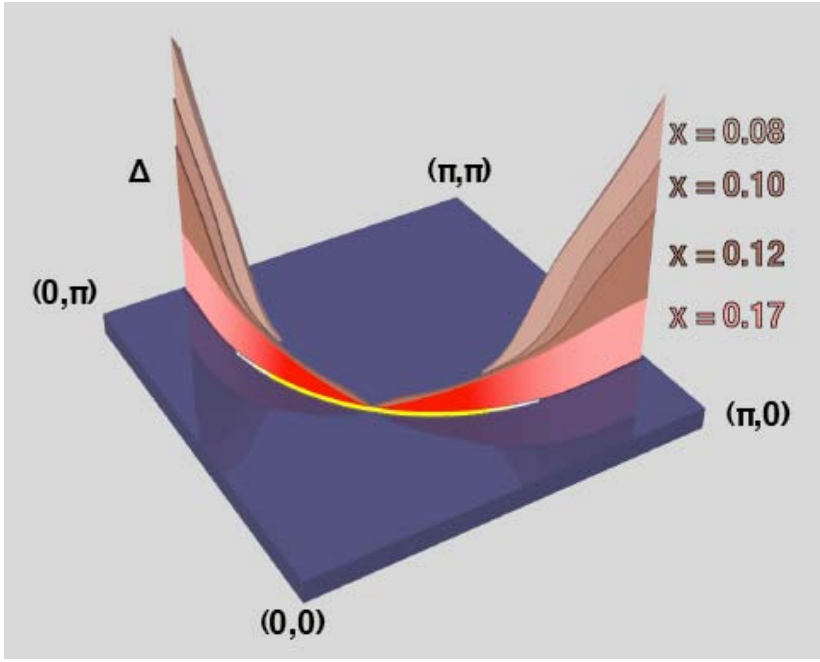
Extending Universal Nodal Excitation Optimizes Superconductivity in Cuprates

Aakash Pushp, Colin Parker, Abhay Pasupathy, Kenjiro Gomes, Jinsheng Wen, Zhijun Xu, Genda Gu, Shimpei Ono,, and Ali Yazdani, Princeton University (DMR-0819860)

In normal superconductors the transition temperature is related to the strength of the binding energy between electrons forming pairs. This binding energy results in an energy gap for adding or removing electrons from a superconductor The high-T_c cuprate superconductors have a *d*-wave pairing symmetry that results in anisotropic binding energy for pairs. Using a novel technique with a scanning tunneling microscope Princeton scientists have been able to study the anisotropic energy gaps across the cuprate doping-temperature phase diagram. They find that gap versus angle does not always follow that of a simple *d*-wave superconductor. In fact, they find that for lowest doping samples, the gap becomes only a simple d-wave along directions 45° to Cu-O bond direction. More surprising is the gap near this direction is independent of doping and T_c of the sample. They find that the range of simple d-wave cos(2Θ) gap correlate with T_c. The wider the range of angle over which the gap follows a cos(2Θ) function, the larger the T_c. Optimal doping occurs when the gap follows cos(2Θ) over all angles. This observation shows that contrary to conventional superconductor it is not just the strength of pairing that determines T_c. The angles over which pairing interaction is most effective also matters.



Schematic of the pairing gap as function of momentum or angle in the Cu-O plane. The direction from (0,0) to (ΠΠ) is 45 to Cu-) bond direction. Near this angle the pairing gap follows a universal doping independent cos(2Θ) function (the red shaded function). Beyond this region, different samples are distinguished by the range over which their gap follows this function. Optimal doping comes close to the ideal cos(2Θ) over the entire angle range.

Reference: A. Pushp, C. V. Parker, A. N. Pasupathy, K. K. Gomes,, J. Wen, Z. Xu, G. Gu, S. Ono, Y. Ando, and A. Yazdani *Science* June 26th, (2009).