ARPES Results of '122' Iron-based Superconductors

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Apr 20, 2010

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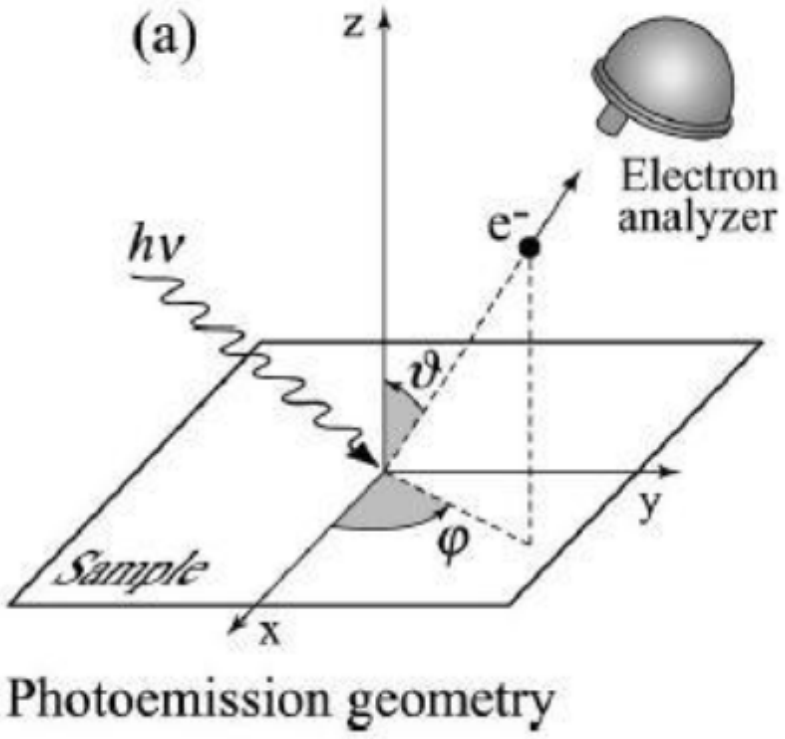
OUTLINES

1. Angle-Resolved PhotoEmission Spectroscopy (ARPES)
2. Crystal structure of "122" system
3. Experimental results
4. Theoretical results
5. Conclusions

