Tuning of the phase diagram and quantum critical point by disordered in Fe-based superconductors.

Marcin Konczykowski[1], *Yuta* Mizukami[2], *Takasada* Shibauchi[2], *Shigeru* Kasahara[3], *Yuji* Matsuda[3]

[1]*Laboratoire des Solides Irradiés, Ecole Polytechnique, 91128 Palaiseau, France*
[2]*Department of Advanced Materials Science, University of Tokyo, Japan*
[3]*Department of Physics, Kyoto University, Kyoto 606-8502, Japan*

Typical composition – temperature phase diagram of Fe-based superconductors shows dome shaped superconducting region, intersected by magnetic transition line. Other classes of materials: high temperature superconductors, doped Mott insulators and heavy fermions exhibit similar diagrams commonly interpreted as the signature of quantum critical point (QCP) lying beneath superconducting dome. Fluctuations in the vicinity of QCP seem to give rise to nonconventional superconducting pairing, however this effect remains elusive.

Here we explore the effect of crystalline (point like) disorder on the entire phase diagram of canonical iron based superconductor $Ba(FeAs_{1-x}P_x)_2$. Beyond the strong suppression of critical temperature and of the change of topology of superconducting gap by point like disorder (introduced by low temperature electron irradiation) reported previously [1] we found depression of spin density wave (SDW) transition and extension to lower temperatures of non-Fermi liquid behavior in disordered samples. This observation points to possible shift of QCP by disorder synchronized with displacement of the superconducting dome and direct link between QCP and superconducting transition (SC) [2].

In the underdoped region of the phase diagram, we observe on cooling sequential SDW and SC transitions. Superconducting state emerges from antiferromagnetic state leading to singular vortex core. In this region we found fingerprints of novel transition inside of superconducting dome indicating two different superconducting phases. The sequence of transition from para- to antiferromagnetic state can be tuned by disorder to direct transition from paramagnetic to superconducting state.

Finally, we explore the evolution of SDW transition with point and correlated disorder in parent compound $Ba(FeAs)_2$. We observe strong downward shift of the SDW transition temperature. Detailed analysis of Hall coefficient vs. T variations at different disorder levels shows that transition remains sharp and SDW transition is robust against disorder.

[1] Y. Mizukami et al., Nature Comm. 5, 5657 (2014)
[2] Y. Mizukami et al., submitted to PNAS

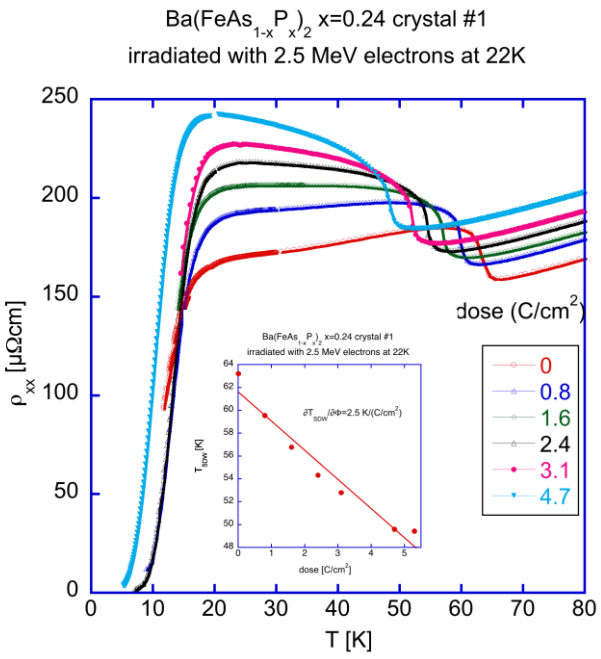

Fig.1. Shift of SDW and SC transition by Irradiation-induced disorder