Transport Limited by Emergent Defect States in Fe-Based Superconductors

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Introduction

Correlated electron systems near the metal-insulator transition are often unstable to a variety of inhomogneous phases like charge and spin density waves (SDW). Impurities are known to be able to "freeze" fluctuations of these ordered phase around themselves, creating an emergent defect state. In a phase in proximity to magnetic stripe order characteristic of Fe-based superconductors, these "nematogens" take the form shown below: they elongate and grow above the transition, then freeze below into remarkably long defect structures which have been seen in STM. Recently, the PI and group calculated the scattering rate anisotropy to be expected from such objects, and were able to explain a number of puzzling aspects of transport experiments on $BaFe_2As_2$:

Results and Discussion

We performed Bogoliubov-de Gennes (BdG) calculations of simple □-function defects to simulate impurities in the spin density wave (SDW) state and nematic state ($T_N<T<T_s$) of Fe-based superconductors, including Hubbard and Hund's rule couplings treated in mean field [2-4]. As expected, the impurities nucleated droplets of distorted magnetic order for sufficiently large correlation strength. We calculated the effective scattering potential by taking the matrix elements between plane wave states of the BdG Hamiltonian with and without the impurity, then used Boltzman theory to calculate the transport rate.

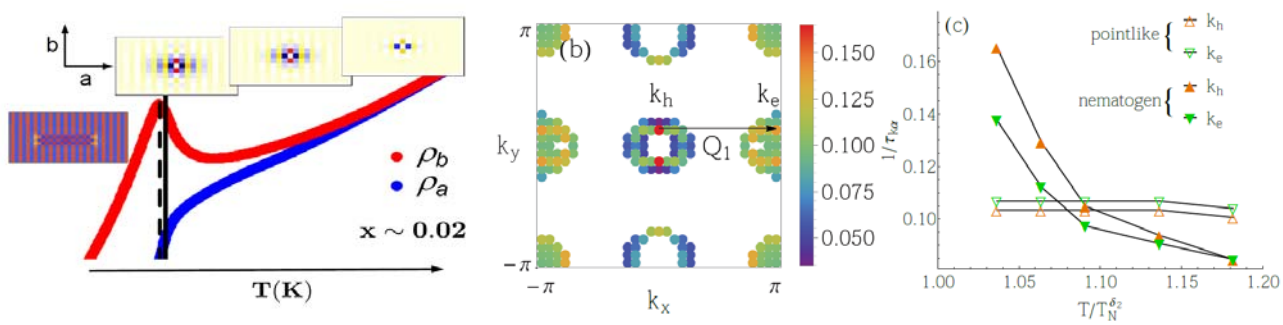

Fig. 1 a) Anisotropic resistivity in Ba(Co,Fe)2As2 [1] and schematic picture of calculated result for defect in each case. b) Transport cattering rate from nematogen above T_N calculated over Fermi surface. c) comparison of total momentum-integrated scattering rate for nematogens (self-consistently evaluate emergent defects) and pointlike scatterers in orthorhombic state [3].

Conclusions

We discussed an impurity-driven scenario for the remarkable transport anisotropy in Fe-based superconductors that explains all essential features of these measurements, and argues for an increased focus on the unusual role played by impurities in these systems with strong spin fluctuations near a magnetic transition.

Acknowledgements

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References

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