ARPES

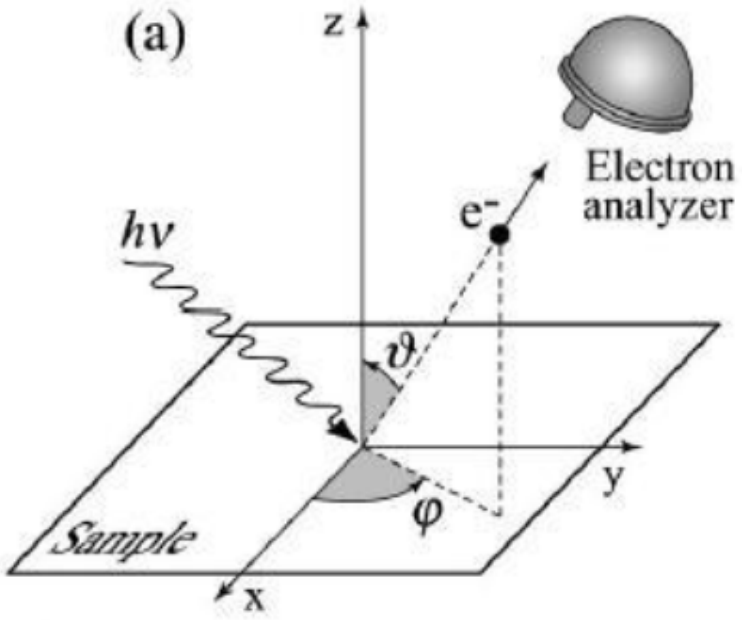


Photoemission geometry

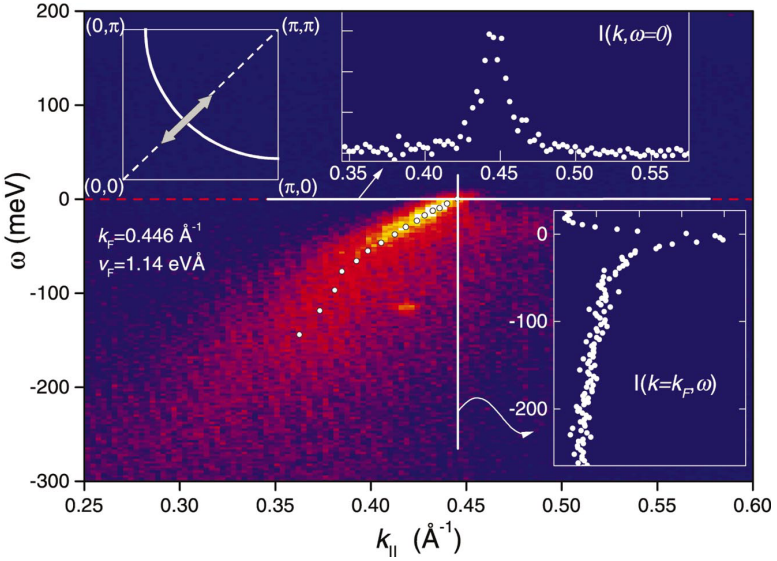
- based on Photoelectric Effect (Hertz 1887, Einstein 1905)
- powerful technique to mearsure the electronic structure directly (Energy vs. Momentum)

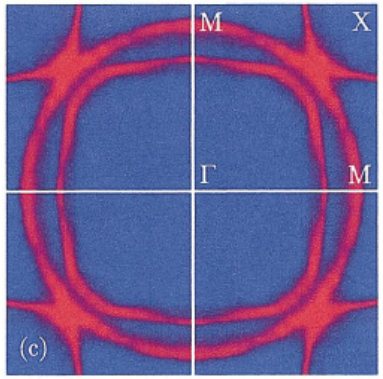
Damascelli, Hussain and Shen, Rev.Mod.Phys., **75**, 473 (2003)

ARPES



Photoemission geometry





Sr_2RuO_4 cleaved at 180 K
T= 10 K hν=28 eV

- incidence of monochromatic photons
- photoelectrons with different energy and momentum

Damascelli, Hussain and Shen, Rev.Mod.Phys. **75**, 473 (2003)

