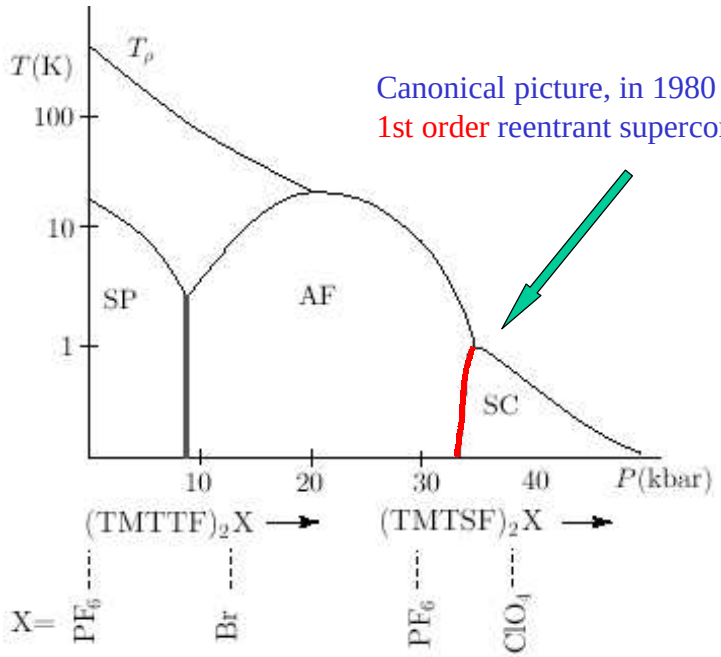
The AF insulator-metal transition

Three cases of phase segregation

The TM_2X phase diagram
BEDT-TTF_2X
and V_2O_3

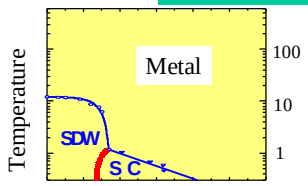
Acknowledgements to:
T.Vuletic
M.Héritier
C.Pasquier
P.Auban
E.Semel
S.Lefebvre

The border between AF (insulating) and SC



Canonical picture, in 1980 !
1st order reentrant superconductivity ??

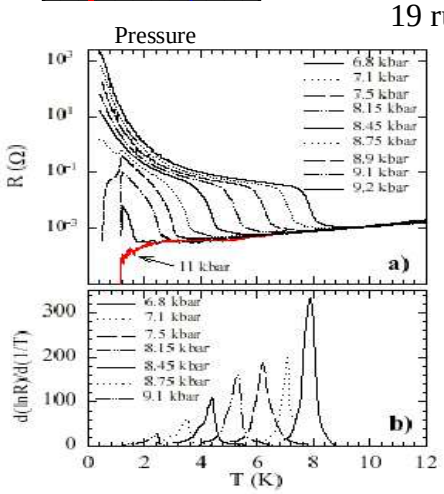
Revisiting the border SDW/SC in $TMTSF_2PF_6$



Canonical picture!

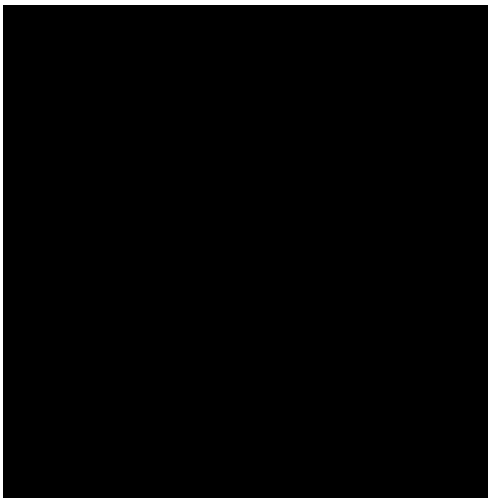
1st order reentrant superconductivity ??

Better quality measurements,
Very good pressure control at low T and
19 runs made with the same sample!!



