Subdominant *d*-wave coupling in $Ba_{0.6}K_{0.4}Fe_2As_2$

Strong Correlations and Unconventional Superconductivity

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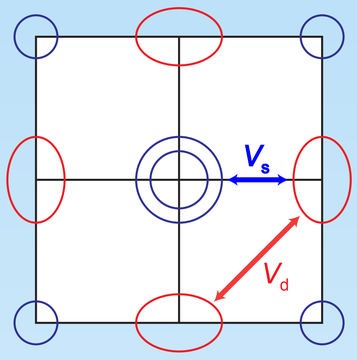
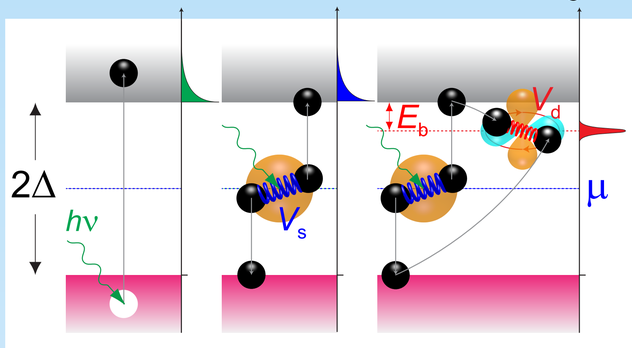
1 Introduction

Relevant interactions



States and excitations below T_C



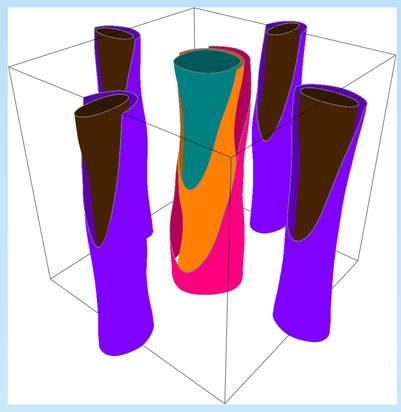
- $Ba_{0.6}K_{0.4}Fe_2As_2$ optimally hole doped
- dominant *s* interaction V_s
- subdominant $d_{x^2-y^2}$ interaction V_d

- Cooper pairs created by V_s → pair breaking gives a peak at 2Δ in the Raman spectra
- Excitation of a pair bound by V_d gives a peak at $2(\Delta - E_b)$ in the Raman spectra, Raman selection rules require a $d_{x^2-y^2}$ excitation to be in B_{1g} symmetry for an *s*-symmetric ground state

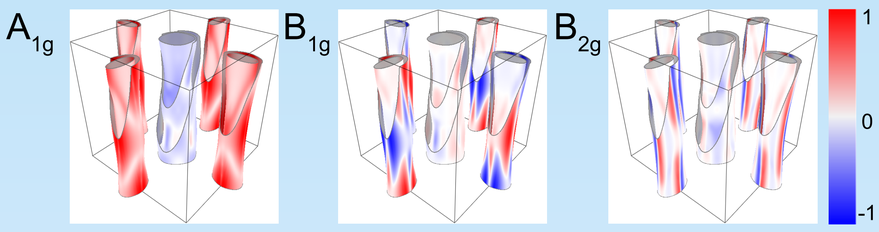
2 Theoretical approach

- Tight binding model from 5 Fe *d*-orbitals

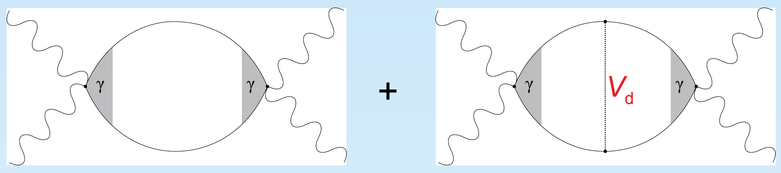
Fermi surfaces



- Effective mass approximation gives Raman vertices



- Raman response



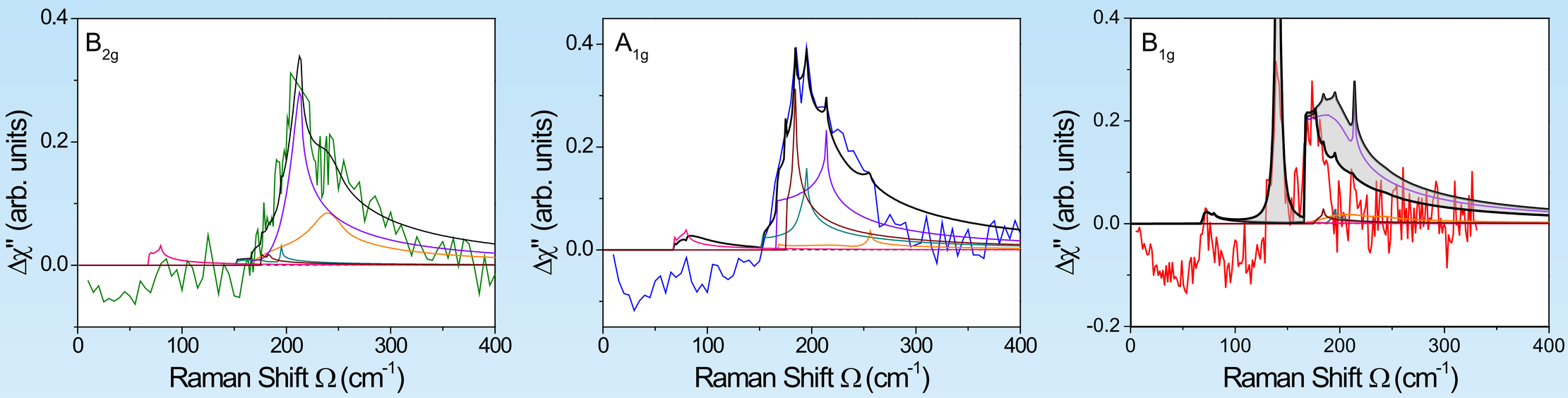
Bare bubble approximation for pair breaking