Crystal Structure

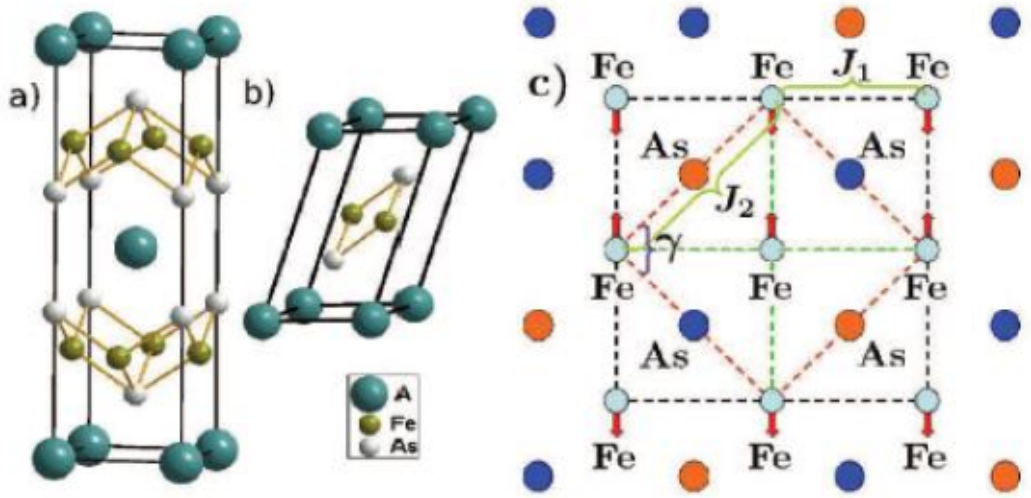
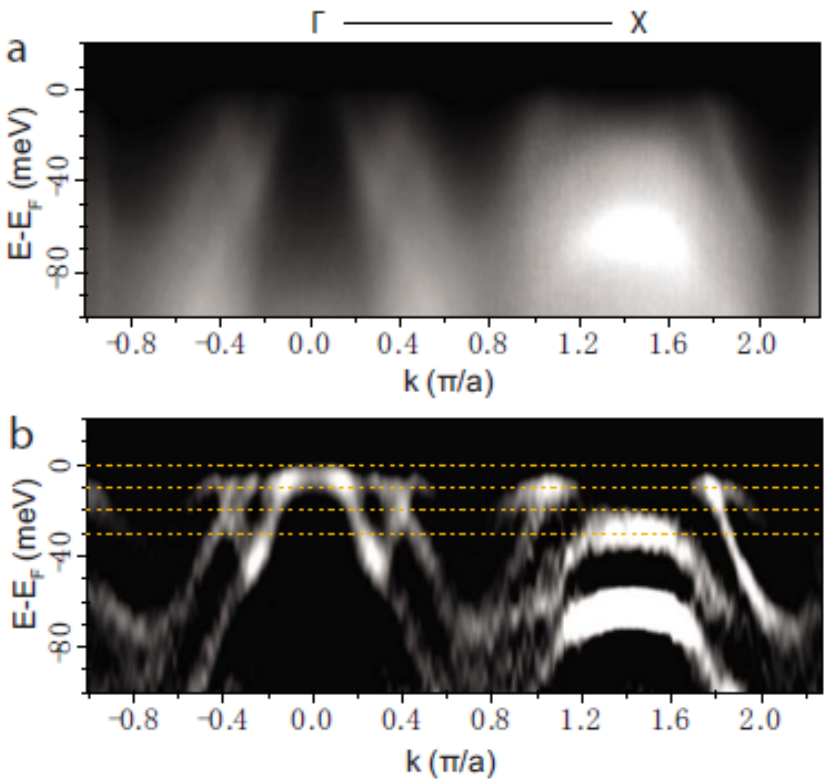


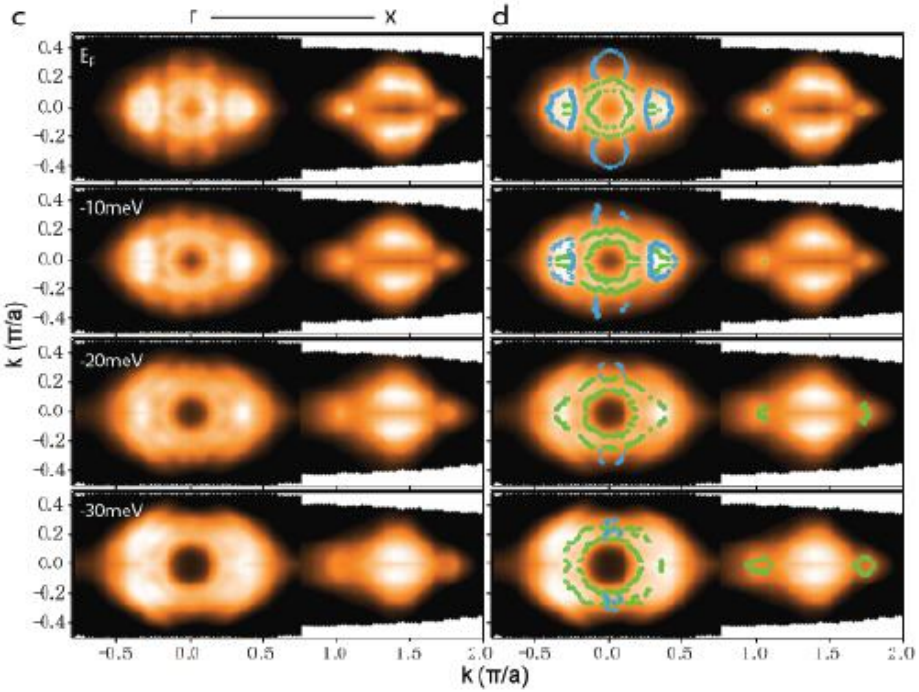
FIG. 2: Crystal structure of AFe_2As_2 (A=Ba, Sr, Ca).

