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Frustrated Magnetism and Superconductivity in the Iron Chalcogenides[1]

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While studies in the early stage on the iron-based supercondoctors (FeSCs) focused on the iron pnictides, considerable efforts in the more recent past have also been directed towards iron chalcogenides. These studies are giving us renewed hope for even higher transition temperatures in the iron-based materials. In this talk, I will discuss several theoretical issues on the microscopic physics of the iron chalcogenides that teach us much about the overall physics of the FeSCs. One is the proposal we made on the orbital selective Mott phase [1], for which considerable evidence has come from ARPES [2] and other experiments. The second issue concerns magnetism, in particular the correlation-induced magnetic frustration effect. A major puzzle arises in bulk FeSe, which shows a structural phase transition similar to that seen in the iron pnictides but, unlike the latter, does not exhibit any static antiferromagnetic order. We studied the effect of magnetic frustration associated with the bilinear-biquadratic spin-exchange interactions [3]. Based on the derived phase diagram, we proposed that the structural transition in FeSe originates from an Ising-nematic order of an antiferro-quadrupolar phase. Within this picture, we have predicted that the collective modes of this quadrupolar state show (pi,0) magnetic fluctuations, which have since been verified by inelastic neutron scattering experiments [4]. These results considerably expand on the notion [5] regarding the importance of the bad-metal behavior, and provide a substantially broadened perspective on the magnetic and nematic correlations in the FeSCs. Finally, implications of the frustrated magnetism for superconductivity [5] will also be discussed. References: [1] R. Yu and Q. Si, Phys. Rev. Lett. 110, 146402 (2013). [2] M. Yi et al., Nature Commun. 6, 7777 (2015). [3] R. Yu and Q. Si, Phys. Rev. Lett. 115, 116401 (2015). [4] M. Rahn et al., Phys. Rev. B 91, 180501(R) (2015); Q. Wang et al., arXiv:1502.07544. [5] Q. Si and E. Abrahams, Phys. Rev. Lett. 101, 076401 (2008). [6] E. Nica, R. Yu and Q. Si, arXiv:1505.04170.

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