T.Vuletic (thesis) and
Eur.Phys.Jour-B 25, 319, 2002
cond-matt 0109031

Coexistence between SDW and SC at the border in $(TMTSF)_2PF_6$



T.Vuletic EPJ-B,25,319,2002
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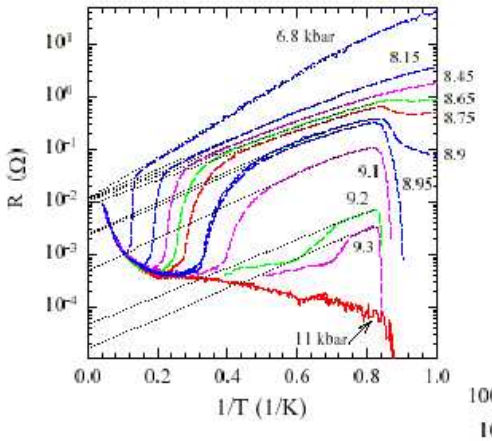
T_{sc} decreasing under pressure in the homogeneous domain

T_{sc} stays constant in the SDW/SC domain

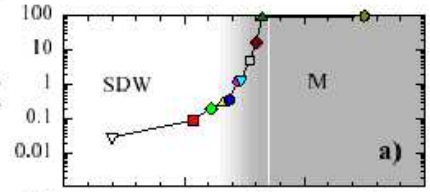
Activation plots close to T_{SDW}



Model:
SDW and metallic domains in parallel

$1/R=c/R_m+(1-c)/R_{SDW}$

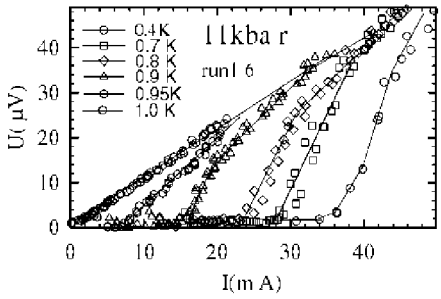
c= fraction of metallic volume



6 8 10 12 kbar

----> c versus Pressure

The SDW/SC coexistence regime

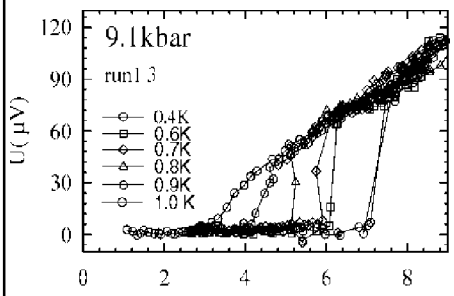


High pressure

Homogenous SC state

I_c=45mA
J_c=200A/cm^2
R_n =1.2 mΩ
Normal state R_n is recovered

Lower pressure

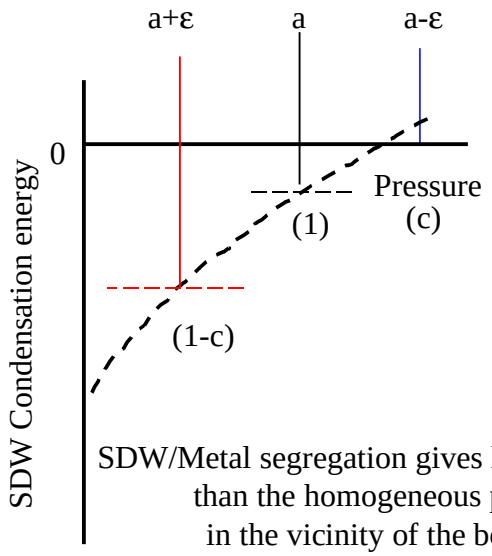


Heterogenous SC state

I_c=7 mA, only a fraction of the cross section is SC

R_n =15 mΩ
<< extrapolated R_{SDW} =120mΩ
Sliding SDW (E/E_T =5)

