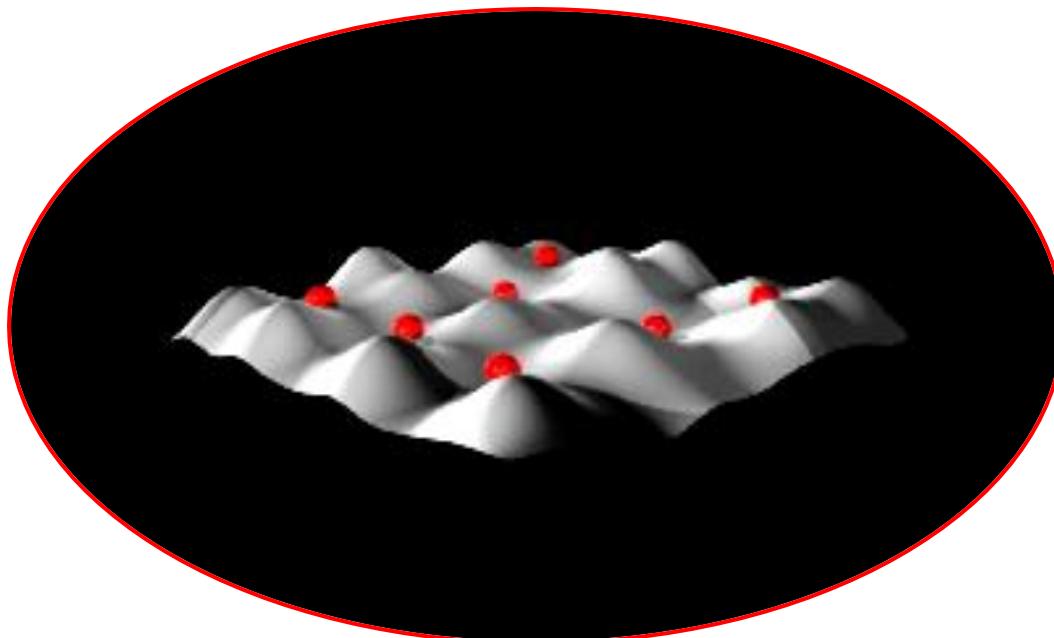


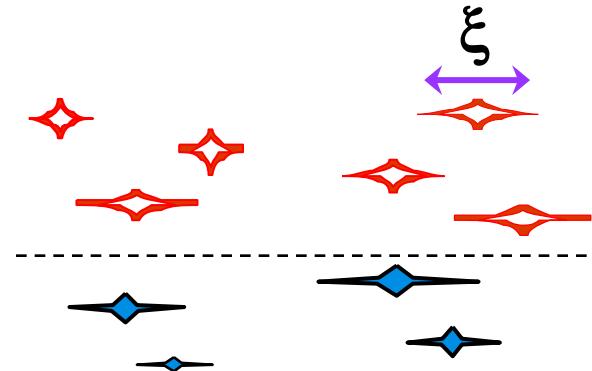
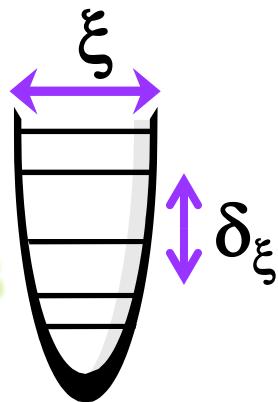
Anderson-insulators; Thermalization vs. Glassiness



Zvi Ovadyahu, Hebrew University

Anderson-insulator & Interactions

For $k_B T \ll \delta_\xi$

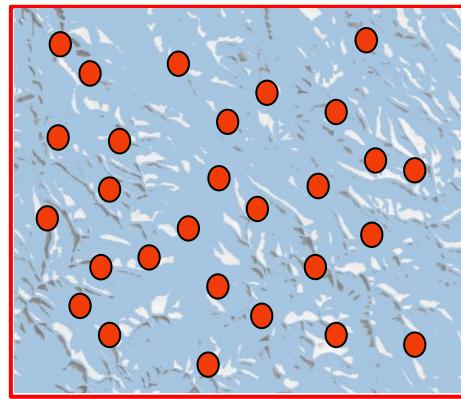


*Can electrons equilibrate **just** by e-e interaction ?*

Theory : { Short-range e-e interaction, 2D- no !
Long-range; e-e interaction, 3D - ?

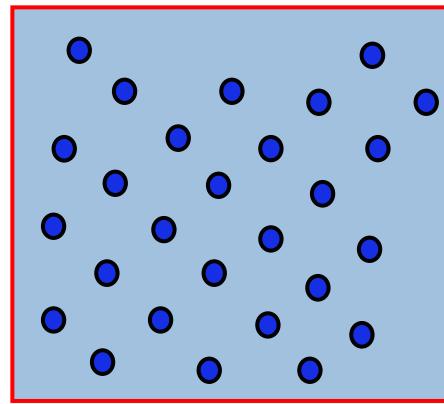
Disorder versus Interactions

disordered potential

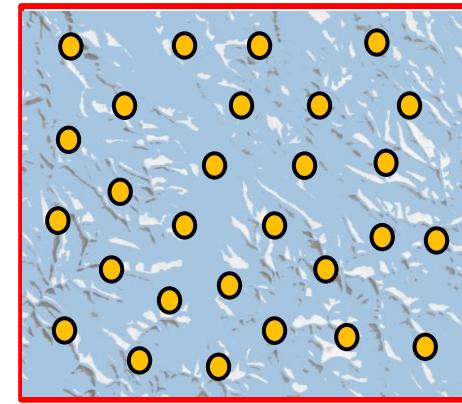


ordered potential

(+ Coulomb interaction)



