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S_4 Symmetric Microscopic Model for Iron Based Superconductors

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How are cuprates and iron-based high temperature superconductors correlated? What is the common mechanism behind two different families of iron-based superconductors, iron-pnicitides and iron-chalcogenides? These two questions are two major challenges in the today's field of high temperature superconductors. In this talk, we will show when the lattice symmetry, the $\mathbf{S_4}$ symmetry, of the building block, the tri-layer structure of FeAs or FeSe, is properly considered, the low energy physics of iron-based superconductors is governed by a two-orbital Hamiltonian near half filling that can be divided two weakly coupled one-orbital model. We will discuss the microscopic origin and some unique properties of the model, including magnetism and pairing symmetry. The model provides a unified understanding of iron pnictides and iron chalcogenides, and suggests that cuprates and iron-based superconductors share an identical high-T_c superconducting mechanism. The model leads to a natural classification of pairing symmetry according to $\mathbf{S_4}$ symmetry. When the pairing is driven by antiferromagnetic exchange couplings, there are two different s-wave states. One s-wave is the well-studied s± pairing which is in the A phase of $\mathbf{S_4}$ symmetry (even under $\mathbf{S_4}$ symmetry operation), and the other is a new type of extended s-wave pairing which is in the B phase of $\mathbf{S_4}$ symmetry (odd under$\mathbf{S_4}$ symmetry operation). The superconductivity order in the B phase are characterized by opposite signs between up and bottom As(Se) layers in the trilayer Fe-As(Se) structure. The 122 Iron-chalcogenides and the single layer FeSe are most likely in the B-phase. We believe that the model establishes a new foundation for exploring novel properties of iron based superconductors.

References: J.P. Hu and Ningning Hao, Phys. Rev. X, 021009 (2012); T. X. Ma, H.Q. Lin and J.P. Hu, Arxiv:1206.6277 (2012); N.N. Hao, Y.P. Wang and J.P. Hu, Arxiv: 1207.6798 (2012); J.P. Hu, and NingNing Hao, unpublished; J.P. Hu, Arxiv: 1208.6201 (2012)