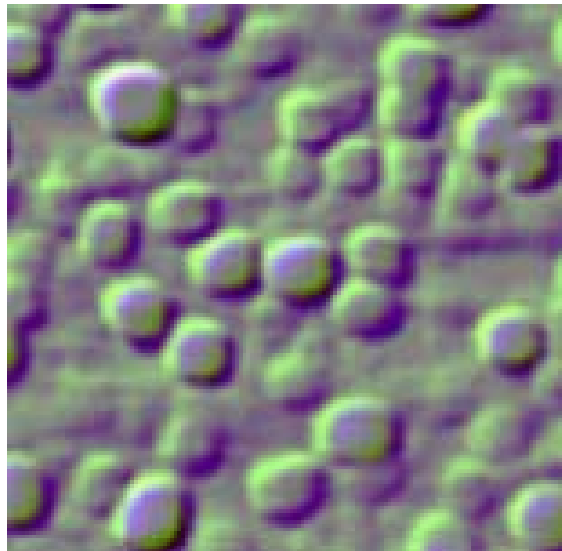


Ferromagnetic electron glasses

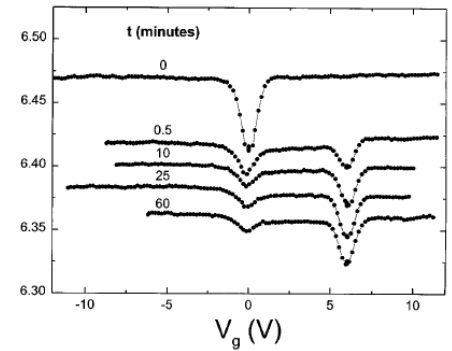
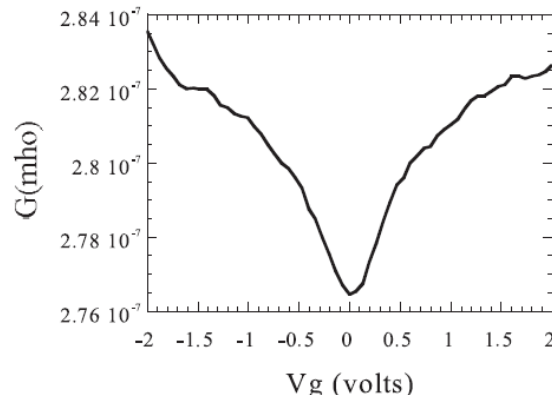
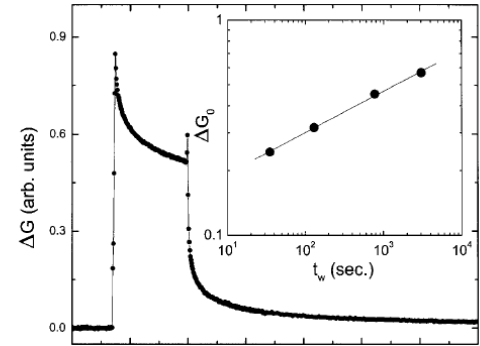
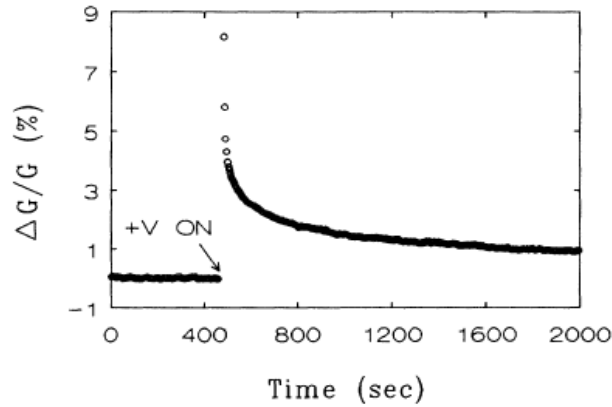
Ariel Eisenbach and Aviad Frydman
Bar Ilan University



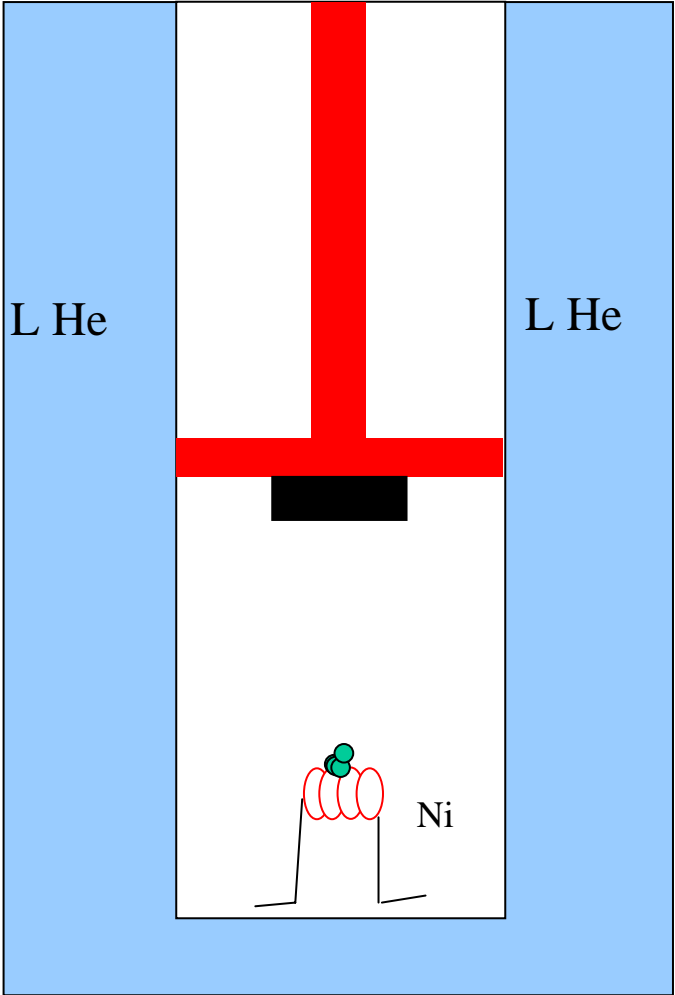
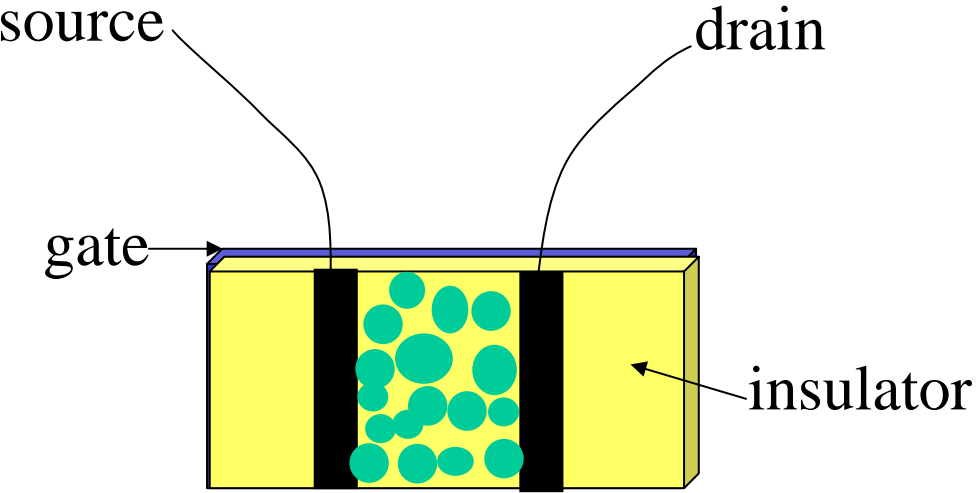
Electron Glasses