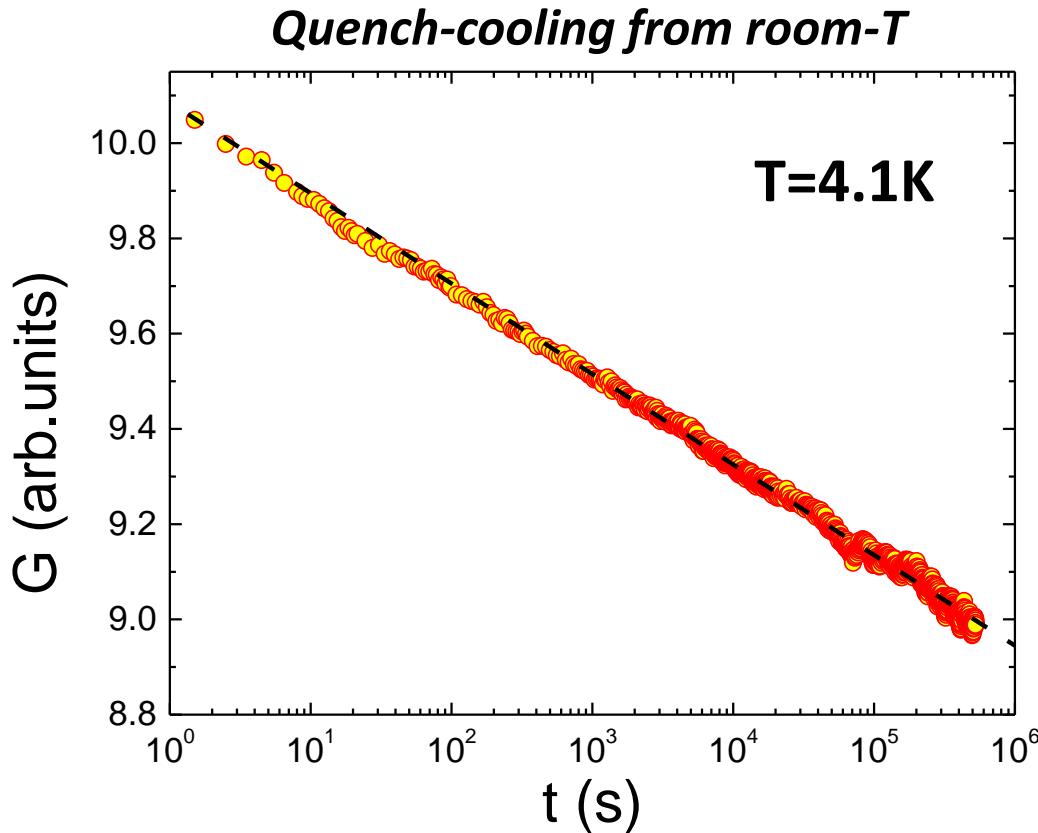
both



$$\text{wavy line} + e^2/r \equiv \text{frustration !}$$

Anderson-Insulator = Electron-Glass !

...basic feature of the electron-glass...

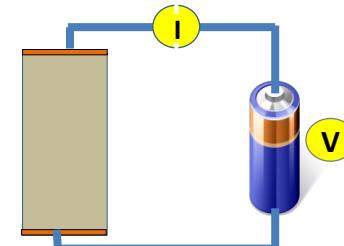


...relaxation is logarithmic;
 $G(t)=G_0-a \cdot \log(t)$

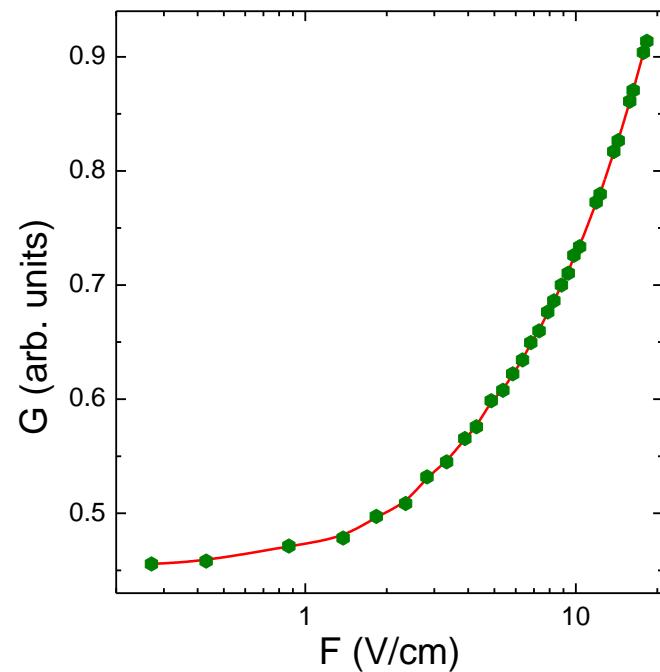
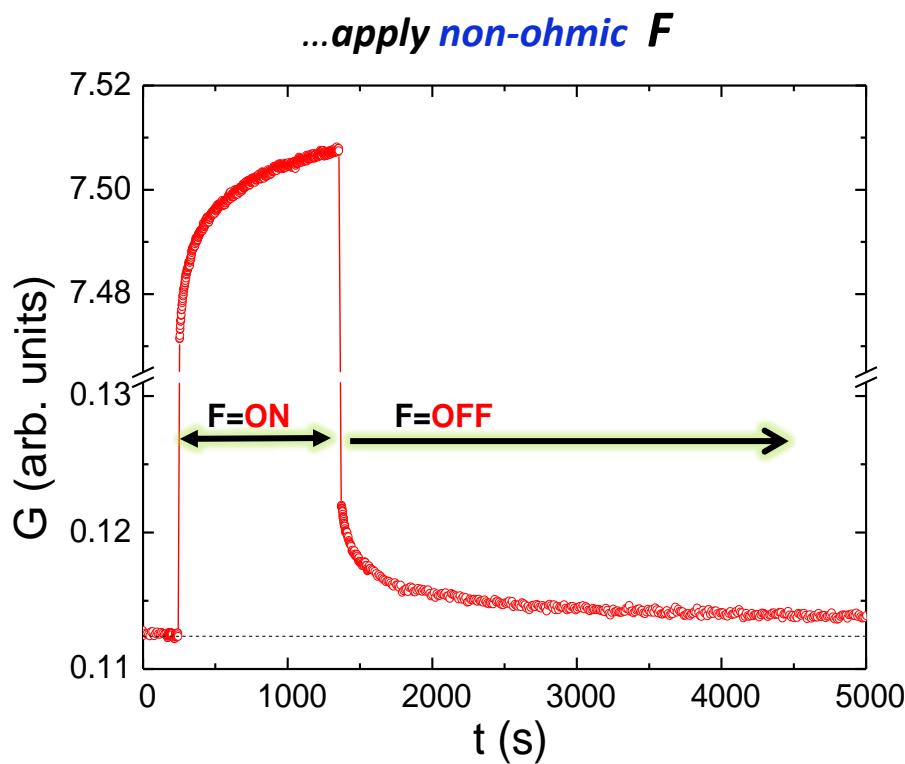
$\text{In}_2\text{O}_{3-x}$ film; $T=4.1\text{K}$
and $R_{\square} > 1 \text{ M}\Omega$

...get it out of equilibrium...

Pump energy into the system:

