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Using controlled disorder to study superconductors gap structure[1]

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Studying the response to deliberately introduced disorder is a phase - sensitive tool to probe the pairing mechanisms of superconductors. Pair breaking scattering depends on the gap anisotropy and the relative sign of the order parameter on different parts of the Fermi surface. Comparing many compositions with the various amounts of disorder gives direct access to the gap evolution across the superconducting "dome. We use 2.5 MeV electron irradiation performed at 22 K to induce vacancy interstitial Frenkel pairs. Some pairs recombine, interstitials migrate and anneal upon warming leaving a quasi-equilibrium concentration of defects that act as point like scatterers. Probing several properties of the same sample before and after irradiation is essential to avoid experimental ambiguity. We measure normal and superconducting state properties, such as various transition temperatures, anisotropic resistivity, Hall coefficient, polarized light optical response, specific heat and London penetration depth. The combination of these measurements also allows examining the role of the coexisting magnetic and superconducting orders, magnetic fluctuations, quantum critical behavior, nematicity, and pseudogap. Several families of Fe based superconductors will be reviewed, including hole, electron and isovalently doped $BaFe_2As_2$, as well as stoichiometric $CaKFe_4As_4$ and FeSe, which together show an impressive variety of features and a very different behavior. Yet, these features can be understood within generalized extended $s_\pm$ pairing mechanism. **References:** R. Prozorov *et al.*, Phys. Rev. X **4**, 041032 (2014); K. Cho *et al.*, Science Advances **2**, 1600807 (2016); M. A. Tanatar *et al.*, Phys. Rev. Lett. **117**, 127001 (2016); S. Teknowijoyo *et al.*, Phys. Rev. B **94**, 064521 (2016); V. G. Kogan and R. Prozorov, Phys. Rev. **B** 93, 224515 (2016); J. P. Reid *et al.*, Phys. Rev. B **93**, 214519 (2016).

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