- ★ InO
- ★ In₂O_{3-x}
- ★ Granular Al
- Granular Au
- Pb
- Bi
- Be

Granular Ni



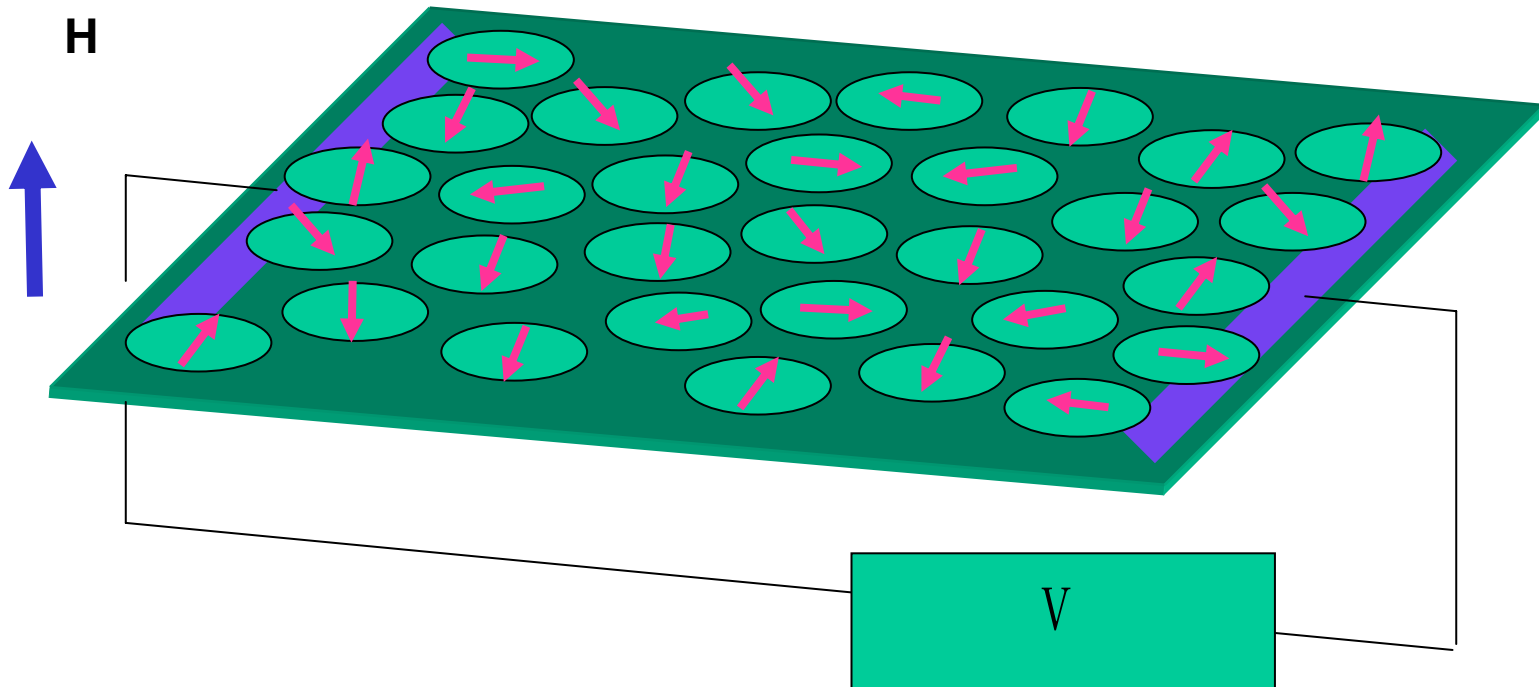
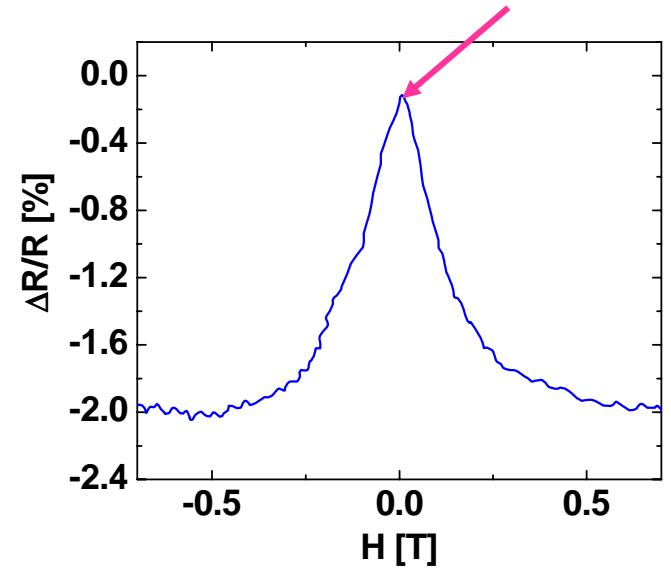
Quench Condensation