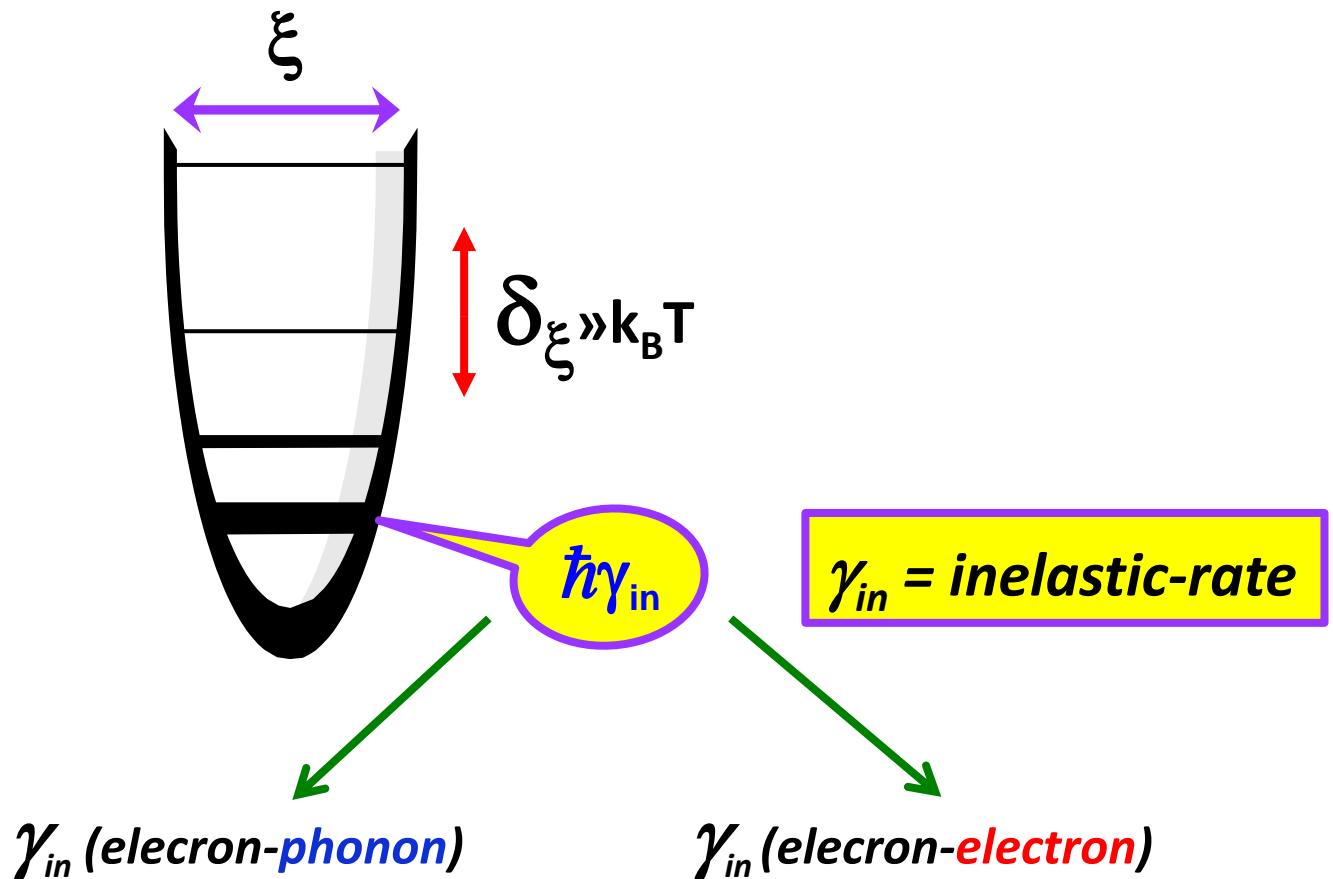


$$G=I/V$$

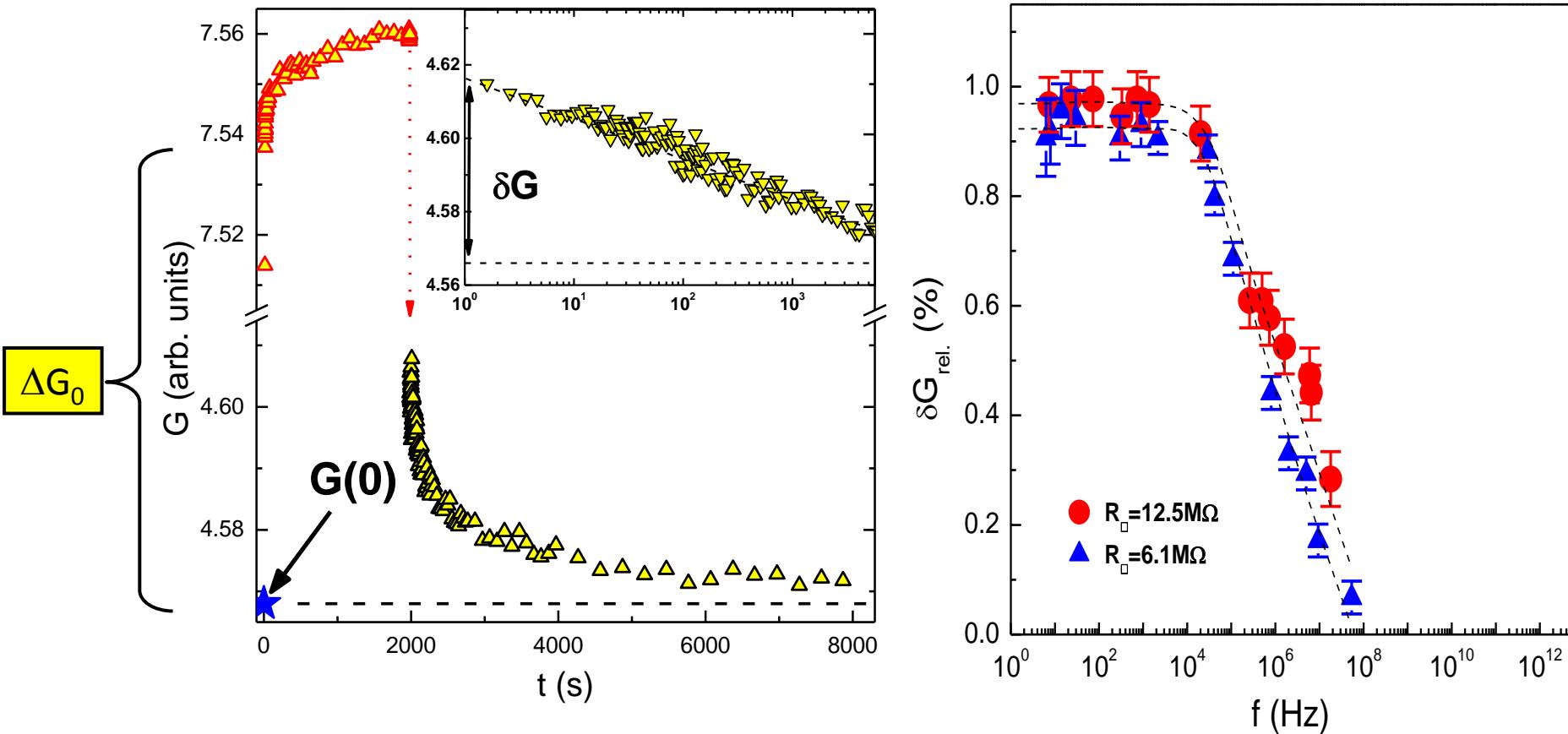


...How can a system be Joule-heated...

...if it has a **discrete** spectrum?



...absorption measured via transport...