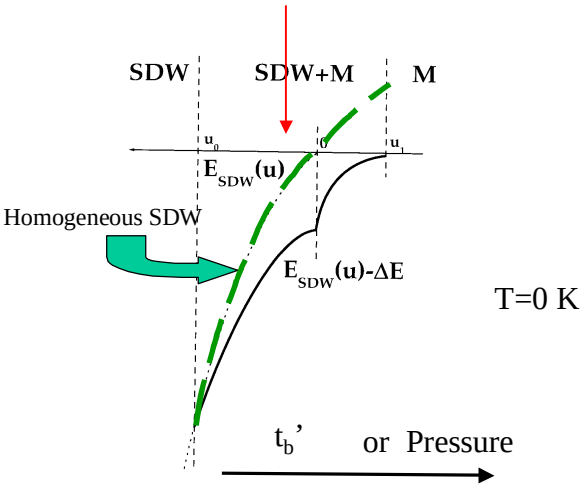
Phase segregation



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

Coexistence between SDW and M : a simple model

$E_{SDW}(u)$ from (Yamaji and others)



Free energies

$$\Delta F_{total} = \Delta E_{elastic} + \Delta F_m$$

$$\delta b_2 / \delta b_1 = (1-c)/c$$

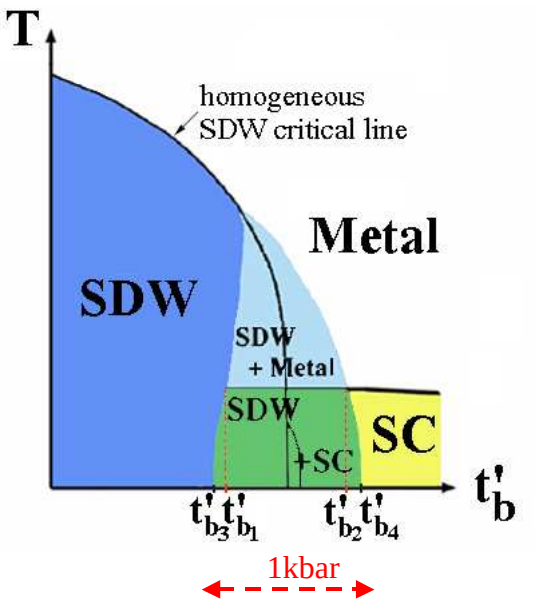
Gain $$\Delta F_m = (1-c)\left(\frac{\partial F_m}{\partial t_b'}\right)\left(\frac{\partial t_b'}{\partial b}\right)\delta b_1 - cF_m\left(t_b'\right)$$

Loss $$\Delta E_{elastic} = (1-c)\,K\,(\delta b_1)^2 + cK\,(\delta b_2)^2 = \frac{1-c}{c}K\,(\delta b_1)^2$$

Minimization / c and δb_1

$$\Delta F_{total} = -\frac{1}{4}\frac{\left[\frac{1}{4K}\left(\frac{\partial F_m}{\partial t_b'}\right)^2\left(\frac{\partial t_b'}{\partial b}\right)^2 - F_m\left(t_b'\right)\right]^2}{\frac{1}{4K}\left(\frac{\partial F_m}{\partial t_b'}\right)^2\left(\frac{\partial t_b'}{\partial b}\right)^2} < 0$$

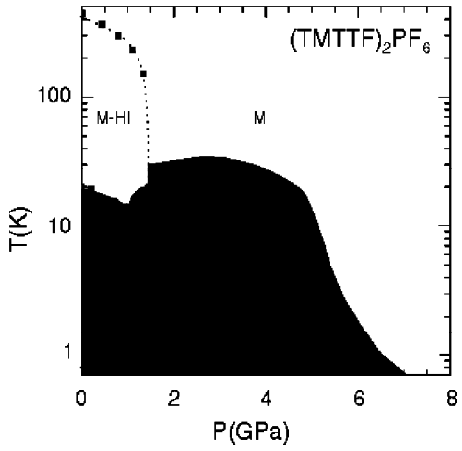
The segregation scenario in TM_2X and related compounds



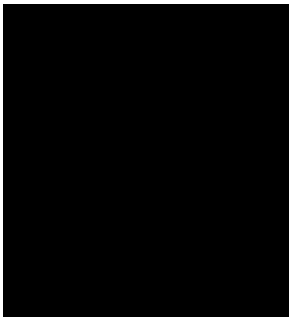
T.Vuletic et-al,
EPJ-B,25,319,2002
cond-matt 0109031

