Discussion

The scale-invariant form of the magnetoresistance holds robustly (Fig. 1), but the relative strength of magnetic field and temperature changes. Kohler's scaling plots allow us to compare the magnetoresistance of samples with different levels of disorder scattering (Fig. 2). Validity of Kohler's rule between disordered samples at higher temperatures suggests semiclassical motion fully captures the magnetoresistance. This orbital motion breaks down at lower temperature.

Conclusions

The validity of Kohler's rule suggests that a semiclassical description is a correct starting point. The low-temperature corrections could arise naturally from scattering from incipient antiferromagnetism. These corrections only occur below the superconducting transition, suggesting that the same fluctuations that produce scale-invariant resistivity are the same as those involved in superconducting pairing.

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References

[1] Hayes, I.M., *et al.*, Nature Physics, **12,** 916–919 (2016)