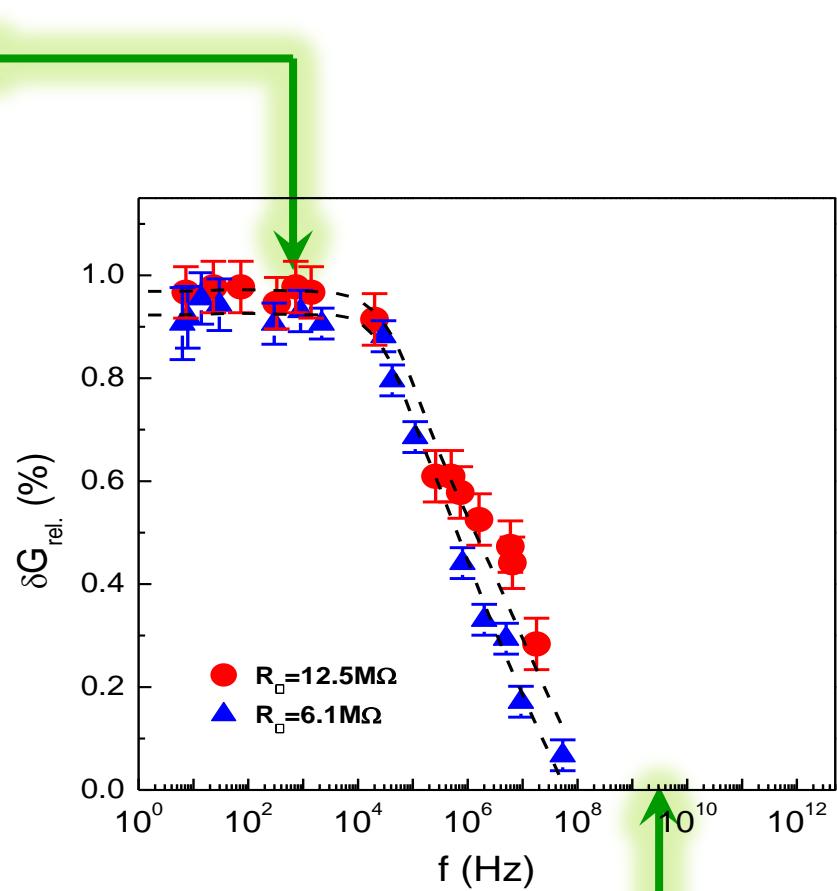
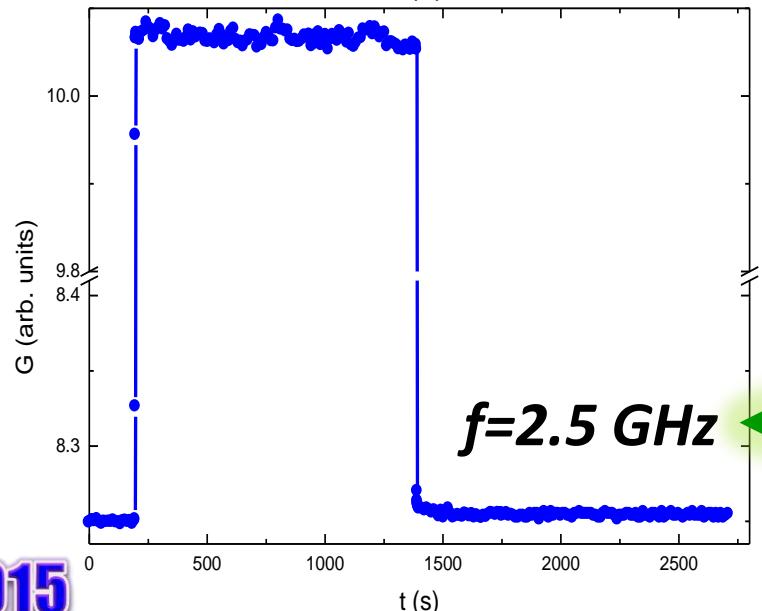
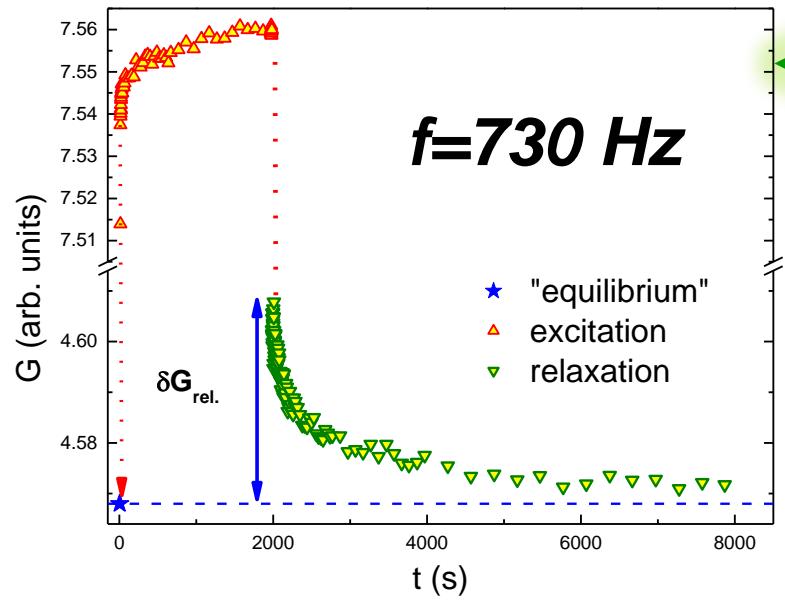
ΔG_0 is the **same** for all f

...and F is kept for the **same** time for all f

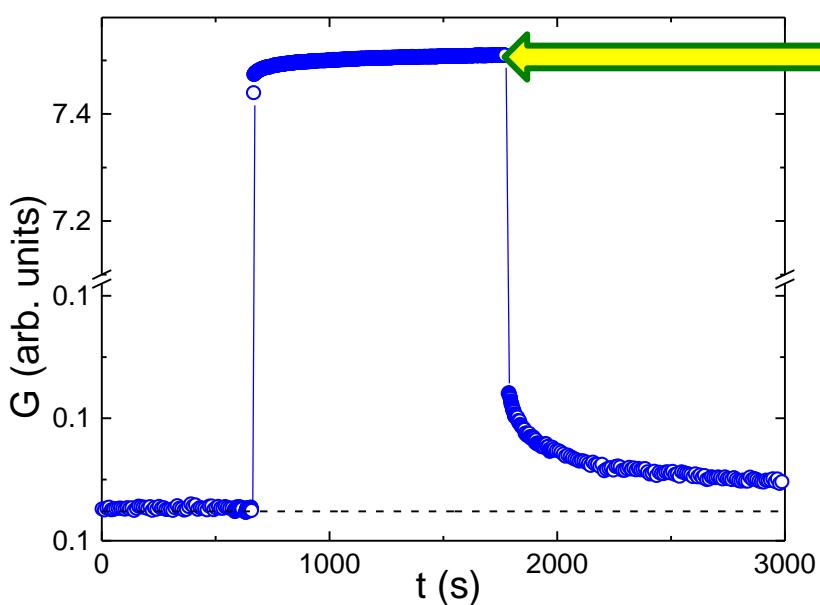
... $\delta G_{\text{rel}} = \delta G/G(0)$ is **NOT**...

...no absorption at high f !!

...it is small in the microwaves regime...



...roll-off frequency \approx rate of “heat” removal...

