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Unexpected Complexity in Iron Based Superconductors

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Fermi surface nesting ideas guided the initial theoretical studies of iron-based high critical temperature superconductors and they may have captured correctly important properties such as the superconducting state symmetry. However, evidence is accumulating that these materials are more complex than previously anticipated. Along these lines, two areas of research that are receiving considerable attention will be addressed: (a) The spin nematic regime from the perspective of spin-fermion model simulations [1]. Recent efforts include the influence of disorder to enhance the nematicity window [2] and the case of FeTe [3] where we have shown that coupling electrons to the monoclinic lattice distortion reproduces the bicollinear magnetic order and the "reversed" resistivity anisotropy found experimentally. Moreover, a novel form of nematicity is predicted. (b) The two-leg ladder compound BaFe2S3 [4]. This material is the only member of the iron-based family that becomes superconducting (at high pressure) without having iron layers in its crystal structure. Recent results using the density matrix renormalization group for a two-orbital Hubbard model [5] will be discussed. They correctly reproduce the dominant magnetic order, as in neutron scattering, and, moreover, have revealed indications of pairing tendencies at intermediate/strong couplings upon doping [6]. [1] S. Liang, A. Moreo and E. Dagotto, Phys. Rev. Lett. 111, 047004 (2013), and references therein. [2] S. Liang et al., Phys. Rev. B 92, 104512 (2015). [3] C. B. Bishop, A. Moreo, and E. Dagotto, Phys. Rev. Lett.117, 117201 (2016). [4] H. Takahashi et al., Nat. Mater. 14, 1008 (2015); T. Yamauchi et al., Phys. Rev. Lett. 115, 246402 (2015). [5] N. D. Patel, A. Nocera, G. Alvarez, R. Arita, A. Moreo, and E. Dagotto, Phys. Rev. B. 94, 075119 (2016). [6] Density functional theory studies suggest that pressure may induce self-doping of BaFe2S3, favoring superconductivity: Y. Zhang, L. Lin, J-J. Zhang, E. Dagotto, and S. Dong, submitted to PRB.