F. Ma, et al, arXiv:0806.3526v2

- The parent compounds undergo a tetragonal to orthorhombic structural transition together with a magnetic transition

Experiments: $BaFe_2As_2$

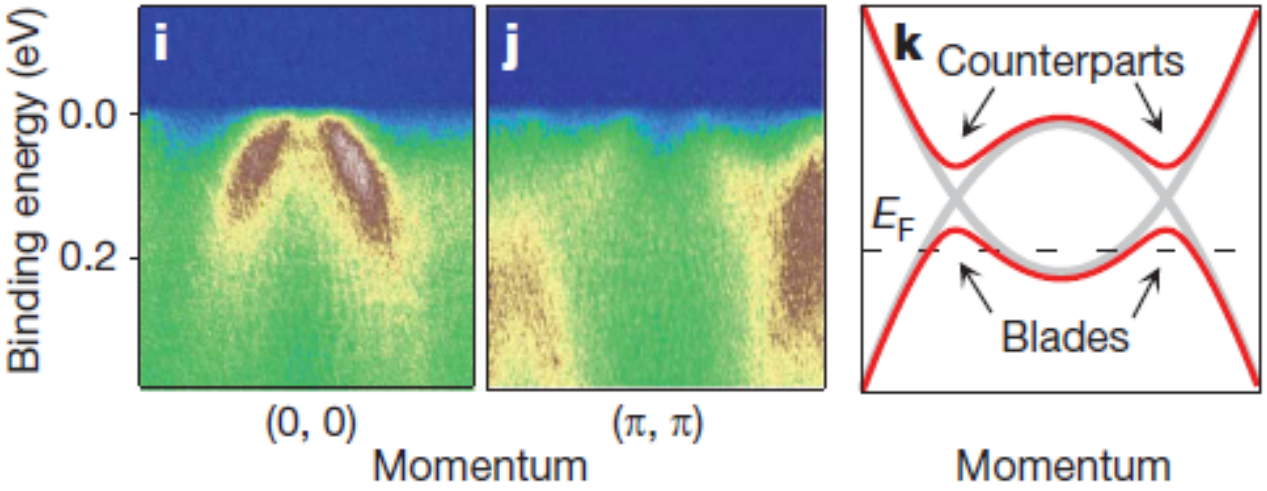




M. Yi, et al, PRB, **80**, 174510 (2009)

- below T_{SDW}
- two enclosed hole-like pockets around the zone center
- four petal-like electron-like pockets below T_{SDW}
- an electron-like pocket around zone corner

