Fe-based SC

- review of normal state
- review of sc state
- standard model
- new materials & directions

Discovery of $\text{LaO}_{1-x}\text{F}_x\text{FeAs}$

Kamihara et al. JACS 2008

$T_{\text{c, max}} = 26\text{ K}$
Iron-based superconductors


LaFe\textsubscript{AsO}  
- \(T_c=28\text{K}\)  
- (55K for Sm)  

Ba\textsubscript{Fe\textsubscript{2}As\textsubscript{2}}  
- \(T_c=38\text{K}\)  

Li\textsubscript{FeAs}  
- \(T_c=18\text{K}\)  
- (single xtals)

FeSe  
- \(T_c=8\text{K}\)  

Hsu et al PNAS 2008  
- No arsenic 😊!
Comparison with cuprates

Strong vs. weak coupling?

Single vs. multibands?

2D vs. 3D?

Can we learn what the essential ingredients for high-$T_c$ are from the comparison?

<table>
<thead>
<tr>
<th>Property</th>
<th>Conventional superconductors</th>
<th>Copper oxides</th>
<th>MgB$_2$</th>
<th>Iron-based superconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_c$ (maximum)</td>
<td>$&lt;30$ K</td>
<td>134 K</td>
<td>39 K</td>
<td>56 K</td>
</tr>
<tr>
<td>Correlation effects</td>
<td>None (nearly-free electrons)</td>
<td>Strong local electronic interaction</td>
<td>None (nearly-free electrons)</td>
<td>Long-range (non-local) magnetic correlations</td>
</tr>
<tr>
<td>Relationship to magnetism</td>
<td>No magnetism</td>
<td>Parent compounds are magnetic insulators</td>
<td>No magnetism</td>
<td>Parent compounds are magnetic metals</td>
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<tr>
<td>Order parameter</td>
<td>One band, same-sign s wave</td>
<td>One band, sign-changing d wave</td>
<td>Two band, same-sign s wave</td>
<td>Two band, presumably sign-changing s wave</td>
</tr>
<tr>
<td>Pairing interaction</td>
<td>Electron-phonon</td>
<td>Probably magnetic (no consensus)</td>
<td>Electron-phonon</td>
<td>Presumably magnetic</td>
</tr>
<tr>
<td>Dimensionality</td>
<td>Three dimensional</td>
<td>Two dimensional</td>
<td>Three dimensional</td>
<td>Variable</td>
</tr>
</tbody>
</table>

I. Mazin, Nature 2010
Phase diagrams of Cu-based and Fe-based superconductors are similar.

Parent compounds are insulators for Cuprates, and Parent compounds are metals for Pnictides.
Insulating behavior of parent compounds of the cuprates
Metallic behavior of parent compounds of Fe pnictides

Fang et al 2009
Electronic structure calculations

LOFP Lebegue 2007 ($T_c=6K$)

LOFA Singh & Du 2008 ($T_c=26K$)

Band structures for 2 materials nearly identical!
Hole pocket near $\Gamma$, electron pocket near $M$

Kotliar et al, Cao et al: correlations can be significant
**Multiorbital physics**

DOS near Fermi due almost entirely to 5 Fe d-states

*Complications:* calculations will be harder

*Novelty:* surprising new aspects of multiorbital/multiband physics
(Some) theorists find folded BZ already too complex.

Unfolded BZ  
Folded BZ

2D cross-sections
Magnetic order in most (not all) parent compounds

de la Cruz et al Nature 453, 899 (2008)