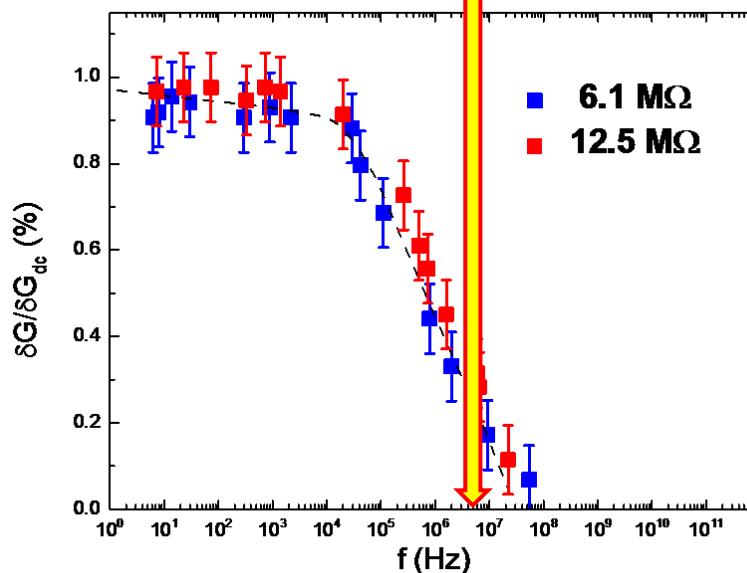


$$G(V) \cdot V^2 = C_{el}(T^*) \cdot (T^* - T_{bath}) \cdot \gamma(T^*)$$

C_{el} = electronic heat-capacity

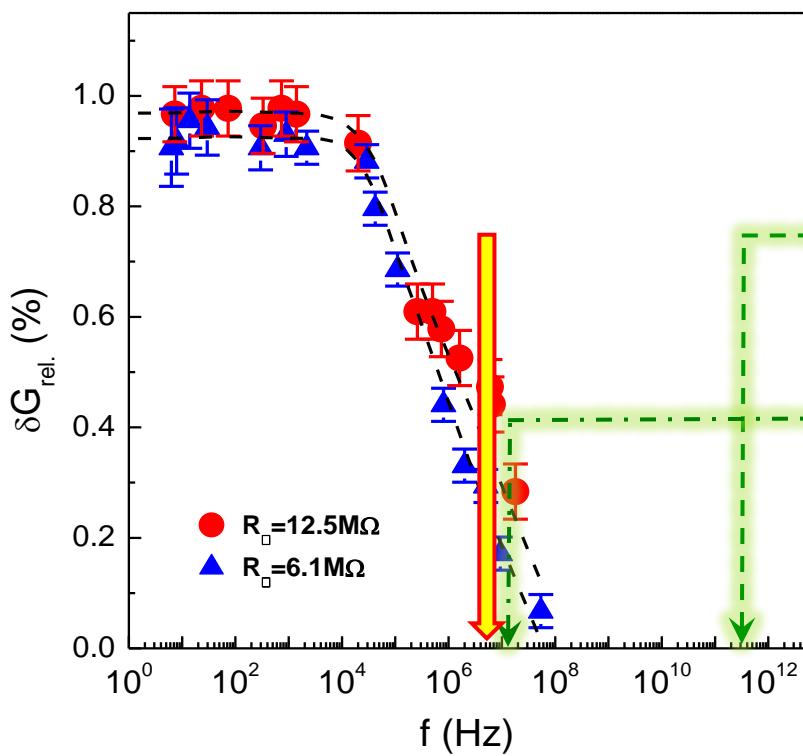
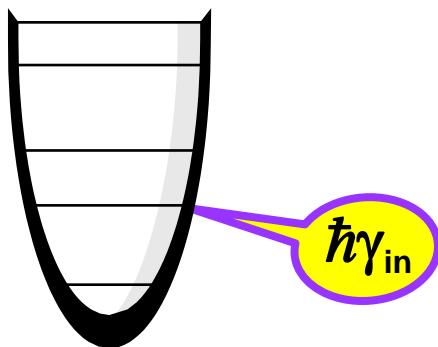
T^* = effective temp.

$\gamma(T^*)$ = rate heat is removed
from the system

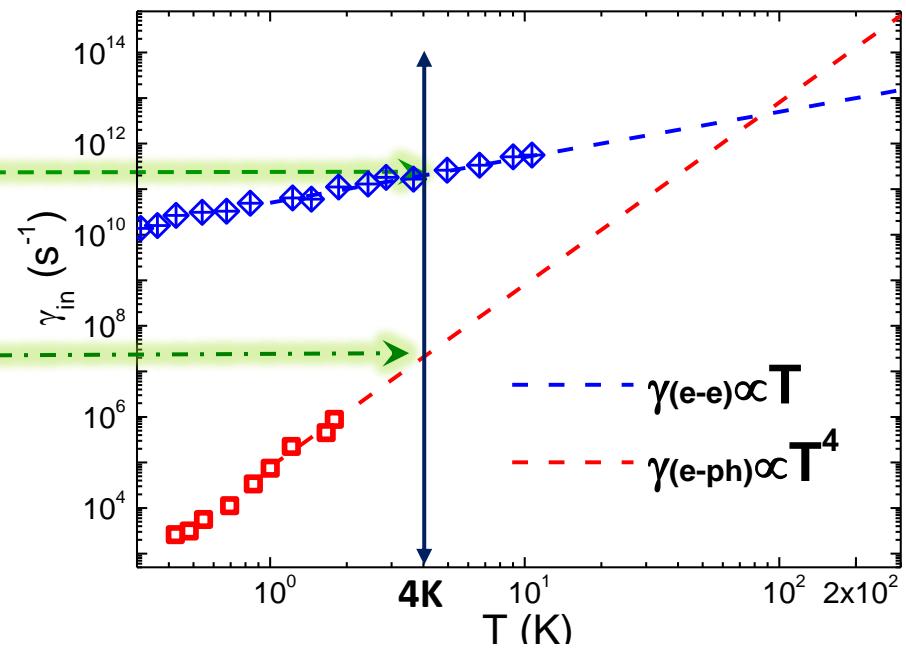


γ_{in} is due to e-ph...

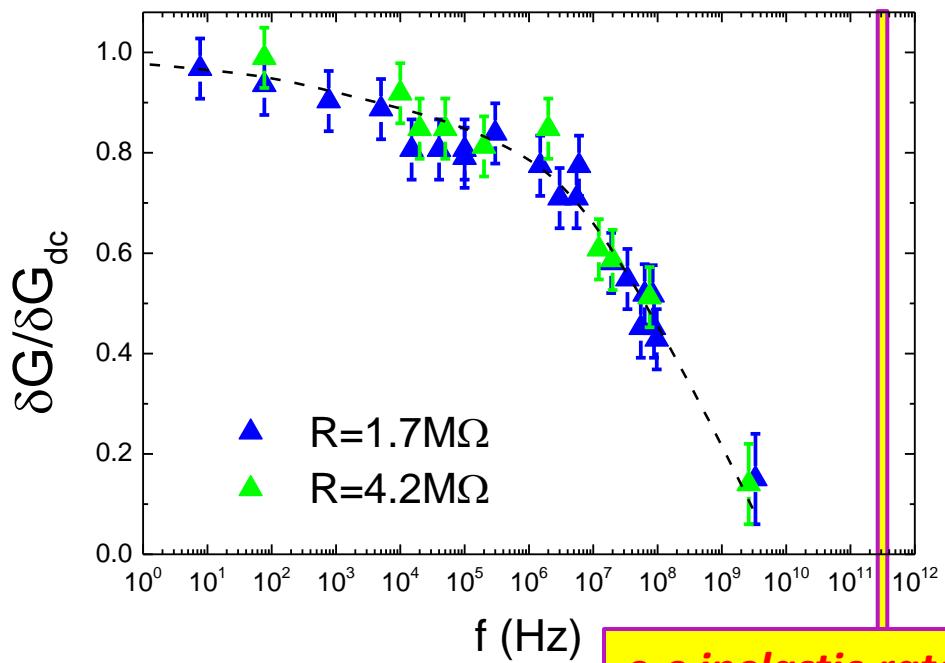
...compared with γ_{in} in the diffusive regime...



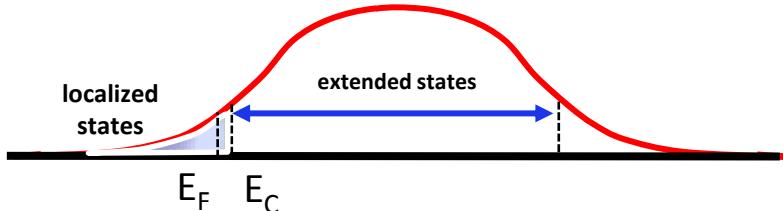
*In the diffusive regime ($R \approx 3k\Omega$)
of the same system, and
at the same temperature ($\approx 4\text{K}$):*



...is 3D different ?