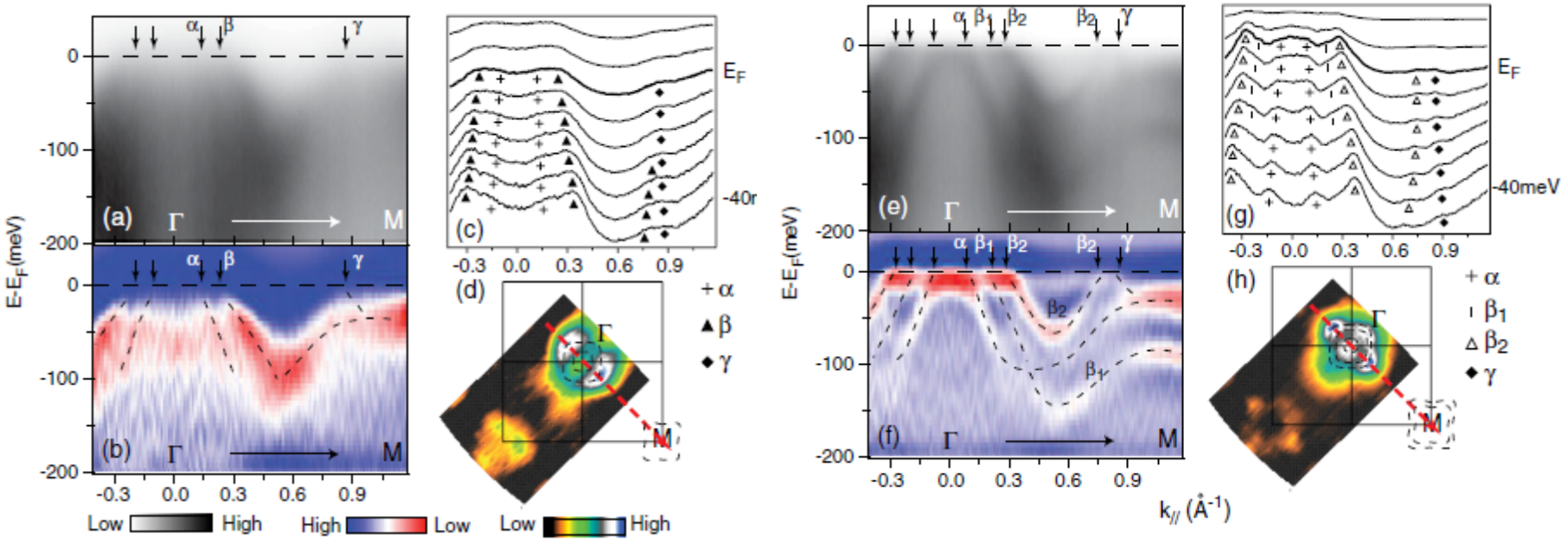
Experiments: $BaFe_2As_2$



V.B. Zabolotnyy, et al, Nature, **457**, 569 (2009)

- Nesting: replica of Γ-centred hole-like band (grey)
- electron-like band (grey)
- interaction of these two bands opens a gap and forms the blades (red)

Experiments: $SrFe_2As_2$



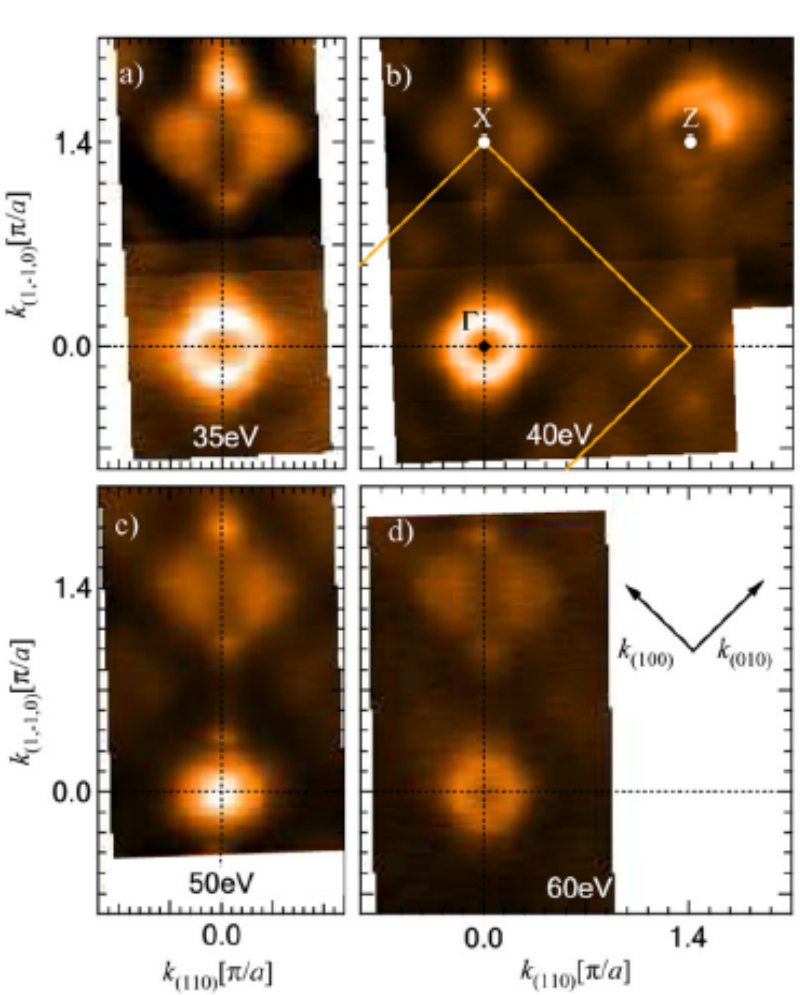
Y. Zhang, et al, PRL, **102**, 127003 (2009)