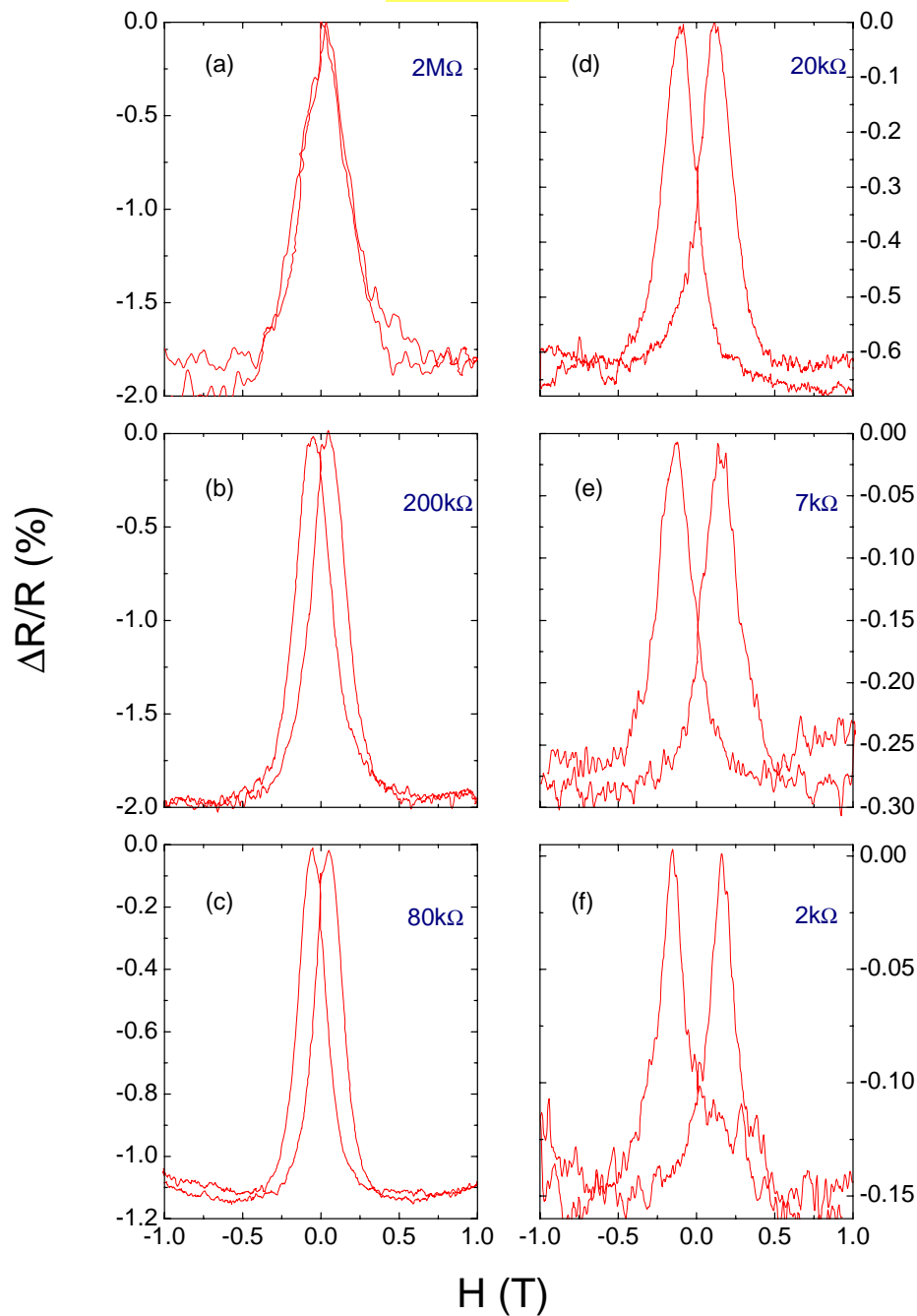
Magnetoresistance of granular ferromagnets

$$\frac{\Delta R_{ij}}{R_{ij}} = \frac{1 + P^2 \cos \theta_{ij}}{1 + P^2} - 1$$

Slonczewski, PRB, 1989.

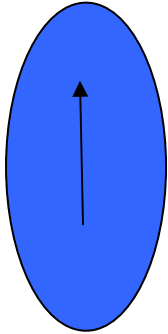


T=4k

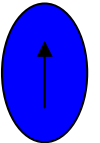


superparamagnetism

$$k_B T < KV$$



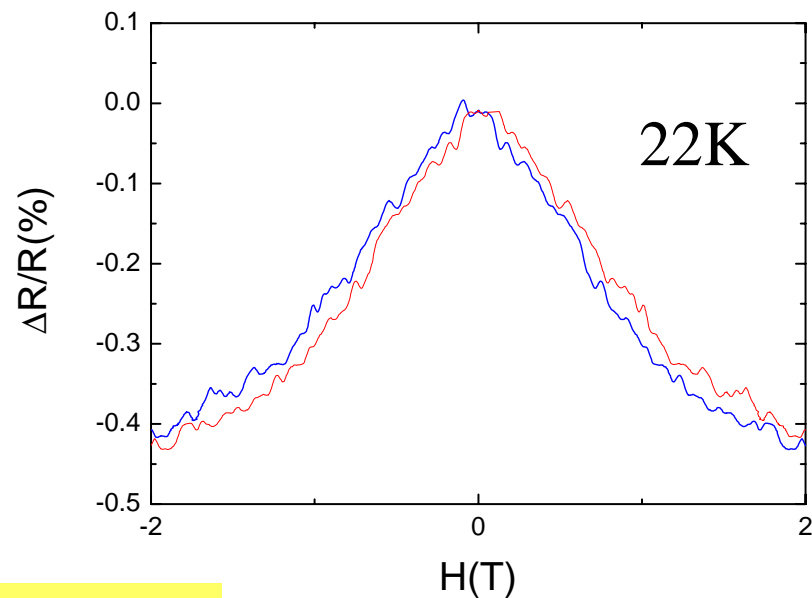
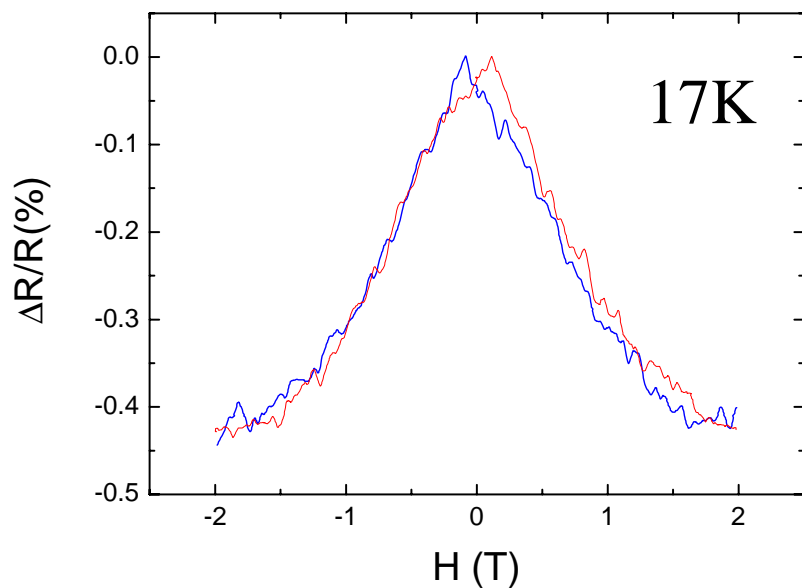
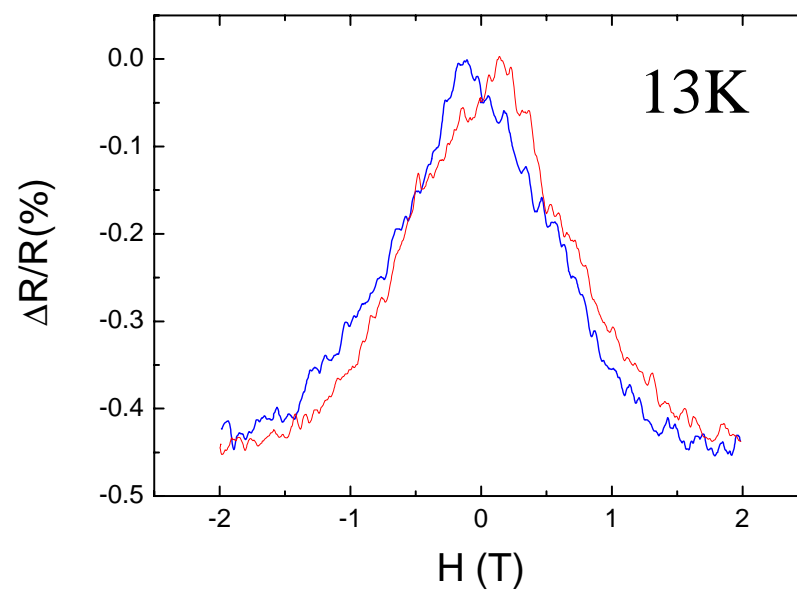
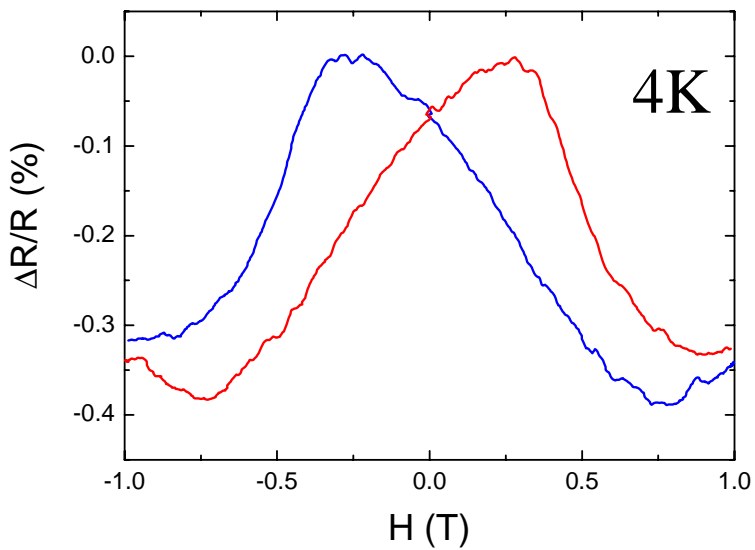
$$k_B T > KV$$



