Summary

CORPES13

International workshop on strong correlations
and angle-resolved photoemission spectroscopy

Experimental part

Jörg Fink

Leibniz Institut für Festkörper- und Werkstoffforschung
Dresden

some help from Dan Dessau

August 2 2013

Hamburg

COR

PES

COR PES

MAN PES

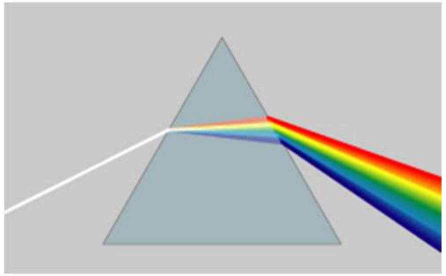
TI PES

ARPES meets theory

CORPES is not a corpse

It‘s alive and kicking

Advances in spectroscopy techniques I



Light sources

Laser 0.3-2 meV Δk ↑ hν=6 eV

SR beamlines ΔE ~ 1 meV up to hν= 100 eV

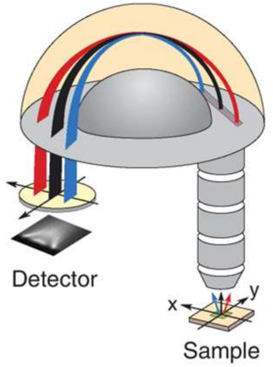
SR SX beamlines ΔE~100 meV ~~COR ?~~
λ ↑ Δk ~ 1/λ resonant ARPES depth profile by standing waves

SR HX beamlines HAXPES ~~COR ?~~
λ ↑ ↑ ΔE~ 100 meV huge phonon excitations for light elements.

HHG hν< 100 eV ΔE= 100 meV

XFEL Δt = 2-100 fs SASE3 hν=250- 3000 eV
Repetition rate 30 000 p/sec (space charge ↓)

Advances in spectroscopy techniques II

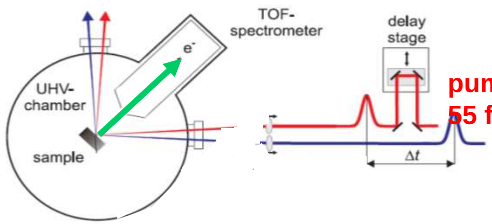


Analyzers

Wide angle detection $\Delta E = 0.3$ meV

Time of flight analysers $\Delta E = 5$ meV

Spin resolved ARPES $\Delta E = 5$ meV



Time resolved ARPES

$h\nu = 6 – 43$ eV $\Delta E \sim 80$ meV $\Delta t \sim 50$ fsec
Σ from t-dependend relaxation, hope to separate
e and ph relaxation processes, non equilibrium phases,
THz excitations of specific phonons

inverse ARPES

$\Delta E \sim 300$ meV, with gratings better but intensity problems
2 photon ARPES - intensity problems

Advances in spectroscopy techniques III

Sample environment and preparation

T= 1 K (**Kondo systems, thermal broadening ↓**)

PLD MBE artificial structures

(tr)-XAS, RSXS, RIXS, IR, VIS, Raman ………

Low dimensional (0D, 1D) systems

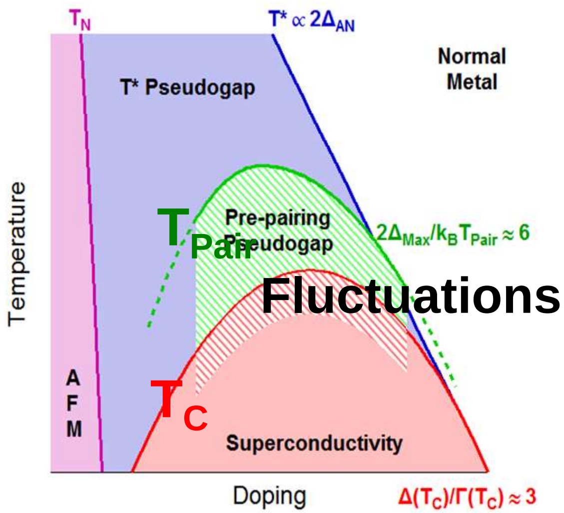
Mn, Fe, Co, and NI on Ag(100)
Higher energy features which decrease with filling of the 3d shell.
Non-monotonic spectral weight near E_F. Hund‘s exchange J can explain evolution.