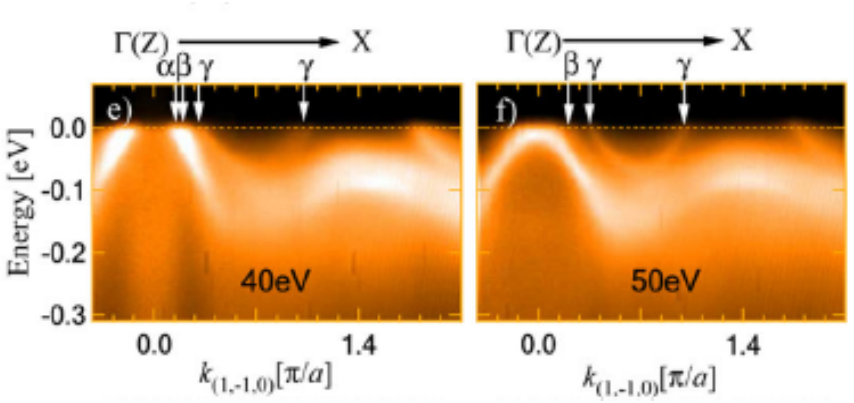
Normal state (T = 230 K)

SDW state (T = 10 K)

- High T, only two hole-like pockets at zone center and one electron-like pocket at zone corner.
- Low T, β band split into two bands β_1 β_2. And the petal-like pockets appear, but hole-like.