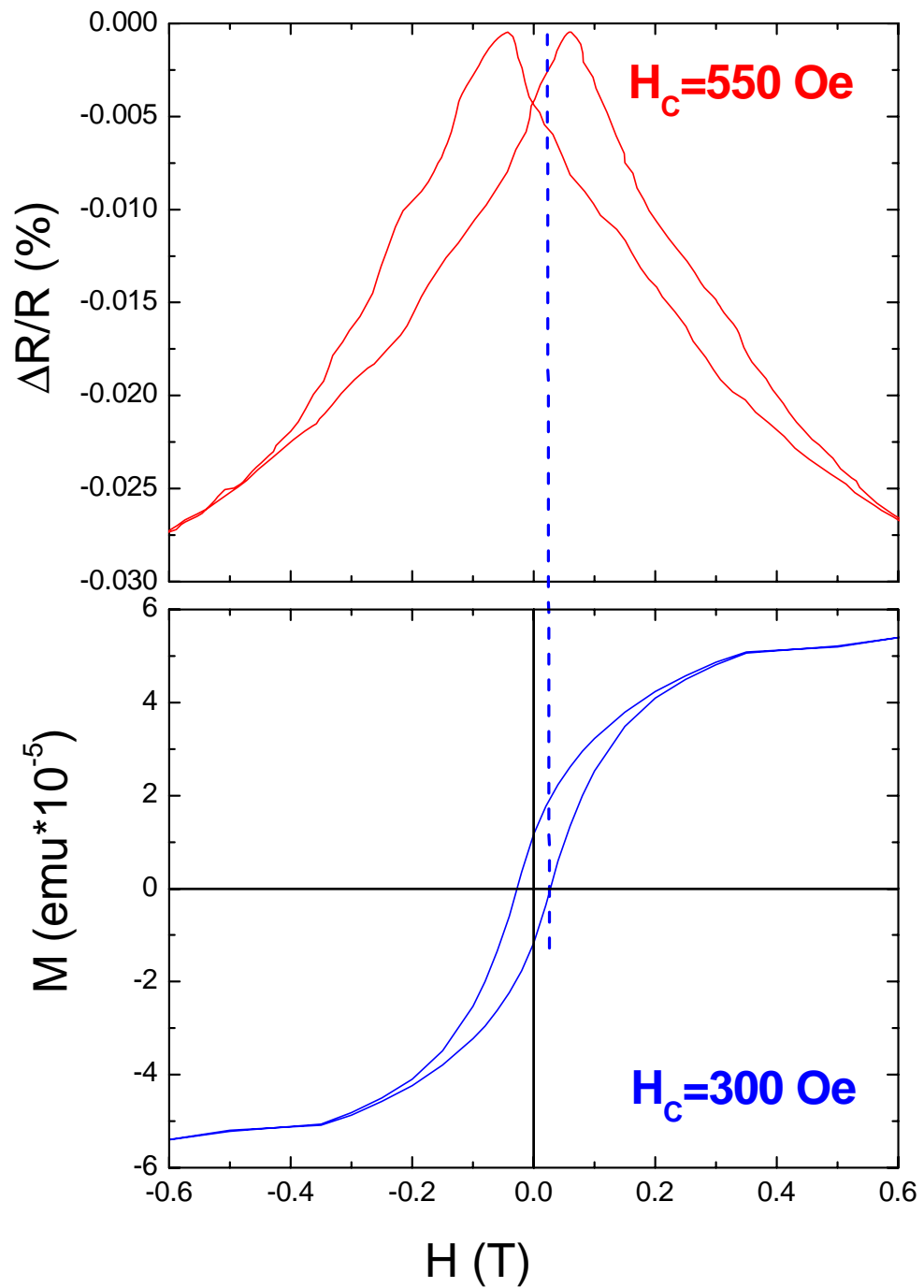
$$T_B = \frac{KV}{C \cdot k_B}$$

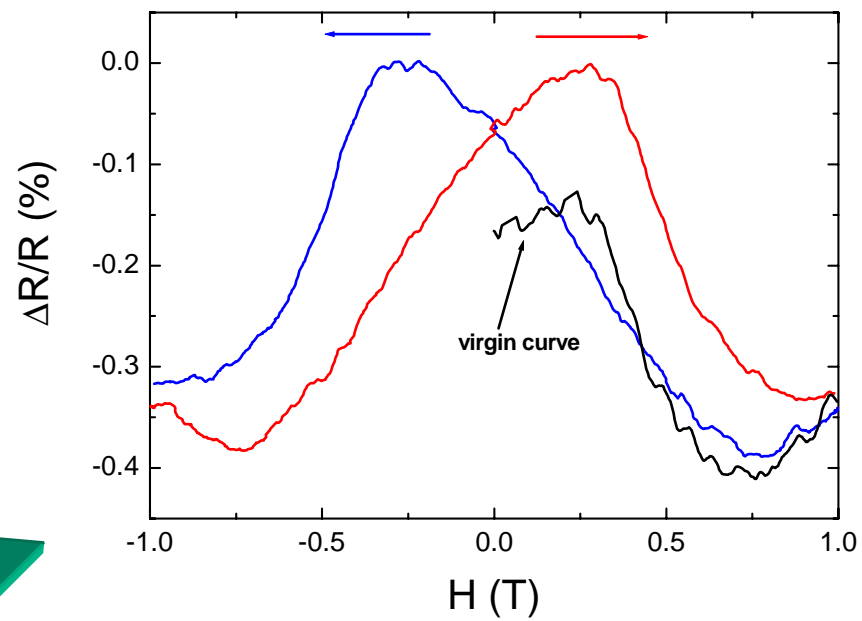
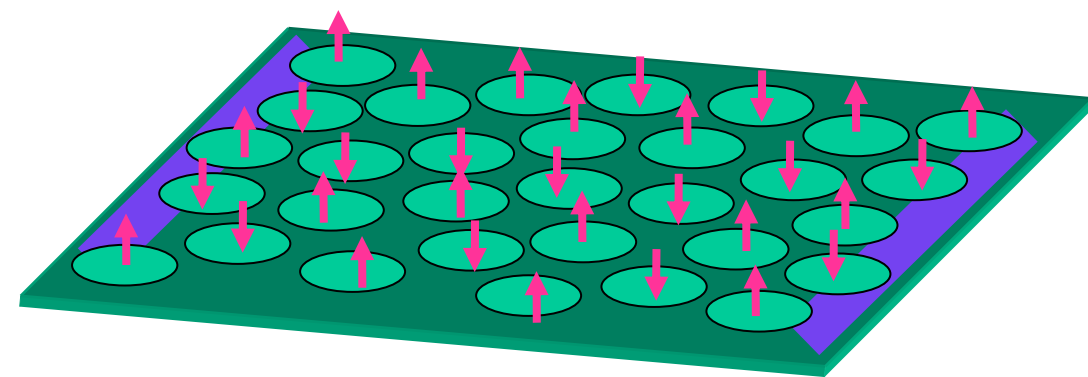
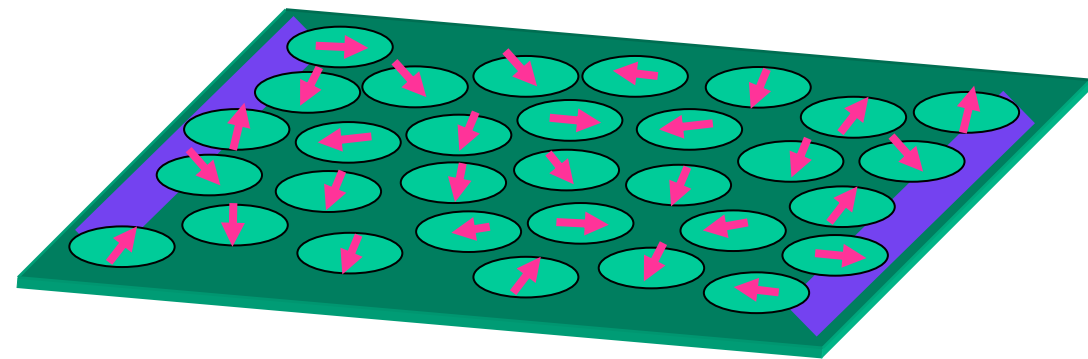