$Li_{0.9}Mo_6O_{17}$ system in which correlation effects are determined not by the Coulomb interaction but by the low dimensionality.
ARPES T>30 K TLL behavior, 30K>T>1.5K unclear 1D-3D transition.
Interchain interaction is important.
On the other hand, LDA band structure can explain many features.

Cuprates

phonon spin

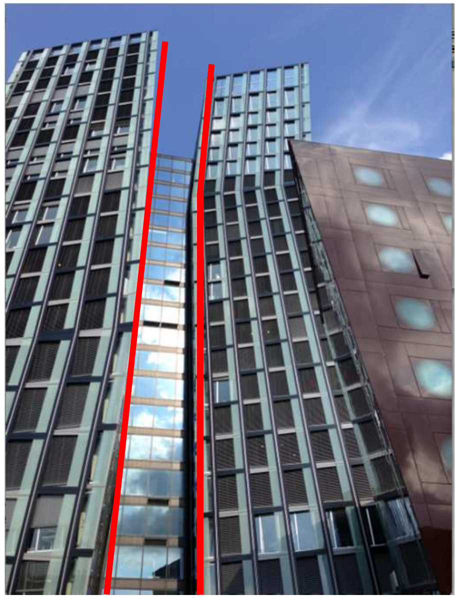
only 2 experimental talks on cuprates



TDoS measurements of the superconducting gap and pair-breaking fluctuations.

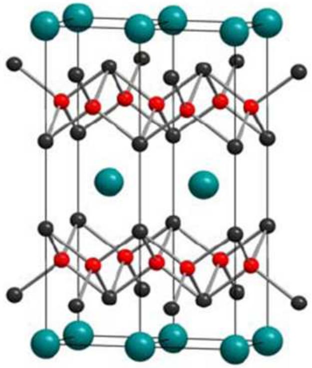
Non-equilibrium optical spectroscopy
Disentanglement of the electronic and the phononic
Contributions to the Eliashberg function.

d-electron oxides



$SrVO_3$ with the $3d^1$ configuration. A bench-mark system.
Impressive ARPES study with an evaluation of the complex self-energy which causes kinks similar to the cuprates. High energy kink (waterfall?) was interpreted in terms of high-energy (0.7 eV) e-e interaction.

Ferropnictides/chalchogenides


Ba(FeAs)$_2$

8 experimental talks on iron based SCs

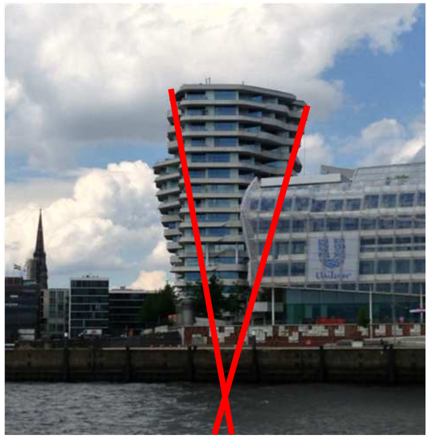
Spectacular: Tc= 65 K in a monolayer of FeSe/STO
ARPES has developed into analytical materials-research tool.

Pseudogap in the underdoped region, possibly related to the nematic phase. Gap 30 meV => not precursor.
P (even in overdoped samples) > Co > K

Clear evidence for a coupling to magnetic resonance mode below Tc
Similar to the cuprates.

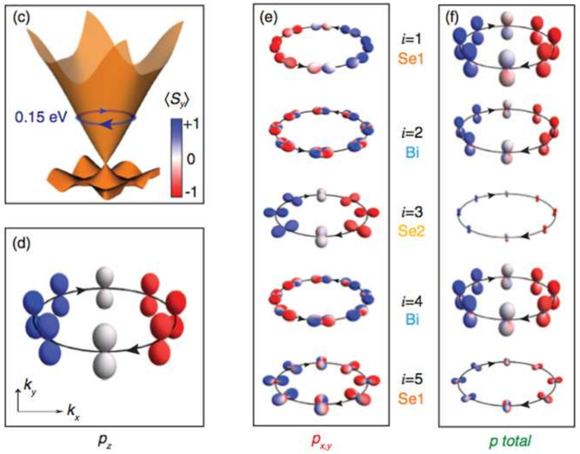
Ru replacement of Fe does not change the electronic structure
Magnetic dilution could lead to a suppression of AF order => SC