Experiments: $CaFe_2As_2$

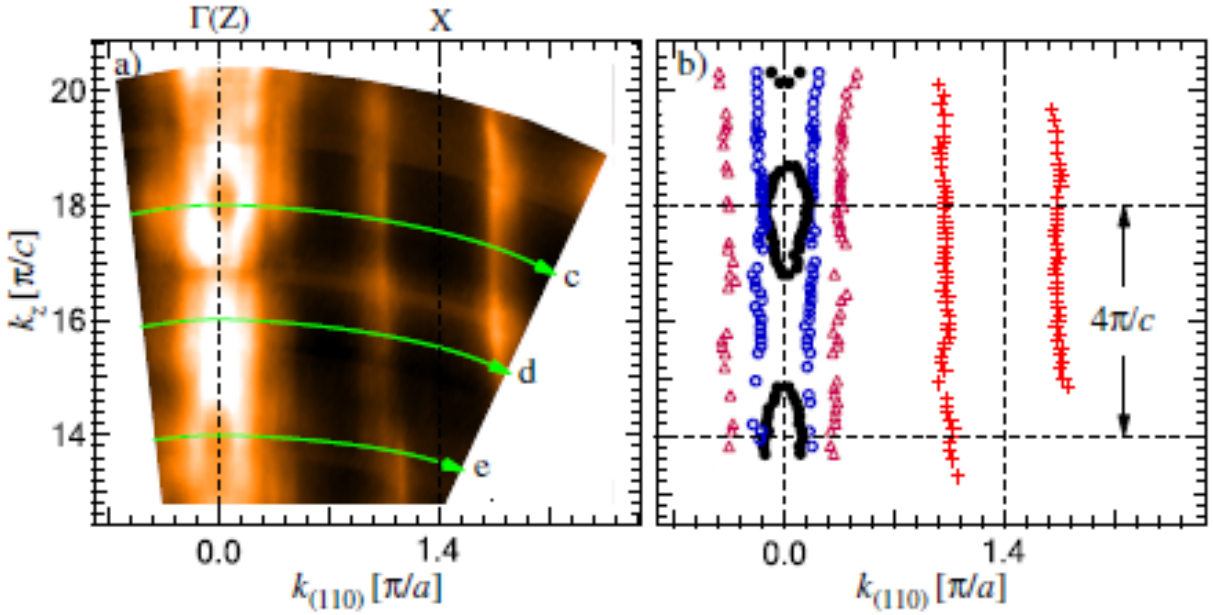




- two hole-like pockets around zone center and one electron-like pocket around zone corner

