Hirschfeld research group

Background: Superconductivity

- a) Thermodynamic phase at low temperatures characterized by:
  - zero resistance (important for technical applications)
  - ideal diamagnetism (Meissner effect, full expulsion of magnetic fields)
- b) Formation of Cooper Pairs due to attractive interaction and their condensation leads to superconducting properties
- c) Origin of attractive interactions
  - Phonons: Fröhlich mechanism (realized in conventional superconductors)
  - Spin-fluctuations / orbital fluctuations (most probable mechanism for high $T_c$ superconductors)

Known materials:

- a) Conventional superconductors: simple materials with strong electron-phonon interaction.
- b) Cuprates (discovered 1986): high-temperature superconductors with complicated layered structure.

Research topics

- a) Iron-based superconductors
  - Spin-fluctuation theory: "glue" for Cooper pairs

  \[ \Delta(k) = \sum_{k'} \Gamma_i(k, k') \frac{\Delta(k')}{2E_{k'}} \tan \frac{E_{k'}}{2T} \]
  - superconducting gap (order parameter)
  - pair scattering vertex

- b) Cuprate superconductors:
  - Fermi surface with different Fe 3d-orbital weights indicated by color: $xz$: red, $xy$: blue

  Recent project: non-local correlations effects in Fe-based Superconductors

  Spectral function of LiFeAs under self-energy renormalization effect. Non-interacting bands shown with black curves.

  Recent project: Impurity states in BSCCO

  Calculation of Zn impurity in BSCCO-2212 (Kreisel et al PRL 2015)
    - (a) traditional Bogoliubov-de Gennes (bGdG) solution;
    - (b) bGdG+W approach from Chudov et al PRR 2014;
    - (c) exp. from Pan et al Science 2001.

  Recent project: charge order imaged by STM in BSCCO

  (a), (b) s, s', and d-form factors in BSCCO-2212 vs. STM bias: (a) experimental results from Hamidian et al, Science 2015
  - (b) Theory of Chudov et al, NFP 2017
  - (c), (d) conductance maps:
    - (c) BSCCO
    - (d) Theoretical LDOS

Current group members:

Collaborators:

Social activities: