Evidence of Phase Separations in TMTSF2X Compounds and V2O3

The AF insulator-metal transition

Three cases of phase segregation

The TM2X phase diagram
BEDT-TTF2X
and V2O3

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The border between AF (insulating) and SC

Canonical picture, in 1980!
1st order reentrant superconductivity ??
Revisiting the border SDW/SC in TMTSF$_2$PF$_6$.

**Canonical picture!**

1st order reentrant superconductivity ??

Better quality measurements,

Very good pressure control at low T and

19 runs made with the same sample!!

T. Vuletic (thesis) and
cond-matt 0109031

Coexistence between SDW and SC at the border in (TMTSF)$_2$PF$_6$

T. Vuletic EPJ-B, 25, 319, 2002
cond-matt 0109031

$T_{sc}$ decreasing under pressure in the homogeneous domain

$T_{sc}$ stays constant in the SDW/SC domain
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### Activation plots close to $T_{SDW}$

**Model:**
SDW and metallic domains in parallel
\[
\frac{1}{R} = \frac{c}{R_{m}} + \frac{(1-c)}{R_{SDW}}
\]

$c =$ fraction of metallic volume

### The SDW/SC coexistence regime

- **High pressure**
  - $I_{c}=45$ mA
  - $J_{c}=200$ A/cm²
  - $R_{n}=1.2$ mΩ
  - Normal state $R_{n}$ is recovered

- **Lower pressure**
  - $I_{c}=7$ mA, only a fraction of the cross section is SC
  - $R_{n}=15$ mΩ
  - $\ll$ extrapolated $R_{SDW}=120$mΩ
  - Sliding SDW ($E/E_T=5$)

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**Phase segregation**

SDW/Metal segregation gives lower energy than the homogeneous phase in the vicinity of the border.

**Coexistence between SDW and M: a simple model**

\[ E_{\text{SDW}}(u) \quad \text{from (Yamaji and others)} \]

\[ E_{\text{SDW}}(u) - \Delta E \]

SDW + M

Homogeneous SDW

\[ T = 0 \text{ K} \]

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\[ \Delta F_{\text{total}} = \Delta E_{\text{elastic}} + \Delta F_m \]
\[ \delta b_2 / \delta b_1 = (1 - c) / c \]

**Gain**
\[ \Delta F_m = (1 - c) \left( \frac{\partial F_m}{\partial t_b'} \right) \left( \frac{\partial t_b'}{\partial b} \right) \delta b_1^2 - cF_m(t_b') \]

**Loss**
\[ \Delta E_{\text{elastic}} = (1 - c) K \left( \delta b_1 \right)^2 + cK \left( \delta b_2 \right)^2 \]
\[ = \frac{1 - c}{c} \frac{K}{\delta b_1^2} \]

Minimization / c and \( \delta b_1 \)
\[ \Delta F_{\text{total}} = -\frac{1}{4} \left[ \frac{1}{4K} \left( \frac{\partial F_m}{\partial t_b} \right)^2 \left( \frac{\partial t_b}{\partial b} \right)^2 - F_m(t_b') \right]^2 < 0 \]

The segregation scenario in TM2X and related compounds

T. Vuletic et-al,
EPJ-B, 25, 319, 2002
cond-matt 0109031

Adding the superconducting condensation energy broadens the coexistence regime

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Universal TM,X phase diagram from TMTTF,PF, under pressure

Divergence of Hc2//c in the coexistence regime

Hc2 //c in TMTTF,PF, from \( \rho_a \) data vs T

No triplet pairing is needed to explain the large critical fields close to the border

H Wilkinson et al
J Phys. Cond. Matt
13, 1, 2001
EPJB 21, 175, 2001
cond-mat/005378

H. Wilhelm et al, unpublished

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Superconductivity in TMTTF2BF4

Critical current in the coexistence regime

P. Auban et al (to be published)

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\[ \kappa \text{-(BEDT-TTF)}_2 \text{Cu[N(CN)}_2\text{]}\text{Cl Mott transition and SC/AF coexistence} \]

ET\(_2\)X family
2D superconductor
\( T_c = 12 \text{K} \)

\[ \text{S.Lefebvre et al PRL 25,5420, 2000 cond mat 0004455} \]

SC/AF coexistence again!

Epilogue

Bechgaard salts:

« The most interesting materials ever discovered »

Paul Chaikin

all organics are interesting !!

D.J
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**V2O3 series: an old prototype for the Mott transition**

**V2O3, transport near the critical pressure**

P. Auban, E. Semel et al.
Evidence of Phase Separations in TMTSF2X Compounds and V2O3

Entering the AF phase $R_0$ increases 6 times more than $R_A$.

--> Thin metallic walls sensitive to impurities

--> Transport is ohmic in the inhomogenous state --> non interrupted metallic paths

$R = R_0 + R_A T^2$
Phase coexistence is clearly evidenced near $P_c$ in TM$_2$X

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be careful for the study of the superconducting properties

Stay away from the coexistence regime

Seems to be a general phenomenon

in V$_2$O$_3$

and 2D organics