C. Liu, et al, PRL, **102**, 167004 (2009)

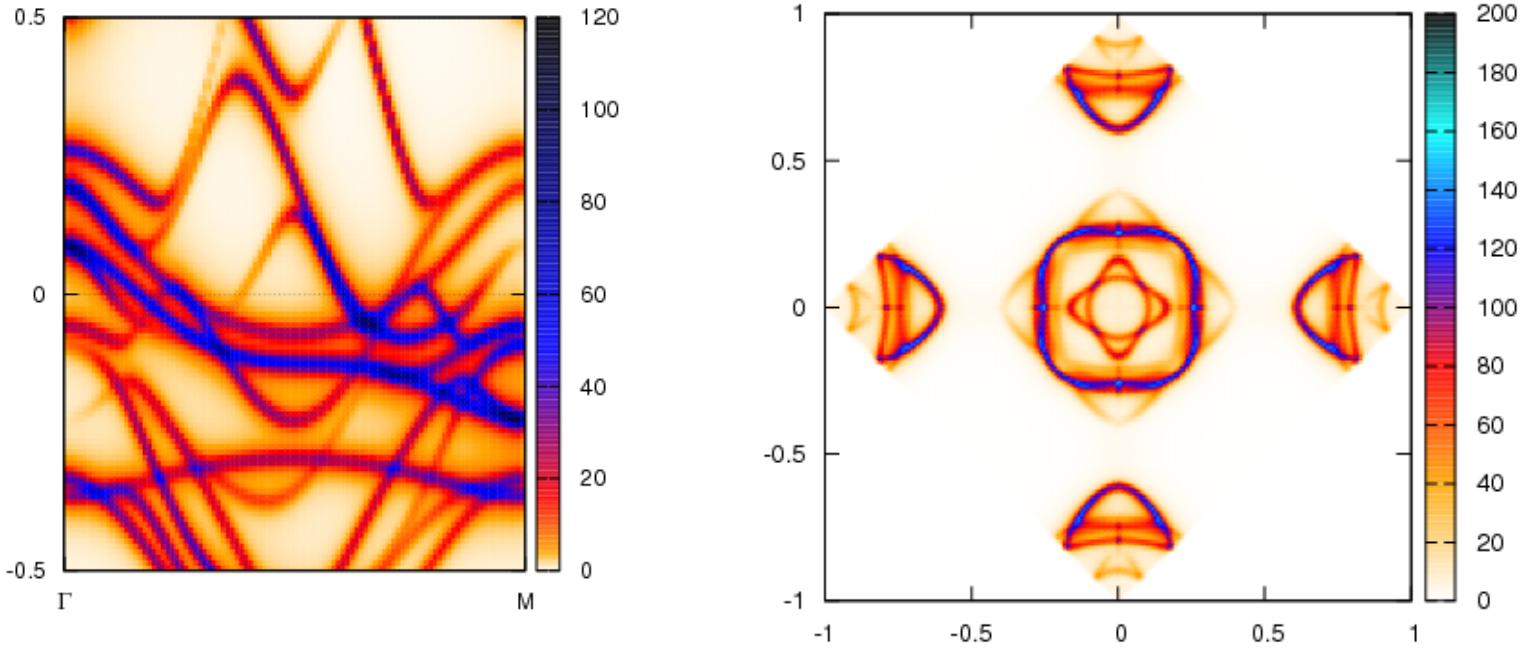
Experiments: $CaFe_2As_2$



C. Liu, et al, PRL, **102**, 167004 (2009)

- z component of momentum is identified by the incident energy of photon.
- the bands around Γ point is more 3D than the bands around M point.

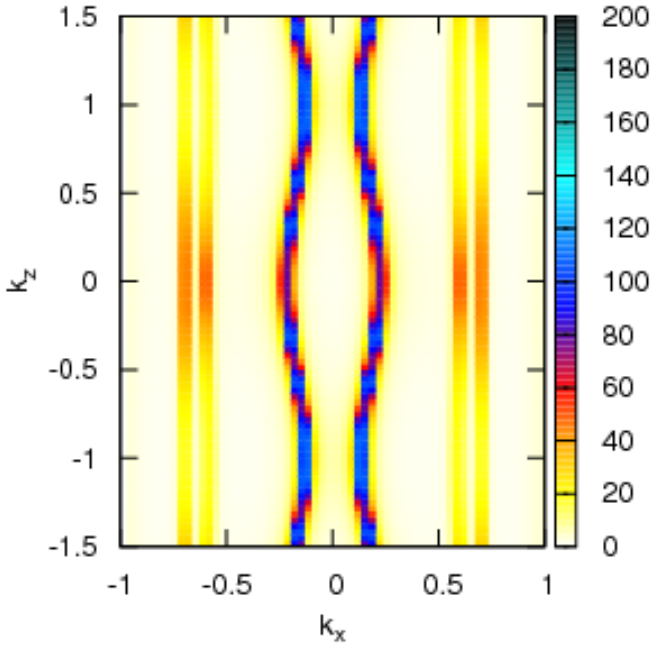
my results



- Five-orbital model + MFA

$$H_0 = \sum_{\mathbf{k},\sigma} \sum_{\alpha,\beta} \left(\xi_{\alpha\beta}(\mathbf{k}) + \epsilon_\alpha \delta_{\alpha\beta}\right) d^\dagger_{\alpha\sigma}(\mathbf{k}) d_{\beta\sigma}(\mathbf{k}) \qquad H_{\text{int}} = U \sum_{\mathbf{i},\alpha} n_{\mathbf{i},\alpha,\uparrow} n_{\mathbf{i},\alpha,\downarrow} + (U' - \frac{J}{2}) \sum_{\mathbf{i},\alpha<\beta} n_{\mathbf{i},\alpha} n_{\mathbf{i},\beta}$$
$$-2J \sum_{\mathbf{i},\alpha<\beta} \mathbf{S}_{\mathbf{i},\alpha} \cdot \mathbf{S}_{\mathbf{i},\beta}.$$

my results



Conclusions

- two hole-like enclosed pockets and four petal-like pockets around zone center
- one electron-like enclosed pocket and four petal-like pickets around zone corner
- more 3D than cuprates
- MFA of 5-orbital model gives consistent results with experiments

References

- Damascelli, Hussain and Shen, Rev. Mod. Phys., **75**, 473 (2003)
- F. Ma, et al, arXiv:0806.3526v2
- M. Yi, et al, PRB, **80**, 174510 (2009)
- V.B. Zabolotnyy, et al, Nature, **457**, 569 (2009)
- Y. Zhang, et al, PRL, **102**, 127003 (2009)
- C. Liu, et al, PRL, **102**, 167004 (2009)