Stripe like order w q=(\pi,0)
Ordered magnetism in FeSC

<table>
<thead>
<tr>
<th>Material</th>
<th>$T_s$ (K)</th>
<th>$T_N(\text{Fe})$ (K)</th>
<th>$\mu_{\text{Fe}}$ ($\mu_B$)</th>
<th>$Q_{\text{Fe}}$</th>
<th>Spin direction</th>
<th>$T_N(R)$ (K)</th>
<th>$\mu_R$ ($\mu_B$)</th>
<th>$Q_R$</th>
<th>Spin direction</th>
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<tbody>
<tr>
<td>LaOFeAs</td>
<td>155</td>
<td>137</td>
<td>0.36</td>
<td>101</td>
<td>likely $a$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CeOFeAs</td>
<td>158</td>
<td>140</td>
<td>0.8</td>
<td>100</td>
<td>$a$</td>
<td>4.0</td>
<td>0.94</td>
<td>101</td>
<td>$a,b,c$</td>
</tr>
<tr>
<td>PrOFeAs</td>
<td>153</td>
<td>127</td>
<td>0.48</td>
<td>100</td>
<td>$a$</td>
<td>14</td>
<td>0.84</td>
<td>100</td>
<td>$c$</td>
</tr>
<tr>
<td>NdOFeAs</td>
<td>150</td>
<td>141</td>
<td>0.25</td>
<td>101</td>
<td>likely $a$</td>
<td>1.96</td>
<td>1.55</td>
<td>100</td>
<td>$a,c$</td>
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<td>CaFe$_2$As$_2$</td>
<td>173</td>
<td>173</td>
<td>0.80</td>
<td>101</td>
<td>$a$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SrFe$_2$As$_2$</td>
<td>220</td>
<td>220</td>
<td>0.94</td>
<td>101</td>
<td>$a$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BaFe$_2$As$_2$</td>
<td>142</td>
<td>143</td>
<td>0.87</td>
<td>101</td>
<td>$a$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe$_{1.068}$Te</td>
<td>67</td>
<td>67</td>
<td>2.25</td>
<td>100</td>
<td>$b$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

"double stripe" $q=(\pi/2,\pi/2)$

Lynn, Dai 2009
Weak coupling/strong coupling picture of magnetism?

Early theories proposing strong coupling: Yildirim 08; Fang et al. 08; Cvectovic & Tesanovic 08, Abrahams & St 08; Manousakis et al. 08

Zhao et al. Natphys 09 spin excitations fit Heisenberg without need for Stoner continuum, but a-b anisotropy hard to understand.

Diallo et al. PRL 09: poor fit at higher E, spin waves are damped by p-h excitations; good fit from 1st principles susceptibility.
Also: “doping” with pressure

Alireza et al. (2008)

Medvedev et al. (2009)
- Magnetic order tied to structural phase transition
- possible coexistence with superconductivity?

[Image of magnetic structure]

structural transition
magnetic transition

Zhao et al 2008

D.K. Pratt et al 09

[Graph showing phase transitions]

Best guess at present: 1111—NO; 122--YES
Two phase transitions

I) Structural Transition

II) Magnetic Transition

122/1111

FeTe

DFT correctly reproduces (or even predicts) correct magnetic and structural ground states, but requires magnetism as a prior condition for distortion

Courtesy of M. Johannes & I. Mazin
Transition driven by orbital ordering?

Theory: Xu et al., Kruger et al., Fang et al. 08

Experiments on untwinned samples: “nematic” susceptibility above $T_s$?

Implications for superconductivity?
ARPES: orbital ordering

(0, π)  (π, 0)  (0, π)  (π, 0)

Yi et al. PNAS 2011
Nematic behavior also in superconducting state!

STM on FeSe, Song et al., Science 2011

Vortex

Impurity states

Strongly 1D defect structures in (barely orthorhombic system)!
Three different types of order which break $x/y$ symmetry

- orbital order  - $dxz$ and $dyz$ orbitals occupied differently (ARPES)
- stripe spin order (neutrons)
- structural order $a_x \neq a_y$ (X-ray diffraction)

which one is the driving force?

Courtesy of A. Chubukov
Nematic degrees of freedom affect the macroscopic properties across much of the phase diagram. Nematic order is a natural consequence of the magnetism of the pnictides (no need to introduce extra degrees of freedom).

- J1-J2 model:
  - Chandra et al (1990)
  - Si et al (2008)
  - Fang et al (2008)
  - Xu et al (2008)

- Itinerant version:
  - Fernandes, Schmalian, Eremin, Chubukov...

- Magnetic origin for nematicity?

  - Nematic order is a natural consequence of the magnetism of the pnictides (no need to introduce extra degrees of freedom)
  - Nematic degrees of freedom affect the macroscopic properties across much of the phase diagram
Magnetic origin for nematicity?

