B6 Collective phenomena in organic charge-transfer salts close to the Mott transition

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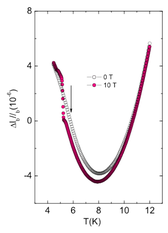
Strong Frustration in Mott Insulators

1) Spin-liquid candidate κ-(BEDT-TTF)$_2$Cu$_2$(CN)$_3$

a) Achievements

- Previous result: Prominent anomaly in α at 6 K, cf. R. S. Manna *et al.*, PRL **104**, 016403 (10)
- Increase in degree of frustration up to t'/t = 0.86 @ 5 K upon cooling **B2**

H.O. Jeschke, M. de Souza, R. Valenti, R.S. Manna, M. Lang, J.A. Schlueter, , PRB **85**, 035125 (12)



- Field-induced abrupt length changes, reminiscent of "pinning effects"

R.S. Manna, M. de Souza, J.A. Schlueter and M. Lang, Phys. Status Solidi C **9**, 1180 (12)

b) Project goals and work programme

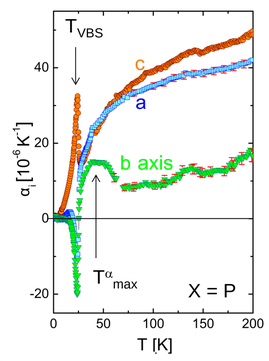
1) Study of "pinning-like" effects via micro-Hall probe studies **B11**

2) $EtMe_3X[Pd(dmit)_2]_2$: dimers form slightly distorted triangular lattice with 1 e$^-$/dimer

a) Achievements

X = P: valence-bond-solid (VBS)

R.S. Manna, M. de Souza, R. Kato and M. Lang, PRB **89**, 045113 (14)

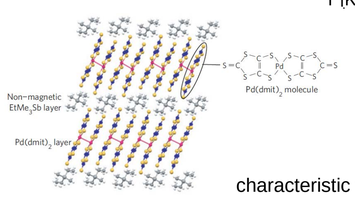


- Strong anisotropic lattice effects at T_{VBS}
- More anisotropic triangular lattice (quasi-1D)

b) Project goals and work programme

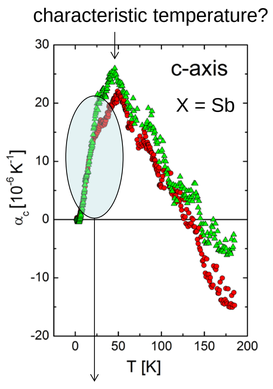
X = Sb: Splin-liquid candiate

1) In-plane α(T): *a*- and *b*-axis
   - Characteristic temperatures? **B2**



2) Low-T α(T) (T < 1.4 K)
   - Low-lying gapless excitations (α ∝ T)? Field-induced spin gap?,
     cf. Yamashita *et al.*, Science **328**, 1246 (10)
   - Signatures of 1 K anomaly (NMR measurements: symmetry breaking and/or topological order?),
     cf. Itou *et al.*, Nature Phys. **6**, 673 (10)
   - Comparison with 6 K anomaly in κ-(BEDT-TTF)$_2$Cu$_2$(CN)$_3$,
     cf. R.S. Manna *et al.*, PRL **104**, 016403 (10)

characteristic temperature?



indicative of anomalous behaviour at T < 1K!

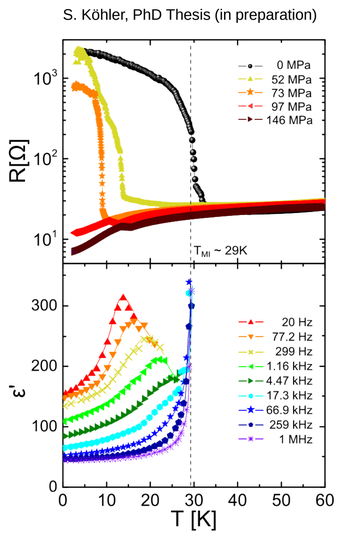
B1 **B2** **B11**

κ-(BEDT-TTF)$_2$Hg(SCN)$_2$Cl

a) Achievements

- Metal-Insulator (MI) transition at 30 K (assigned to charge order, Drichko *et al.*, PRB **89**, 075133 (14)) rapidly suppressed under pressure
- No superconductivity under pressure!
- Relaxor-type dielectric response **P. Lunkenheimer, Augsburg**
- Successful growth of single crystals

S. Köhler, PhD Thesis (in preparation)

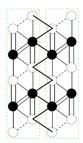


b) Project goals and work programme

1) Search for superconductivity at lower T and higher P

2) Study nature of MI-transition: suggested scenario of paired-electron-crystal

Cf. Drichko *et al.*, PRB **89**, 075133 (14); Li *et al.*, J. Phys. Condens. Matter **22**, 272201 (10)



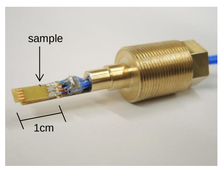
- strong and highly anistropic α(T)?
- Nonmagnetic ground state via χ(T)?
- Entropy release via C(T)?

