High-temperature superconductivity restrained by orbital hybridization

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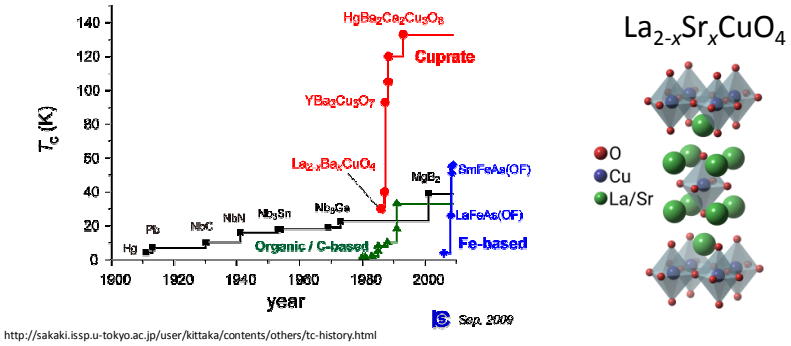
High-temperature superconductivity



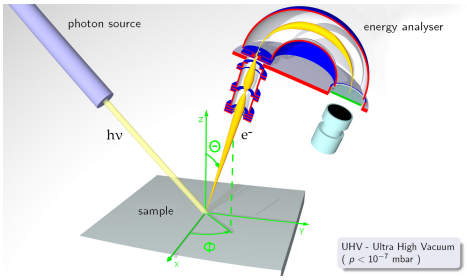
http://sakaki.issp.u-tokyo.ac.jp/user/kittaka/contents/others/tc-history.html

$La_{2-x}Sr_xCuO_4$

Why is T_c lower for La-based cuprates ?

ARPES

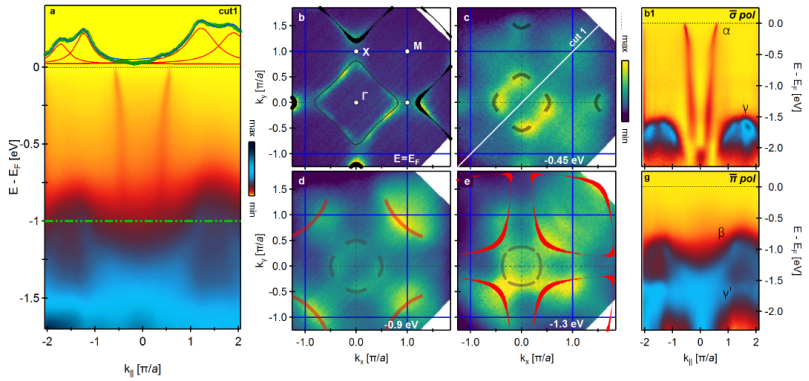
Angle-**R**esolved **P**hoto**E**mission **S**pectrpscopy



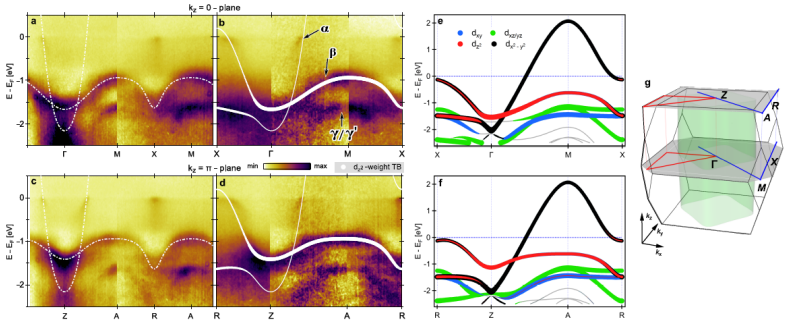
https://en.wikipedia.org/wiki/Angle-resolved_photoemission_spectroscopy

Results

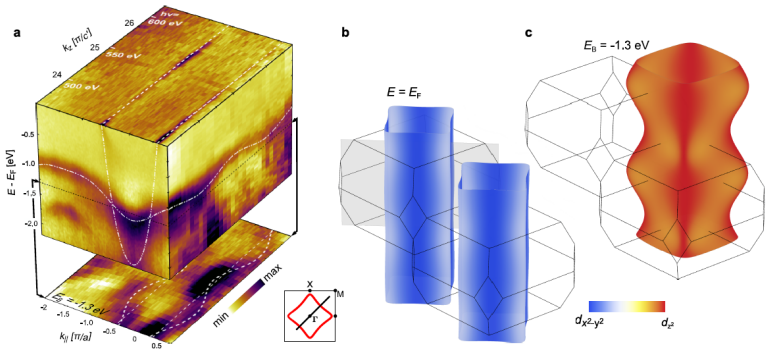
ARPES spectra of overdoped $La_{2-x}Sr_xCuO_4$



Fitting to tight-binding model



Three-dimensional band dispersion



Disentanglement of *d* orbitals

α: d_{x2-y2} β: d_{z2} γ, γ': d_{yz}/d_{zx}

Two-band tight-binding model

$$\varepsilon_{\pm}(k) = \frac{1}{2}\left[M^{x^2-y^2}(k) + M^{z^2}(k)\right] \pm \frac{1}{2}\sqrt{\left[M^{x^2-y^2}(k) - M^{z^2}(k)\right]^2 + 4\Psi^2(k)}$$

$M^{x^2-y^2}(k)$: **intra**-orbital hopping for d_{x2-y2}

$M^{z^2}(k)$: **intra**-orbital hopping for d_{z2}

$\Psi(k)$: **inter**-orbital hopping between and d_{x2-y2} and d_{z2}

Fitting: $\Psi(k) \sim M^{x^2-y^2}(k) \times 0.2$

→ Significant hybridization between d_{x2-y2} and d_{z2} orbitals restrains high-temperature superconductivity in $La_{2-x}Sr_xCuO_4$.

Summary

- One-band (d_{x2-y2}) picture has long been applied to cuprate high-temperature superconductors.
- By ARPES, we disentangled all the *d* orbitals in $La_{2-x}Sr_xCuO_4$ for the first time, and revealed significant hybridization between d_{x2-y2} and d_{z2} orbitals.
- Orbital hybridization restrains high-temperature superconductivity in $La_{2-x}Sr_xCuO_4$ and lowers T_c.

For more details: C.E. Matt *et al.*, arXiv:1707.08491