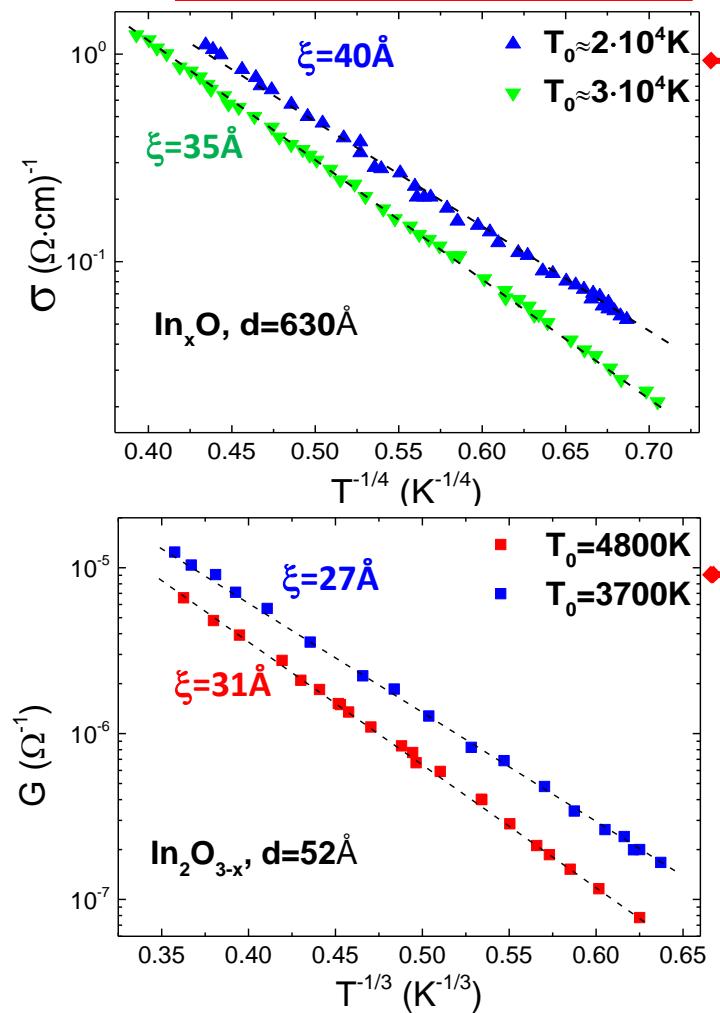


...but E_{int} might be...



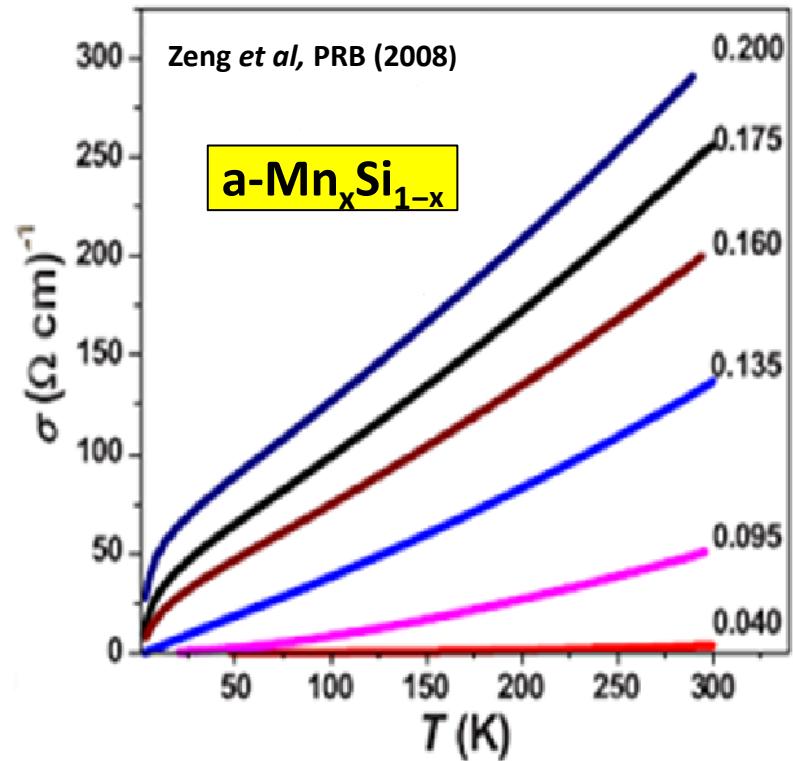
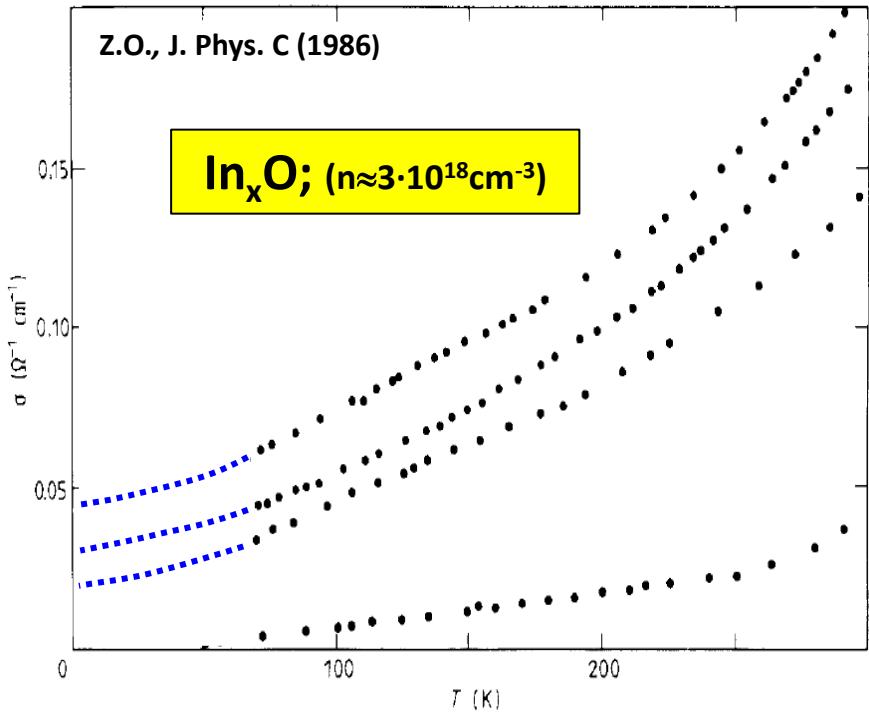
$$E_{int} \geq E_C - E_F$$

$$\sigma(T) \propto \exp\left(-\left(\frac{T_0}{T}\right)^{1/(D+1)}\right)$$



$$E_{int} \approx \frac{e^2}{\varepsilon \cdot r} \approx 200 \text{ K} \ll T_0 \approx \delta_\xi$$

