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Recent Neutron Studies of the Iron-based Magnetic Superconductors

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We present results of recent neutron scattering investigations at the NCNR of the crystal structures, magnetic structures, and spin dynamics of the iron-based ROFe(As,P) (R=La, Ce, Pr, Nd), (Ba,Sr,Ca)Fe_2As_2, and Fe_{1-x}(Se-Te) superconductors [1]. All the undoped materials exhibit universal behavior, where a tetragonal-to-orthorhombic structural transition occurs between ∼140-220 K, at or below which the systems order antiferromagnetically. The magnetic structure within the a-b plane consists of chains of parallel Fe spins that are coupled antiferromagnetically in the orthogonal direction, with an ordered moment typically less than 1 μ_B. Hence these are itinerant electron magnets, with a spin structure that is consistent with Fermi-surface nesting. The exchange interactions are strong, with spin-wave bandwidths ∼200 meV. The rare-earth moments order antiferromagnetically at low T like "conventional" magnetic-superconductors, while the crystal field excitations can be employed to study the properties of the superconducting state. With doping in $CeFeAsO_{1-x}F_x$, $LaFeAsO_{1-x}F_x$, and $SrFe_{2-y}Ni_yAs_2$ [2] the structural and magnetic transitions are suppressed in favor of superconductivity. The application of pressure in $CaFe_2As_2$ transforms the system from a magnetically ordered orthorhombic material to a "collapsed" non-magnetic tetragonal system. In the superconducting doping regime, well defined spin correlations and a clear magnetic resonance in the magnetic excitation spectrum that tracks the superconducting order parameter are observed, reminiscent of the cuprate superconductors [3]. The overall results clearly indicate that the magnetic properties are a key element in these iron-based superconductors. Further information and references can be found at http://www.ncnr.nist.gov/staff/jeff

[1] For a recent neutron review see J. W. Lynn and P. Dai, Physica C **469**, 469 (2009).
[2] N. Kumar, et al., Phys. Rev. B **80**, 144524 (2009).
[3] S. Li, et al., Phys. Rev. B **79**, 174527 (2009).

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