First order correction to include subdominant interaction V_d

S. Graser et al., Phys. Rev. B **81**, 214503 (2010)
M. Yi et al., Phys. Rev. B **80**, 024515 (2009)
D. J. Scalapino, and T. P. Devereaux, Phys. Rev. B **80**, 140512 (2009),
www.wikipedia.org

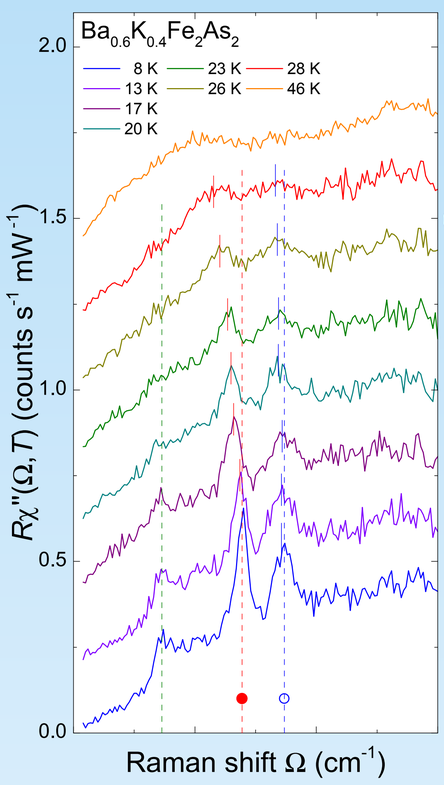
3 Experiment and theory

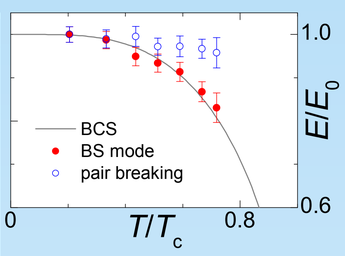
- $\Delta\chi''$ is the response in the superconducting state (8 K) with the normal state (45 K) subtracted off to select the features emerging at the transition to superconductivity (T_c = 39 K).



F. Kretzschmar et al., Phys. Rev. Lett. **110**, 187002 (2013)

4 Temperature dependence

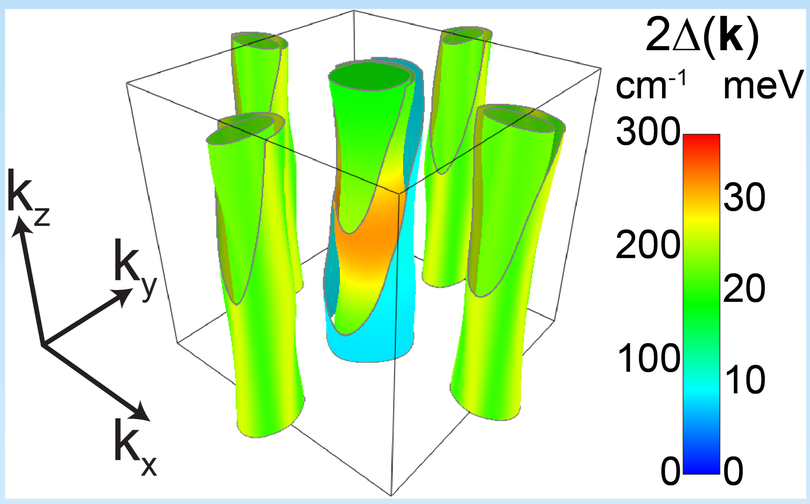




- Bardasis-Schrieffer mode (BS) scales with single-particle gap
- Superconducting gap doesn't change much in strong-coupling systems

5 Results

- Superconducting gaps



- weakly anisotropic gaps
- consistent with ARPES measurements

K. Nakayama et al., EPL (Europhysics Letters) **85**, 67002 (2009)

- B_{1g} Bardasis-Schrieffer mode
  - spectral weight is shifted out of the pair breaking peak of the outer electron band into the excitonic mode
  - V_d acts predominantly at regions with maximal gaps (yellow at the outer electron band)
  - the coupling strength of V_d is 60% of the coupling strength of V_s