Adding the superconducting condensation energy broadens the coexistence regime

Universal TM_2X phase diagram from $TMTTF_2PF_6$ under pressure



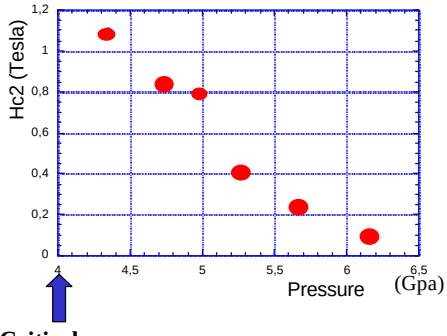
H.Wilhelm et al
J.Phys.Cond.Matt
13,1,2001
EPJ B 21,175,2001
cond- mat/005378



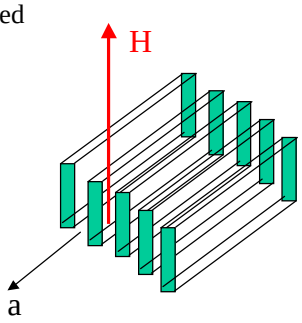
Divergence of H_{c2}//c in the coexistence regime

H_{c2} //c in $TMTTF_2PF_6$ from ρ_a data vs T

H.Wilhelm et-al, unpublished



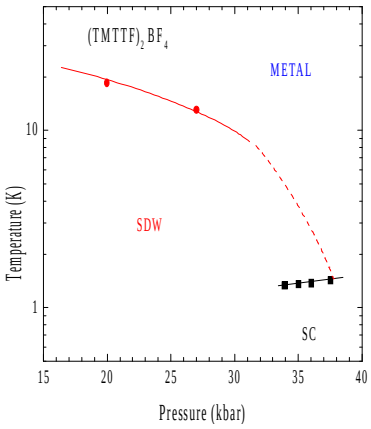
Critical pressure

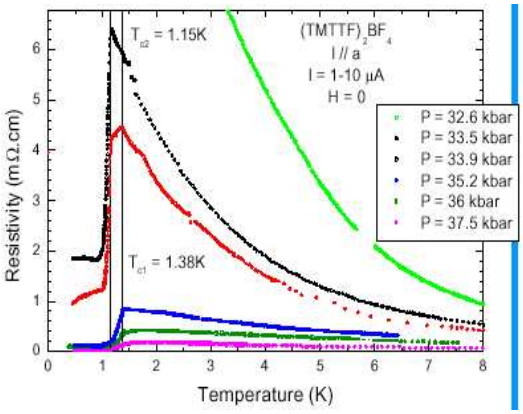


- Superconducting ribbons in a SDW background
- Josephson vortices
  Weak shielding of H//c

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

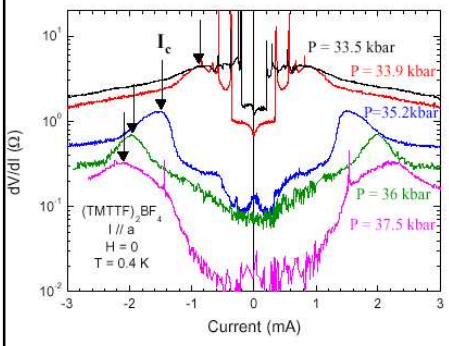
Superconductivity in $TMTTF_2BF_4$

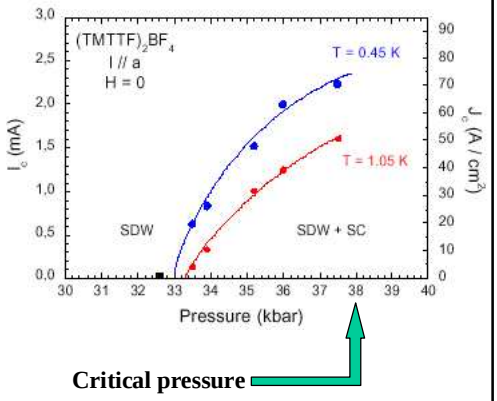




P.Auban et-al (to be published)