Topological insulators



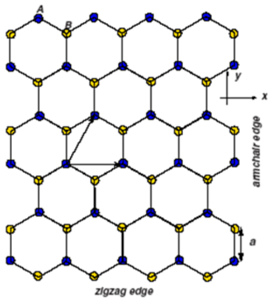
8 experimental talks on TI

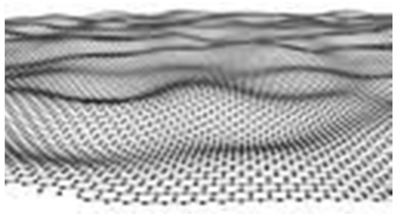
“There is so much out that I am getting overwhelmed” J.A.



Bi_2Se_3. Polarization-dependent ARPES: the topological surface states are characterized by layer dependent entangled spin-orbit effects which becomes apparent through quantum interference effects. This solved the puzzle that in S-ARPES polarizations are observed between 20 and 85 % instead of 100 %.

Graphene

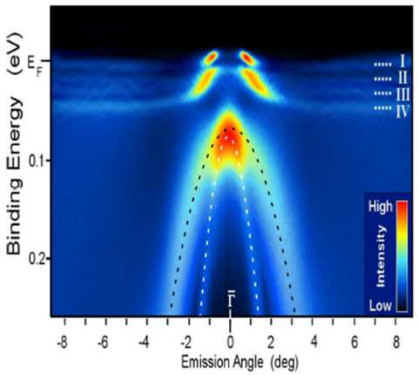




Only 1 experimental talks on graphene

Band structure study of a bilayer of graphite.
Native imperfection – distribution of twists.
New electronic structure of massive and massless fermions.

f-electron systems

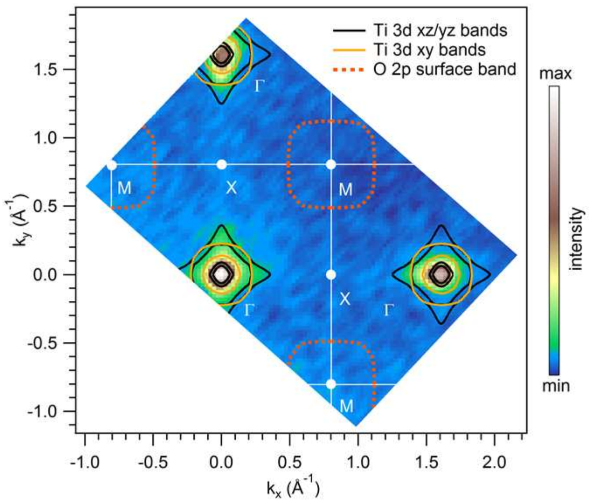


"Unbelievable data" on $YbRh_2Si_2$
=> crystal field splitting, hybridization of the 4f states with d states.

Longstanding puzzle of the finite low-T resistivity in the Kondo insulator SmB_6 seems to be solved: surface conductivity possibly due to a topological insulator state.

Impressive data on the hidden order in URu_2Si_2.
Precursor to the superconducting state???
ARPES indicates a symmetry change.
Not an AF phase, CDW, structural phase.

Surfaces, interfaces, heterostructures



Hetero structure $LaAlO_3/SrTiO_3$, 2D metallic and superconducting interface. Impressive combination of X-ray spectroscopies => no potential gradient is formed. O vacancies at the surface are important for the formation of the metallic layer. Fermi surface is detectable.

2D electron gas in O deficient $SrTiO_3$. ARPES: various bands due to a different potential on the surface layers. Unconventional Rashba-like spin splitting of the Ti d-electron sub-band ladder.

ARPES on a 2D buried delta-layer of P doped Si. Detection of the deeply buried layer is possible by resonance enhancement effects.

Sub-monolayer metal atom layers on semiconductors: Sn/Si, Au/Ge. Magnetic order due to a formation of a Mott insulator. Unconventional Rashba effect.

Thank you