- Symmetry breaking in the striped magnetic state of the iron pnictides:

  \( O(3) \times \mathbb{Z}_2 \) symmetry breaking
doubly-degenerate ground states

\( (0, \pi) \)

\( (\pi, 0) \)
Magnetic origin for nematicity?

- A state that breaks $Z_2$ symmetry but remains paramagnetic
  spontaneous tetragonal symmetry breaking

\[
\langle M_1 \rangle \neq \langle M_2 \rangle \\
\langle M_1 \rangle = \langle M_2 \rangle = 0
\]
Correlation strengths across materials

Qazilbash et al. NatPhys2009

Specific heat (mJ/ mol K²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LaFePO</td>
<td>7</td>
</tr>
<tr>
<td>Ba(CoₓFe₁₋ₓ)₂As₂</td>
<td>15-20</td>
</tr>
<tr>
<td>Ba₁₋ₓKₓFe₂As₂</td>
<td>50</td>
</tr>
<tr>
<td>FeSe₀.₈₈</td>
<td>9.2</td>
</tr>
<tr>
<td>KFe₂As₂</td>
<td>69-102</td>
</tr>
<tr>
<td>K₀.₈Fe₁.₆Se₂</td>
<td>6</td>
</tr>
</tbody>
</table>

Review: Stewart, RMP (2011)
Fix interactions $U, J$, vary material

Not all orbitals are equally correlated!
Can we understand evolution of correlations across 122 phase diagram?
Some empirical measures of correlations

References in: L. de Medici et al, ArXiv:1212.3966  (all data in high-T tetragonal phase)

Sommerfeld coefficient

\[
\gamma \sim N^* (E_F) = \sum_{\alpha} (m^*/m_b)_{\alpha} N_{b}^{\alpha} (E_F)
\]

Optics: Drude contribution

\[
D^* = \sum (m_b/m^*)_{\alpha} D_{\alpha}^b
\]

⇒ selective orbital mass enhancement
Multiorbital Mott physics: $J$ acts as orbital decoupler:

- suppresses inter-orbital correlations
- differentiate orbitals with respect to distance from Mott transition

**Theory (LDA+Slave-spins)**

[Graph showing orbital mass enhancement vs. hole/electron doping for $KFe_2As_2$ and $BaFe_2As_2$.]

[Graph showing orbital mass enhancement vs. temperature for $KFe_2As_2$.]

[Graph showing orbital mass enhancement vs. orbital for two different magnetic field orientations ($\parallel c$ and $\perp c$).]

*de Medici et al, ArXiv:1212.3966*
Correlations have strong effect on LDA+DMFT Fermi surface of KFe$_2$As$_2$ (unlike BaFe$_2$As$_2$)

Backes et al (Frankfurt group)
SC state: gap symmetry vs. structure

\[ s_{++}, s_\pm, \text{nodal } s_\pm, d \]

\[ A_{1g}, B_{1g} \]
SC state: experimental “lack of universality”
e.g., penetration depth experiments

Hicks et al. 2008
LaFePO $T_c=6$K

Prozorov, 2011
Co-doped Ba122 $T_c=25$K

Hashimoto et al. 2009
K-doped Ba122 $T_c=40$K

$\Delta \lambda \approx \int d\omega \left( -\frac{\partial f}{\partial \omega} \right) N(\omega)$

$N(\omega) \approx N_0 + a\omega^2$

$\delta \lambda_{ab}(T)/\lambda_{ab}(0)$

$d$-wave

$\Delta \lambda \approx \begin{cases} T^2 & \text{dirty} \\ T & \text{clean} \end{cases}$
Thermal conductivity (H=0)
(bulk probe, lowest temperatures thus far)

LaFePO: Yamashita et al aXv:0906.0622
Big linear T term

K-doped Ba-122: Luo et al aXv:0904.4049
Tiny or zero linear T term

Recall in theory of nodal SC linear T term ⇒ residual qp excitations (metallic-like)
for d-wave superconductor this term is “universal” \( \kappa/T \sim N_0 v_F^2/\Delta_0 \)
NMR spin-lattice relaxation

\[ \frac{T_1^{-1}}{(T_1^{-1})_N} = 2 \frac{T}{T_c} \int_0^\infty d\omega \left\{ \frac{-\partial f}{\partial \omega} \right\}^2 \frac{N(\omega)}{N_0} \]


