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Magnetism and its interplay with Superconductivity in the Doped Iron Chalcogenide $Fe_{1+y}Te_{1-x}Se_x$

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I examine the relationship of iron superconductivity with impurities, and low energy magnetic excitations in the structurally simple iron superconductor, ($Fe_{1+y}Te_{1-x}Se_x$). In the first part of the talk, the pivotal role played by interstitial iron impurities in the microscopic origin of the quasi-static magnetism at (1/2,0) is demonstrated in $Fe_{1+y}Te_0$ 0.38 [1]. We used polarized and unpolarized neutron scattering together with simulations of the scattering function based on structural data and a semi-metallic 5-band model with super-exchange interactions with the interstitial iron, to show that the formation of magnetic polarons around the interstitial iron atoms seeds the observed (1/2,0) magnetism. Though the quasi-static magnetism occurs at (1/2,0), the low energy spin dynamics are dominated by fluctuations at (1/2,1/2), like other iron based superconductors. In the second part of the talk, I will discuss these fluctuations and in particular the so-called spin resonance – the signature feature in the low energy inelastic neutron scattering spectrum. We show that this scattering is quasi two dimensional and largely isotropic. Further, the first moment sum-rule for the dynamic correlation function is applied to the inelastic data in the normal and superconducting states to quantitatively determine the magnetic component of the superconducting condensation energy [2]. This method is sensitive to changes in the inter-site magnetic correlation energy, ΔEij, associated with superconductivity. We find that the length scale over which ΔEij is appreciable is similar to the superconducting coherence length, as determined by Scanning Tunneling Microscopy. Comparison of the inter-site magnetic correlation energy to the superconducting condensation energy determined through specific heat measurements indicates a significant role of magnetic fluctuations in stabilizing superconductivity.

[1] V. Thampy et al, Phys. Rev. Lett. 108, 107002 (2012).
[2] J. Leiner et al, Manuscript under preparation.