Critical current in the coexistence regime

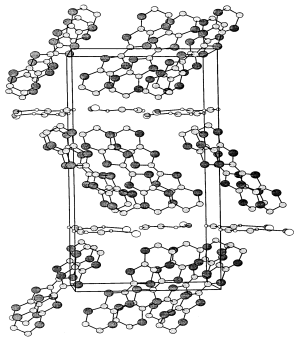


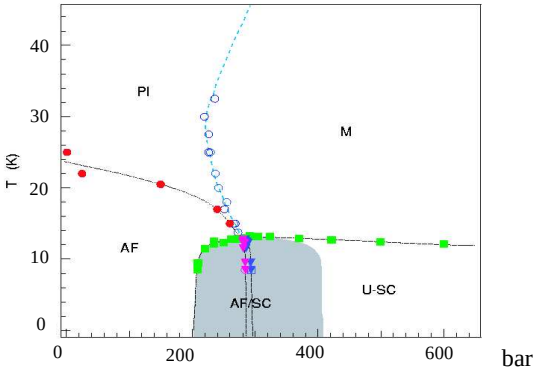


Critical pressure

κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Cl Mott transition and SC/AF coexistense

ET$_2$X family
2D superconductor
T$_c$ = 12K





S.Lefebvre et al PRL 25,5420, 2000
cond mat 0004455

SC/AF coexistence again!

Epilogue

Bechgaard salts:

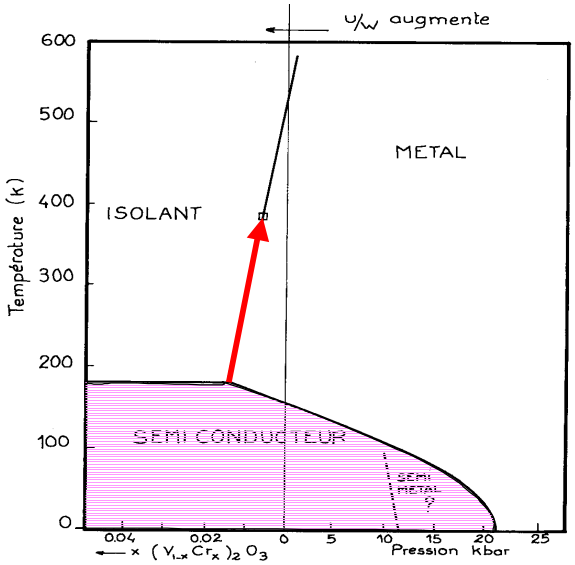
« The most interesting materials ever discovered »

Paul Chaikin

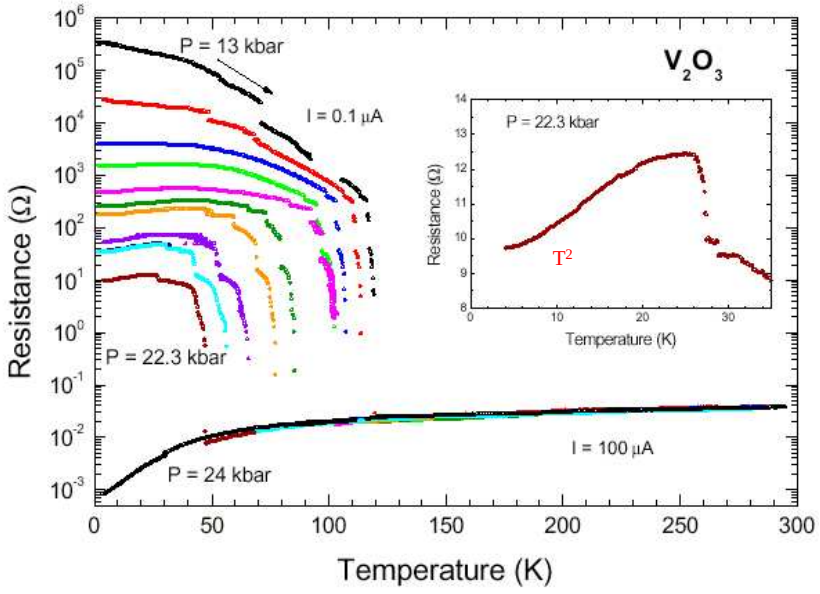
all organics are interesting !!