Nakai et al. JPSJ (2008)

line nodes \( \Rightarrow M(\omega) \sim \omega \Rightarrow T^3 \)
Resonant mode in inelastic neutron scattering

Reminder: cuprates: Fong et al PRB 2000

Ba$_{0.6}$K$_{0.4}$Fe$_2$As$_2$: Christianson et al Nature 2008

In Ba-122 resonance observed near $Q=\pi,0$ (1-Fe BZ)
Appears only in SC state (like opt. doped cuprates)

$$\Delta_{k+Q} = - \Delta_k \Rightarrow \text{sign change of order parameter}$$

• What is the symmetry of SC order parameter?

• What controls whether Fe-based material is nodal or gapped superconductor?

• Why are these systems’ superconducting states nonuniversal?
Pairing by spin fluctuations?

**1) Electron-phonon interaction is weak:**

We have calculated *ab initio* the electron-phonon spectral function, $\alpha^2 F(\omega)$, and coupling, $\lambda$, for the stoichiometric compound [9]. Some moderate coupling exists, mostly to As modes, but the total $\lambda$ appears to be $\sim 0.2$, with $\omega_{\text{loc}} \sim 250$ K, which can in no way explain $T_c \gtrsim 26$ K.

Mazin et al, PRL 2008, see also Mu et al CPL (2008), Boeri et al. PRL 2008

**2) Magnetism is usually nearby:**

1111-pnictides $T_c = 26-55$K  
LaFePO $T_c = 6$K  
KFe$_2$As$_2$ $T_c = 3.6$K

Nonmagnetic  

No magnetism $\Rightarrow$ low $T_c$
Spin fluctuation theories of pairing

Effective interaction from spin fluctuations (Berk-Schrieffer 1966)

\[ V_s(q, \omega) \approx \frac{3}{2} \frac{U^2 \chi_0(q, \omega)}{1 - U \chi_0(q, \omega)} \]

\[ \chi_0(q, \omega) = \int \frac{d^3p}{(2\pi)^3} \frac{f(\epsilon_{p+q}) - f(\epsilon_p)}{\omega - (\epsilon_{p+q} - \epsilon_p) + i\delta} \]
Multiband superconductivity

Assume gaps isotropic on each band:

\[ \Delta_i = -\sum_j \Lambda_{ij} \Delta_j F(\Delta_j, T), \]

\[ \Lambda_{ij} = V_{ij} N_j \]

\[ F = \int_{\omega_D} d\xi \frac{1}{2 \sqrt{\xi^2 + \Delta^2}} \tanh\left(\frac{\sqrt{\xi^2 + \Delta^2}}{2T}\right) \]

Equations may have solutions even when all elements of the interaction matrices are repulsive (\(>0\)).

The simplest example is an off-diagonal repulsion: \( V_{11} = V_{12} = 0, V_{12} = V_{21} = -V < 0 \). In this case the solution reads: \( \lambda_{eff} = \sqrt{\Lambda_{12} \Lambda_{21}} = |V_{12}| \sqrt{N_1 N_2}, \Delta_1(T_c)/\Delta_2(T_c) = -\sqrt{N_2}/N_1. \)
Similar argument from Mazin et al PRL 2008 for pnictides: consider only $\alpha-\beta$ pair scattering

- nesting peaks interaction $V_s$ at $\pi,0$ in 1-Fe zone.
- interaction is constant over sheet since they are small.
- therefore *isotropic* sign-changing $s_{+/\pm}$ state solves gap eqn

$\Delta_p = -\sum_{p'} \frac{V(p-p')\Delta_{p'}}{2E_{p'}}$

also:

- Kuroki et al 2008
- Seo et al. 2008
- Chubukov et al 2008
Spin fluctuation pairing theories in Fe-pnictides

\[ H = H_0 + H_{\text{int}} \]

\[ H_0 = 5\text{-band tight-binding model} \]

\[
H = H_0 + \bar{U} \sum_{i,\ell} n_{i\ell \uparrow} n_{i\ell \downarrow} + \bar{U}' \sum_{i,\ell' < \ell} n_{i\ell \uparrow} n_{i\ell' \downarrow} \\
+ \bar{J} \sum_{i,\ell' < \ell} \sum_{\sigma,\sigma'} c_{i\ell \sigma}^\dagger c_{i\ell' \sigma'}^\dagger c_{i\ell' \sigma} c_{i\ell \sigma'} + \bar{J}' \sum_{i,\ell' \neq \ell} c_{i\ell \uparrow}^\dagger c_{i\ell' \downarrow}^\dagger c_{i\ell' \downarrow} c_{i\ell \uparrow}
\]

most general 2-body Hamiltonian with \textit{intrasite} interactions only!

