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Local moments in iron-based superconductors

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Understanding magnetism in iron-based superconductors presents a difficult challenge facing researchers in this field. While a local spin model seems to describe a large subset of experimental data, these compounds are distinctly metallic and the itinerancy of electrons must be crucial for magnetism. Recent studies have suggested that both local and itinerant nature could be in play, since there are multiple orbitals involved in the electronic structure of iron pnictides and chalcogenides. This viewpoint is supported by our recent x-ray emission spectroscopy (XES) studies, in which local magnetic moments are found in all samples studied. The Fe Kbeta XES is a fast, local probe that is bulk-sensitive and couples directly to the d-electron moment. In our survey of various materials in their paramagnetic phases [1], we found local magnetic moments in all samples studied. The moment size shows very little dependence on temperature or carrier concentration, but varies significantly across different families. Specifically, all iron pnictide samples have local moments of about 1.5-2 Bohr magneton per Fe atom, while FeTe and K2Fe4Se5 families have much larger local moments. The extracted moment sizes agree well with energy and momentum integrated inelastic neutron scattering results. In addition, XES was used to study the spin-state transition in rare-earths doped CaFe2As2 [2]. When about 10-20% of Ca is replaced with Pr or Nd ions, this material goes through the so-called collapsed tetragonal transition below 70 K, in which the c-lattice constant shrinks by almost 10% [3]. The XES data show that the local magnetic moment is quenched in this collapsed tetragonal phase. Our experimental results illustrate the importance of multiorbital physics in describing magnetism of iron-based superconductors.

[1] H. Gretarsson et al., Phys. Rev. B 84, 100509(R) (2011).
[2] H. Gretarsson et al., Phys. Rev. Lett. 110, 047003 (2013).
[3] S. R. Saha et al., Phys. Rev. B 85, 024525 (2012).

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