$$\tau \propto \exp\left(\frac{KV}{k_B T}\right)$$

Temperature dependence

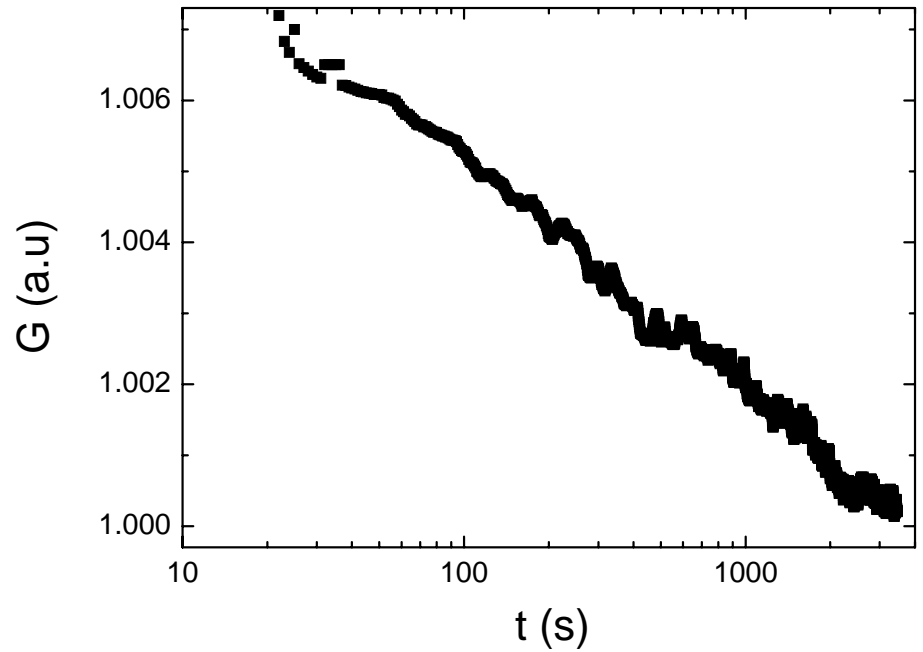
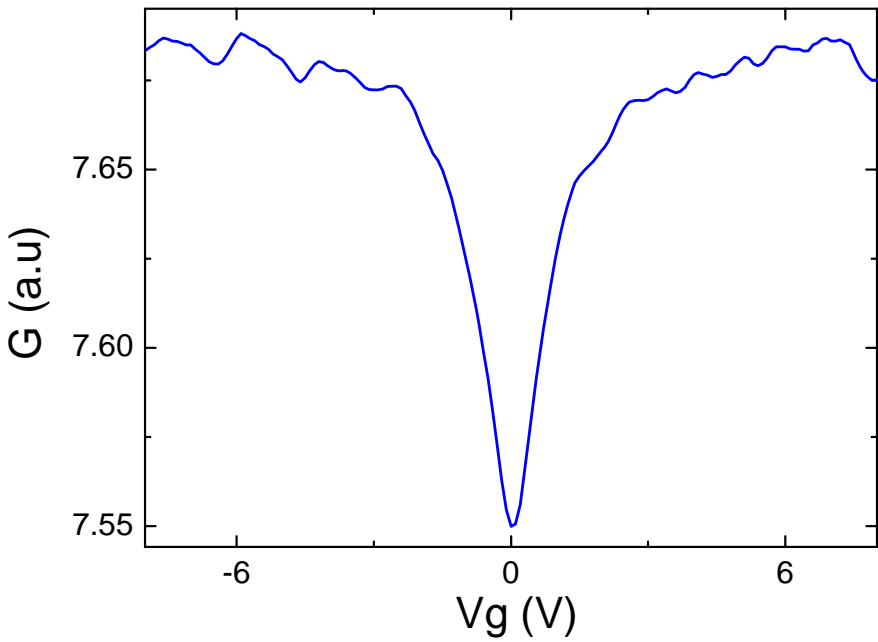