Effective interaction between electrons in orbitals

\[ \Gamma_{\ell_1 \ell_2 \ell_3 \ell_4}(k, k', \omega) = \left[ \frac{3}{2} \bar{U}^s \chi_1^{\text{RPA}}(k-k', \omega) \bar{U}^s + \frac{1}{2} \bar{U}^c \chi_0^{\text{RPA}}(k-k', \omega) \bar{U}^c + \frac{1}{2} \bar{U}^c \right]_{\ell_3 \ell_4 \ell_1 \ell_2} \]
Realistic theories: gaps display strong anisotropy/ nodes

\[ \Gamma_{ij}(k, k') = \text{Re} \left[ \sum_{\ell_1 \ell_2 \ell_3 \ell_4} a_{\ell_1}^{\ell_2, *}(k) a_{\ell_1}^{\ell_3, *}(\mathbf{\pm k}) \Gamma_{\ell_1 \ell_2 \ell_3 \ell_4}(k, k', \omega = 0) a_{\ell_4}^{\ell_1}(k') a_{\ell_4}^{\ell_3}(\mathbf{\pm k'}) \right] \]

\[ -\frac{1}{V_G} \sum_f \int_{\mathbf{F}_{S_f}} dS' \frac{\Gamma_{ij}(k, k') g_{\alpha}(k') \frac{g_{\alpha}(k')}{|v_{\mathbf{F}_L}(k')|}}{\lambda_{\alpha}} = \lambda_{\alpha} g_{\alpha}(k), \]

“anisotropic extended-s”-wave

\( \Delta(k) \)

(d) \( \lambda = 1 \)

(e) \( \lambda = 0.832 \)

(x = 0.125 e-doped) \( U = 1.54 \) \( J = 0.3 \)

Two pairing channels nearly degenerate:

a) Can different FeAs materials have different symmetries?
b) Or, do all have s-wave symmetry, differing gap structures for different materials
What is the origin of the gap anisotropy \cite{Maier et al PRB 09}?

1. **importance of orbital character on Fermi sheets**
2. scattering between $\beta_1$ and $\beta_2$ sheets
3. intraband Coulomb repulsion

See also: Chubukov et al 2009, Thomale et al 2009 (band picture), Thomale et al 2010, Kemper et al 2010
Nonuniversality in experiments: sensitivity to small changes in electronic structure, disorder

any nodes are *accidental* rather than symmetry-enforced in ext.-s states

a) isotropic $s_{+/-}$

b) nodes

c) deep minima
KFe$_2$As$_2$: No electron pockets: d-wave? Thomale et al

KFe$_2$Se$_2$: No hole pockets: d-wave? Wang et al
Graser et al

S-wave? Mazin, Fang et al

Big picture: evolution of gap with doping

s++ or s+-? Few phase-sensitive expts.

Chen et al, Nature 2010

Half-integer fluxes detected (in a small fraction of loops)

Christianson et al Nature 2008

Enhanced susceptibility at $Q$ below $T_c \Rightarrow$ sign change of order parameter

Field dependence of quasiparticle interference peaks depends on order parameter sign

Hanaguri et al Science 2010

Various critiques of all experiments, alternate scenarios: where is the ?
impurity effect in single crystal (Ba,K)Fe$_2$As$_2$

J. Li et al. PRB 85, 214509 (2012).

- ✔ Vegard's law: good crystal
- ✔ X-ray

Other experiments:
- 1111 systems: Sato et al, JPSJ (’08)
- Ba122: Paglione et al, arXiv (’12)
- Irradiation: Nakajima et al, PRB (’10)

Experiment:
- $T_c$ vanishes when \( \rho_{imp} > 500 \mu\Omega \text{cm} \) \[ l_{imp} \sim 3 \text{ Å} \]