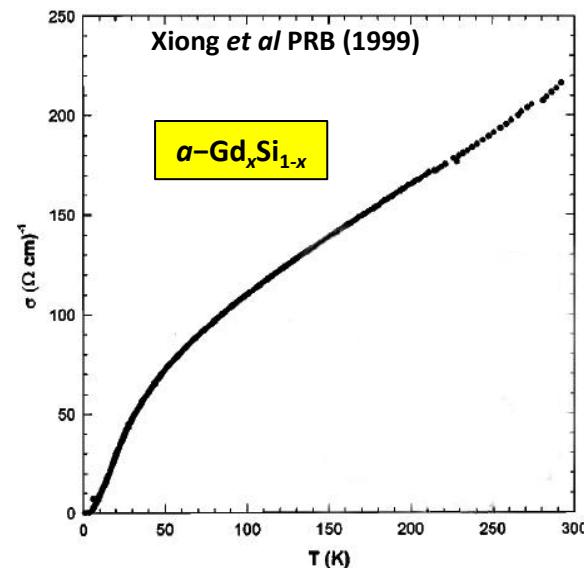
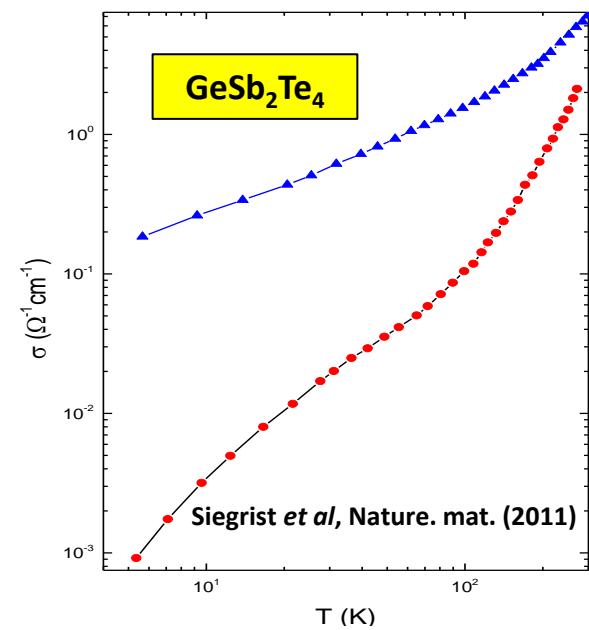
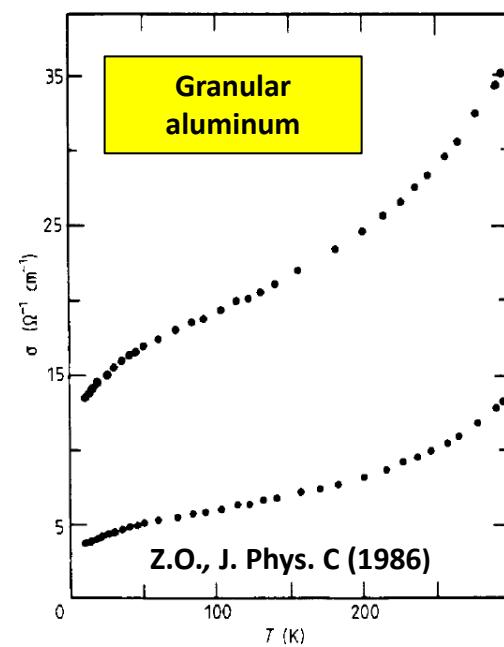
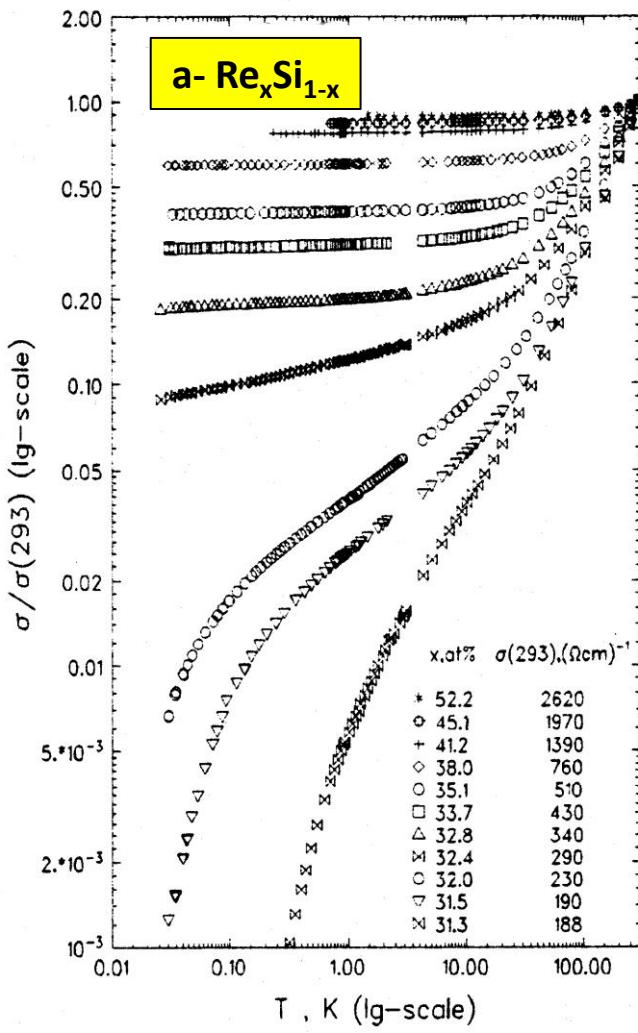
...G(T) peculiarities...



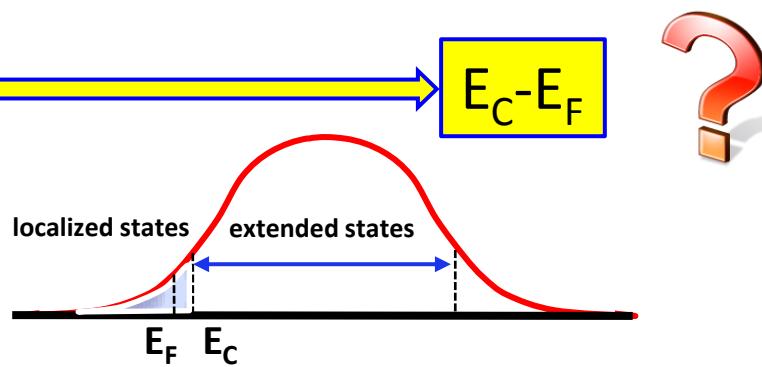
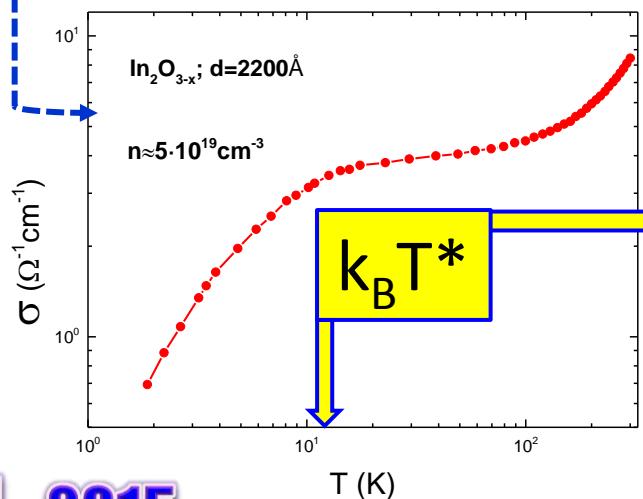
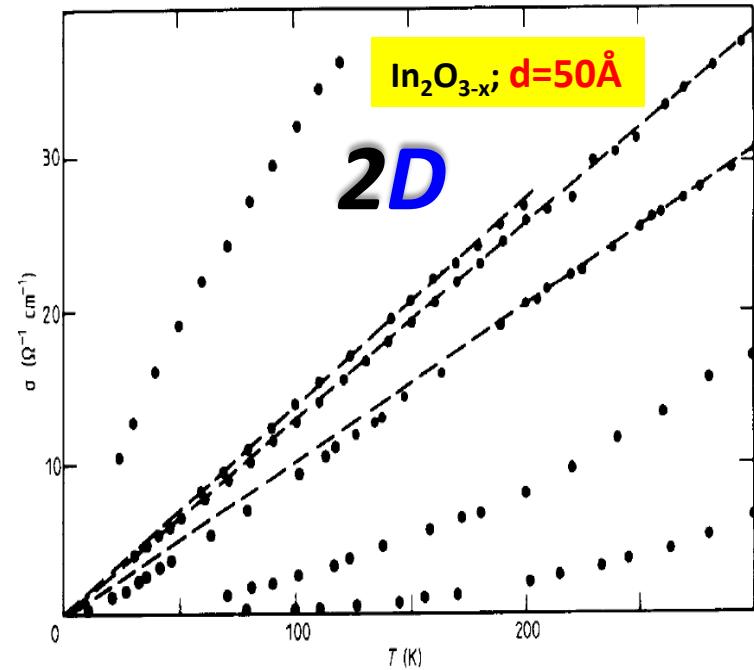
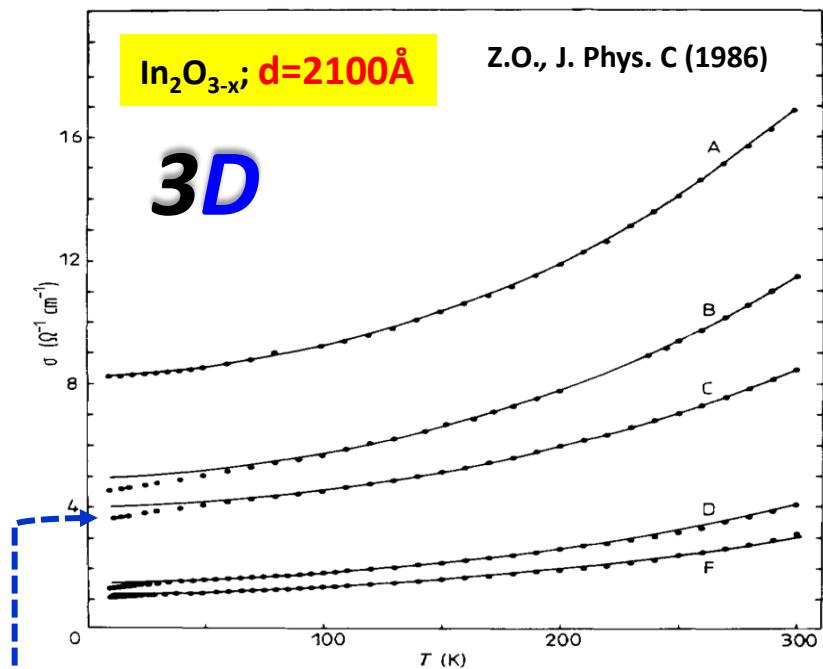
The T^ - problem:*