$T_B \approx 22K$



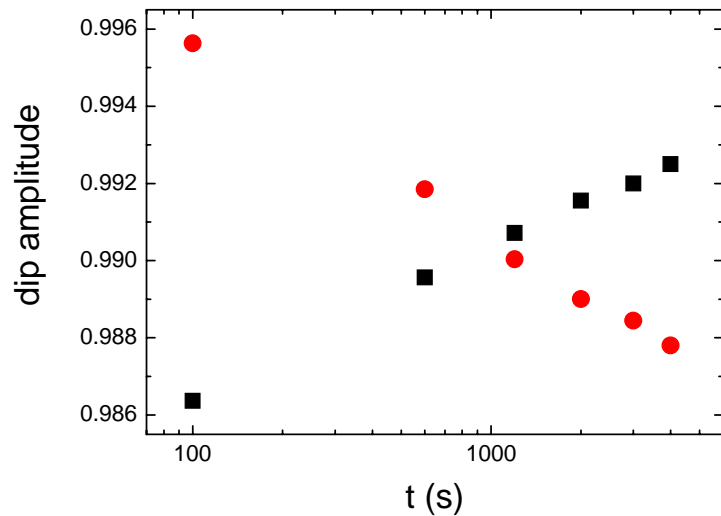
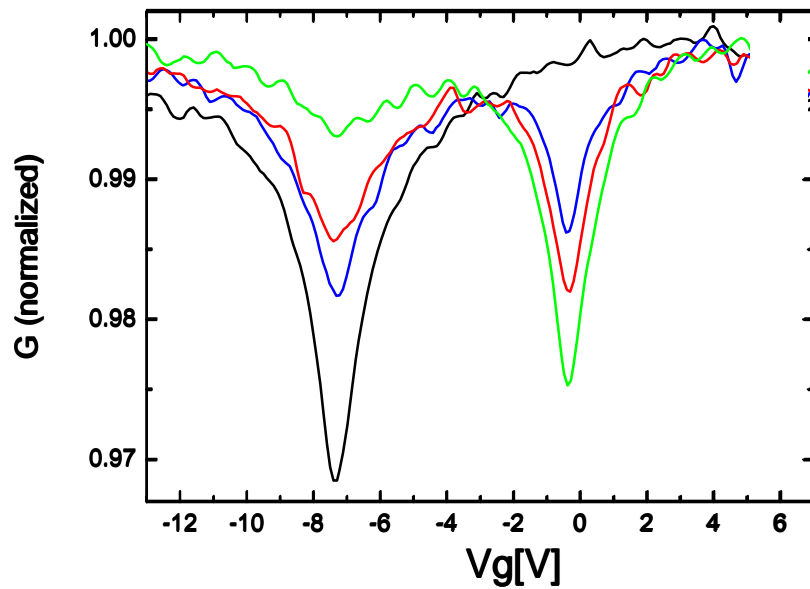
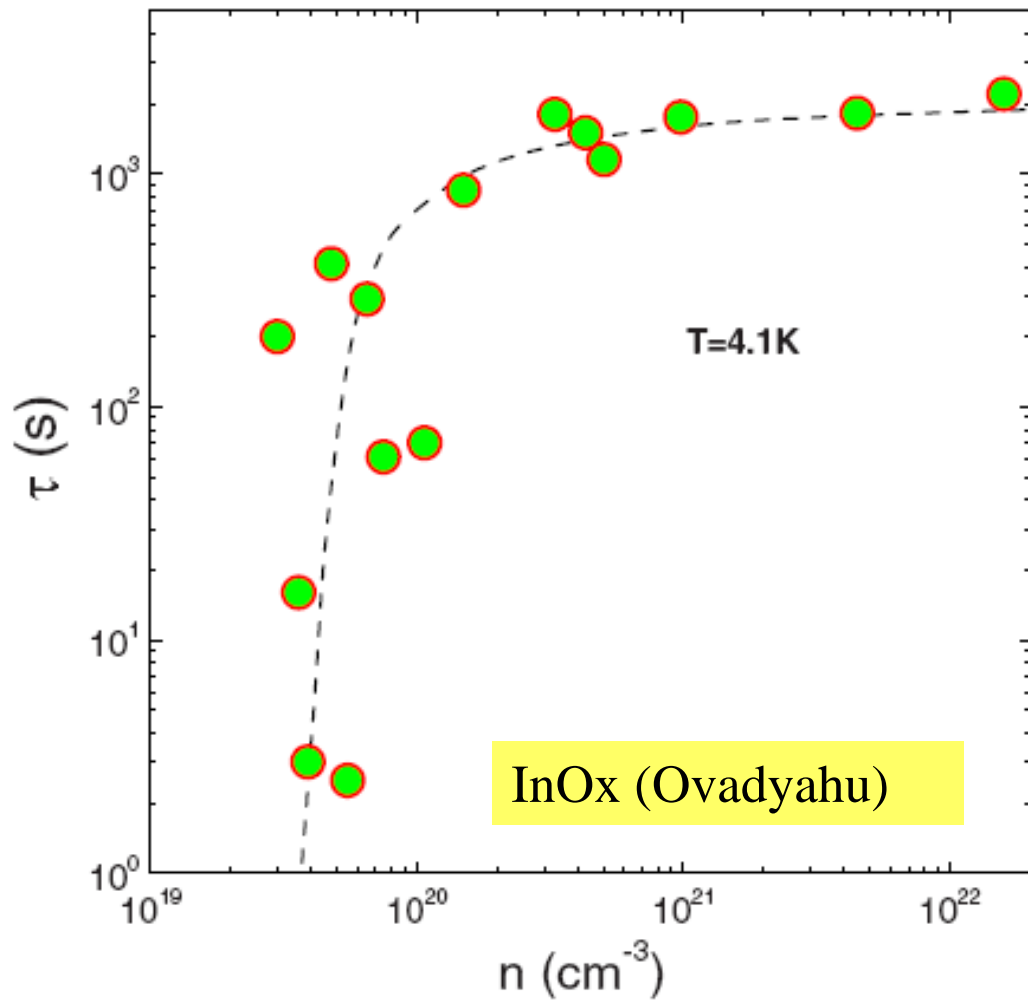