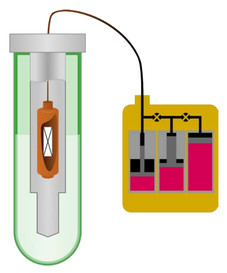
B2 **B11** **B12**

3) Sample-to-sample variations in dielectric measurements:
   - Order-disorder-type in higher-quality single crystals?

Techniques

Transport, dielectric and magnetic measurements @ Helium-gas pressure

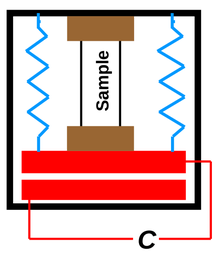




- Hydrostatic conditions p ≤ 13 kbar
- In-situ pressure changes

High-resolution dilatometry @ Helium-gas pressure

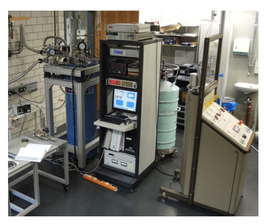
R.S. Manna *et al.*, Rev. Sci. Instrum. **83**, 085111 (12)

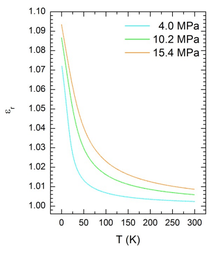


$$\alpha = \frac{1}{l}\frac{\partial l}{\partial T}$$

30 mm

ΔL/L ≥ 10^{-10}



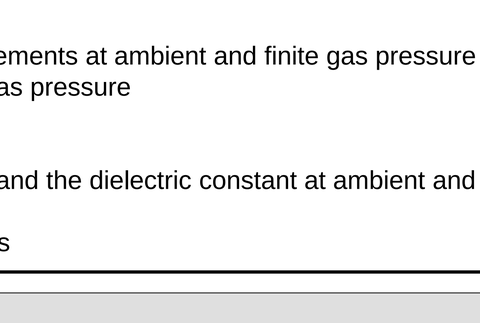


^{4}He-gas pressure P ≤ 2.5 kbar

Requested Funding for Instrumentation

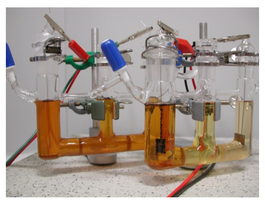
• P ≈ const. only guaranteed by using a Helium gas bottle (P < 300 bar)!

• requested upgrade: second pressure cell with individual T-control, further also equipped with 2nd dilatometer cell for a simultaneous measurement of ε'(T,P)



Price 57.631 €:
- Large-volume pressure cell (18.635 €)
- Connection board including manometer, valves, capillaries etc. (23.526 €)
- Capacative dilatometer cell (15.470 €)

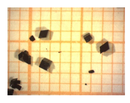
Single crystal preparation of κ-(BEDT-TTF)$_2$X



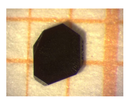
Electro-crystallization

- X = Cu[N(CN)$_2$]Cl

M. Lang *et al.*, IEEE Transaction on Magnetics **6**, 2700107 (14)



- X = Hg(SCN)$_2$Cl



- X = Cu[N(CN)$_2$]Br

e.g.: S. Diehl *et al.*, arXiv: 1410.5245 (14)

B8 **B11** **B12**

Staffing of the project from auxiliary support

• Elena Gati (Ph.D. student)
- high-resolution thermal expansion measurements at ambient and finite gas pressure
- magnetic measurements (SQUID) under gas pressure

• David Zielke (Ph.D. student)
- measurements of the electrical resistance and the dielectric constant at ambient and finite gas pressure
- high-resolution specific heat measurements

Role within SFB/TR49

Close collaborations exist to the following projects

A5 ⇒ 2D-DMRG calculations

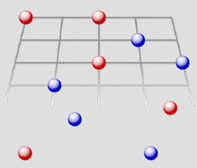
B1 ⇒ Spin-liquid candidate systems

B2 ⇒ Band-structure calculations, calculation of dielectric response

B8 ⇒ Photoemission experiments

B11 ⇒ Noise spectroscopy, dielectric measurements and inelastic neutron scattering

B12 ⇒ STM/STS measurements



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