insulating samples exhibit metallic G(T) (for $T > T^$)*

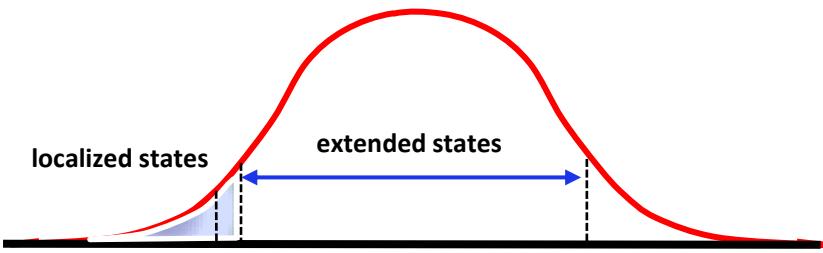
...more “T*- problem”...



...and one more...



...which mobility-edge?...

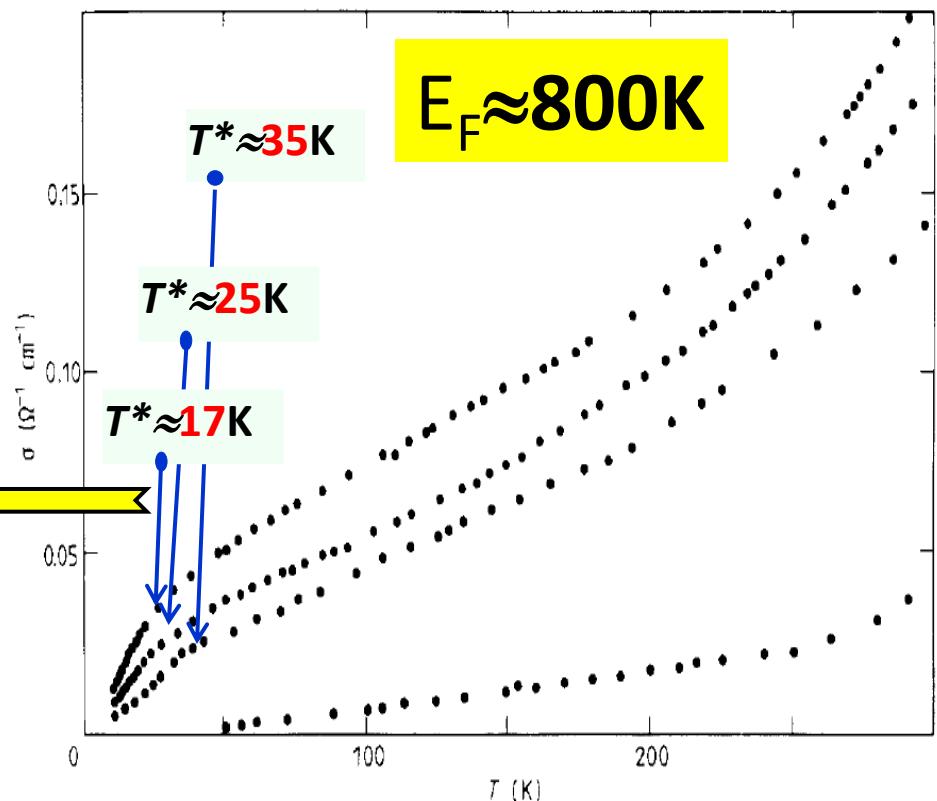


$$\Delta E \equiv E_C - E_F = E^* \cdot (1 - g/g_C)$$

non-interacting mobility edge:

$$E^* \approx E_F$$

$$E^* \approx 70\text{K} \ll E_F$$



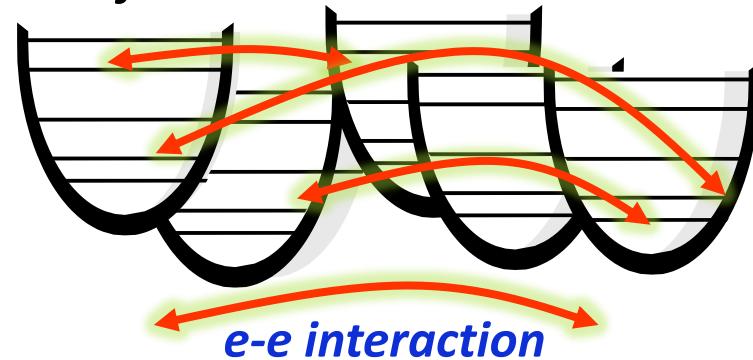
Summary:

for $k_B T \ll \delta_\xi$ in 2D and 3D:

$\gamma_{in}^{e-e}, \gamma_{in}^{e-ph}$ are **suppressed** (relative to the diffusive regime)

Conductivity and thermalization hinge on phonons

*...tested for a **realistic** interaction...*



*...‘de-localization’ in 3D:
Hybridization ?
Many-body effect ?*



MBL, 2015