Glassy behavior

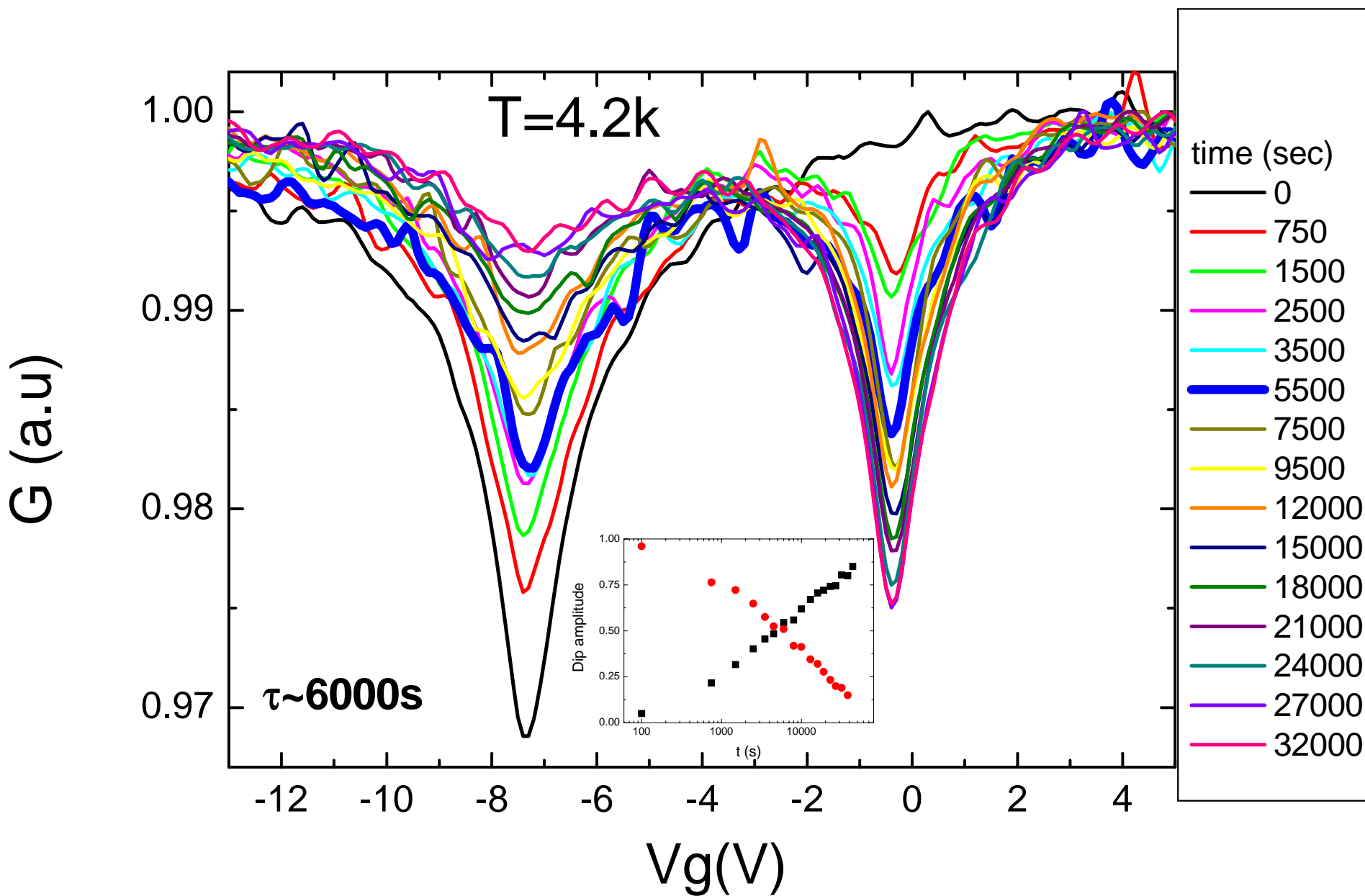


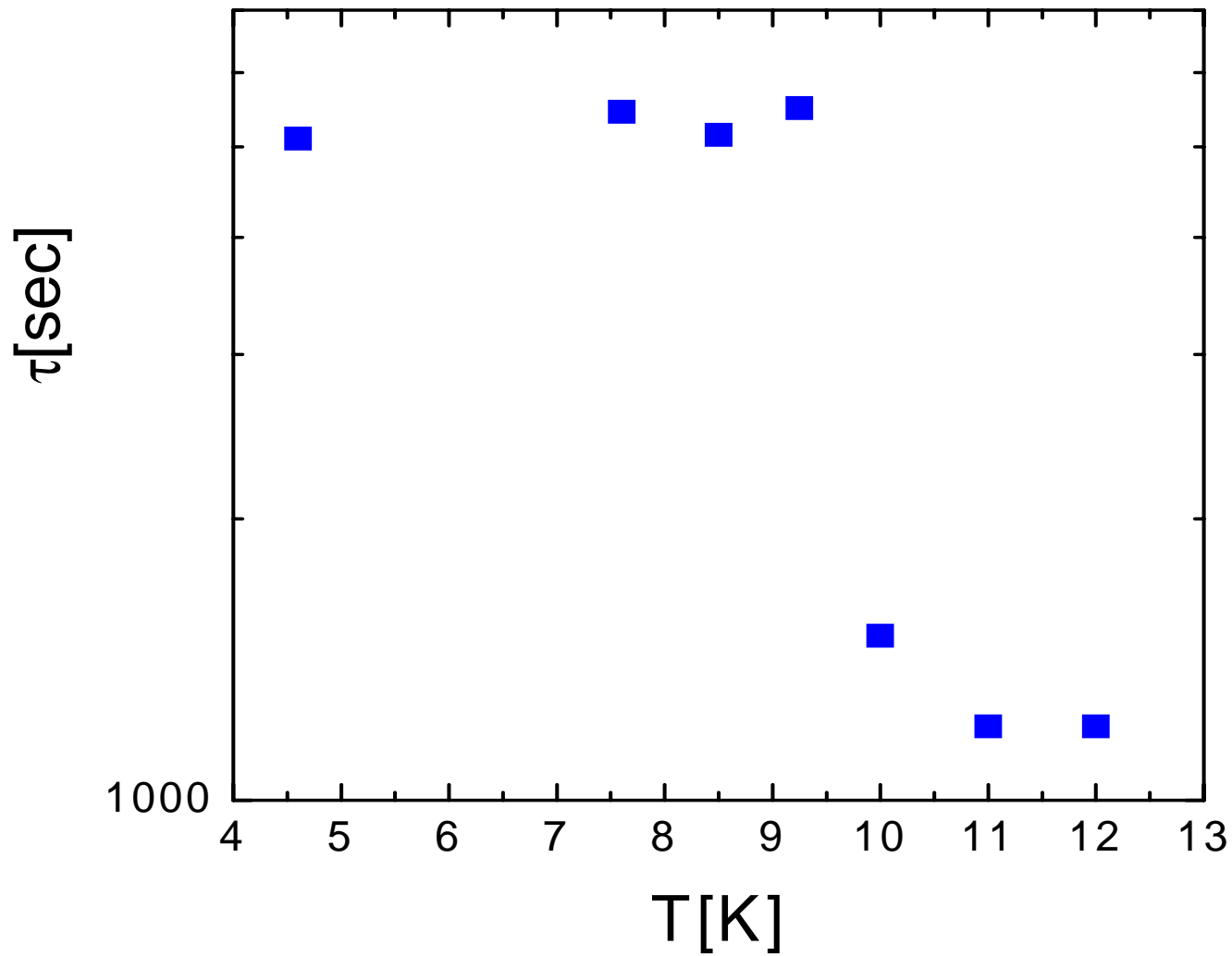
$\tau?$

τ_{2_dip}