D.J

V2O3 series: an old prototype for the Mott transition

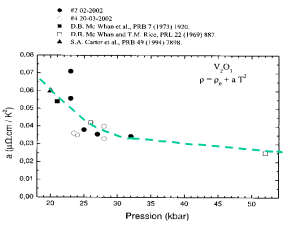


V2O3, transport near the critical pressure



P.Auban,E.Semel et-al

T² law

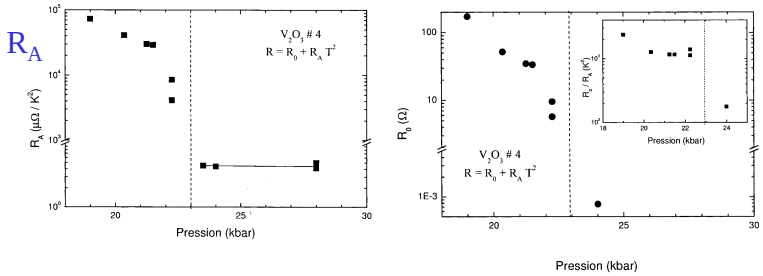


-->T² law of the resistivity in the homogenous metallic regime
-->Use the T² law to calibrate the volume fraction of metal in the inhomogenous state

$$R=R_0+R_AT^2$$

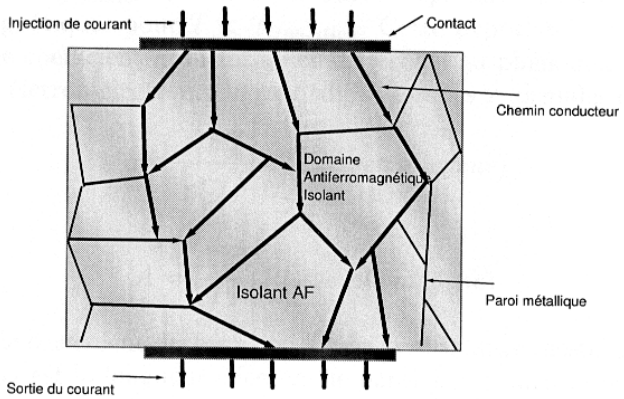
R_0

R_A

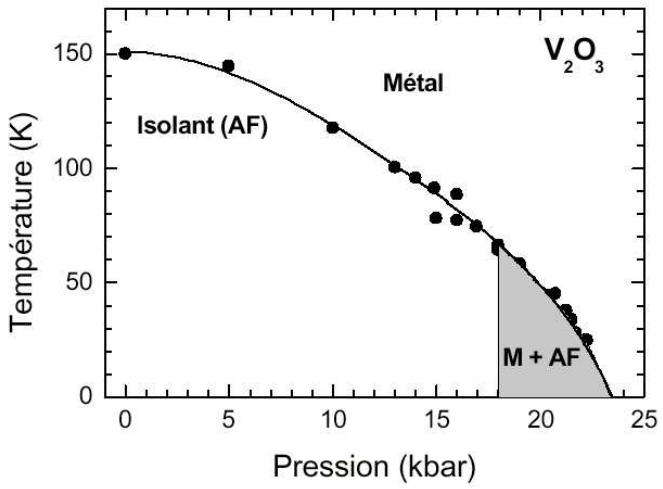


Entering the AF phase R_0 increases 6 times more than R_A

--> Thin metallic walls sensitive to impurities
--> Transport is ohmic in the inhomogenous state--> non interrupted metallic paths



V2O3, phase diagram and coexistence



Summary

Phase coexistence is clearly evidenced near P_c in TM_2X
---> be careful for the study of the superconducting properties
Stay away from the coexistence regime

Seems to be a general phenomenum
in V_2O_3
and 2D organics