Theory:
- $S \pm$ wave state disappears when \( \rho_{imp} = 20 \text{ to } 40 \mu\Omega \text{cm} \)

local impurity on Fe-sites
Inter- and intraband impurity scattering in 2-band s$_{+/−}$ system

- Inter-band scattering mixes $+$ and $−$ gaps, breaks pairs
- Intra-band scattering: no mixing of $+$/$−$, no pairbreaking
e- irradiation experiments
(Prozorov, Shibauchi)

Ba(Fe0.74Ru0.26)2As2

$T_c$ (ref) = 17.85 K

S. Onari and H. Kontani
PRL 103, 177001 (2009)

BaFe$_2$(As$_{1-x}$P$_x$)$_2$

$x = 0.33$
New directions in FeSC

Three materials which don’t quite fit the “standard” paradigm

LiFeAs: stoichiometric 18K superconductor with clean, nonpolar surfaces nonmagnetic, no FS nesting

KFe$_{2-x}$Se$_2$: 31K superconductor with $3\mu_B$ ordered magnetic moment, ordered Fe vacancies, parent compound may be insulating

FeSe under stress: 43K SC intercalated with Li amide, ammonia 40K SC under 10 GPa pressure

?? 65K SC single layer on STO
Importance of correlations?

Yin et al 2011 Nat Mat, Ferber et al PRB 2012

LDA+DMFT: hole pockets shrink, electron pockets unaffected

see also Lee et al, PRL 2012
ARPES results for SC gap function (Dresden group)

\[ \Delta \sim \Delta_0 + \Delta_1 \cos(4\phi) \]

See also
K. Umezawa et al 2012

Borisenko et al Symmetry 2012
Experimental data (Disney version)

Borisenko et al. 2012

Umezawa et al. 2012

~4meV
Results of 3D spin fluctuation calculations I
Leading pairing eigenstate 10-orbital DFT-based or ARPES-fit bands

Wang et al PRB 2013

→ Fermi surface

DFT-derived Fermi surface

ARPES-derived Fermi surface

→ gapfunction

DFT $g(\mathbf{k})$: $\lambda_1 = 0.2361$, $U = 0.88$ eV, $J = 0.25U$

Fit provided by S. Borisenko V. Zabolotnyy

ARPES $g(\mathbf{k})$: $\lambda_1 = 1.029$, $U = 0.75$ eV, $J = 0.37U$
Comparison theory/expt

Y. Wang, A. Kreisel, V. B. Zabolotnyy, S. V. Borisenko, B. Büchner, T. A. Maier, Pj H, D. J. Scalapino, PRB 2013

Conclusion: s+/- pairing from spin fluctuations despite lack of Fermi surface nesting
LiFeAs "ab initio" pairing theory: success or failure?

Comparison with experiment

<table>
<thead>
<tr>
<th>I. Wang et al. PRB '13</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bands</td>
<td>ARPES*</td>
<td>LDA+DMFT</td>
<td>ARPES*</td>
</tr>
<tr>
<td>Full gap</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Ratios of gaps on large pockets</td>
<td>yes</td>
<td>?</td>
<td>yes</td>
</tr>
<tr>
<td>Gap size on α pockets</td>
<td>“no”</td>
<td>?</td>
<td>yes</td>
</tr>
<tr>
<td>Phase of gap on β pockets</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Some disagreement re ARPES Fermi surface: cf. Chi et al 1308.4413 surfaces, samples?
FeSe: 8K superconductor, but:

- Medvedev et al. 2010: Tc → 37K under pressure
- Burrard-Lucas et al. 2012: Tc → 43K molecular intercalation
Conclusions

- Magnetic and orbital correlations at high T both lead to stripe magnetic order and superconductivity: which are more important?

- Repulsive interactions probably lead to $s^{+/-}$ state for “generic” Fe-based SC with hole and electron pockets.

- Orbital character, intraband Coulomb enhance gap anisotropy. Anisotropic $s^{+/-}$ nodal structures show strong sensitivity to small changes in electronic structure (pnicotogen height, surfaces, strain, defects).

- Spin fluctuation theory explains gap anisotropy of 122’s across phase diagram, gets details correct in “generic” FeSC.

- “End point compounds” show tendency to d-wave order.