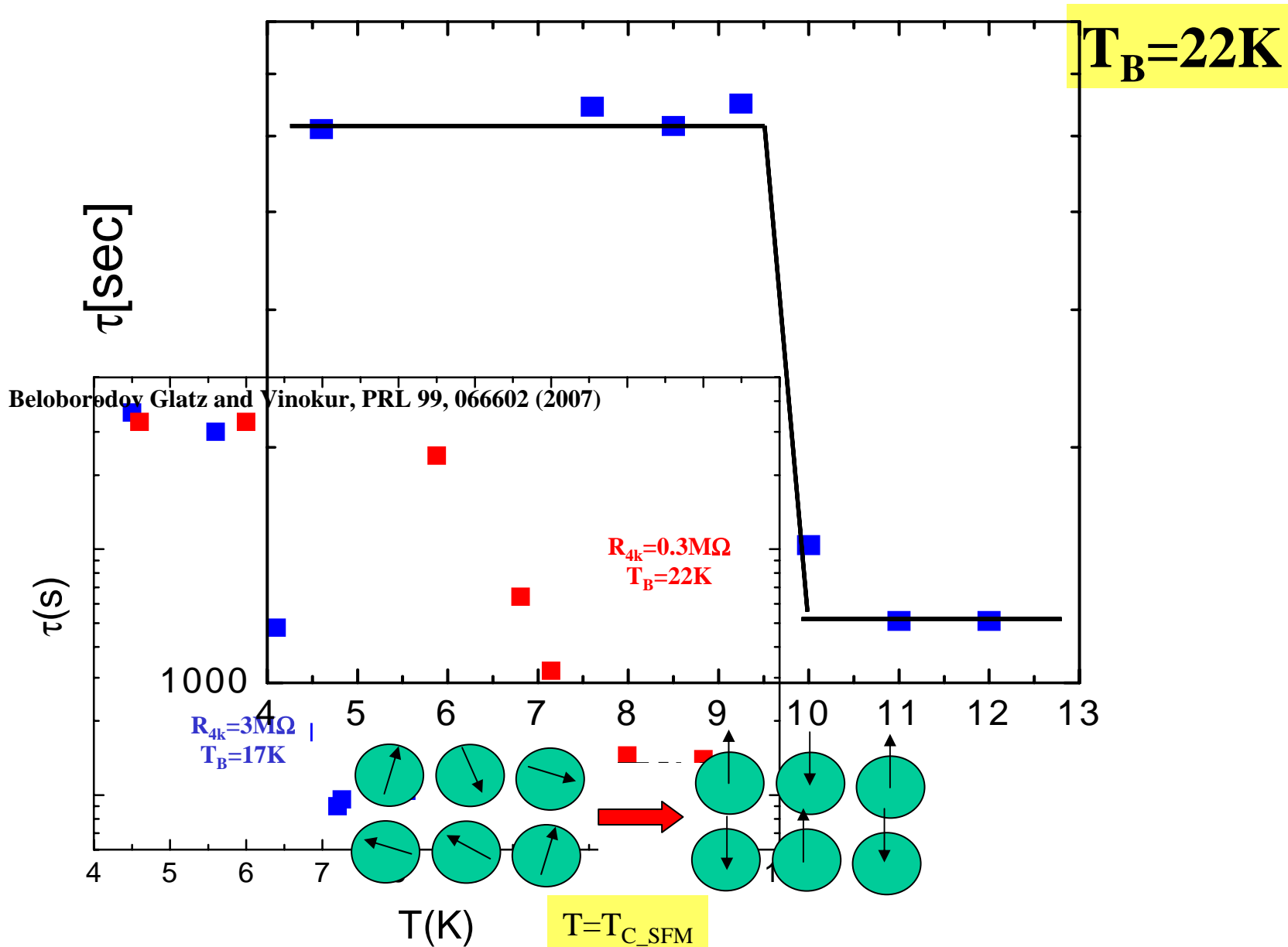


Low T

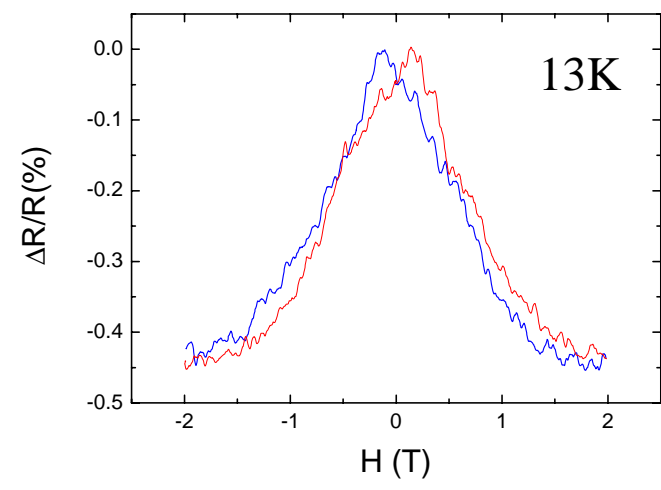
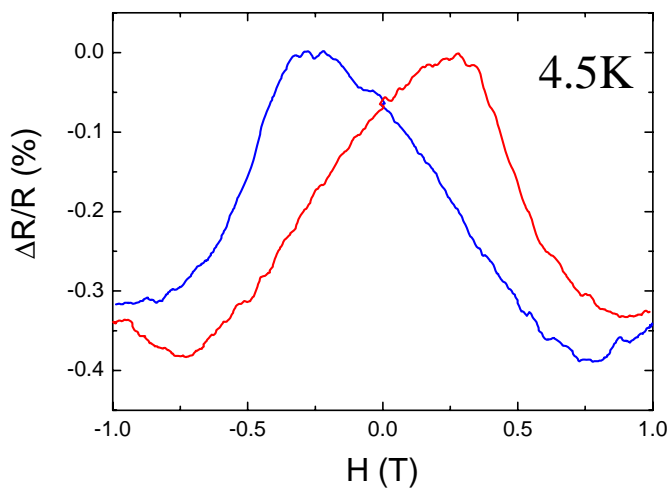
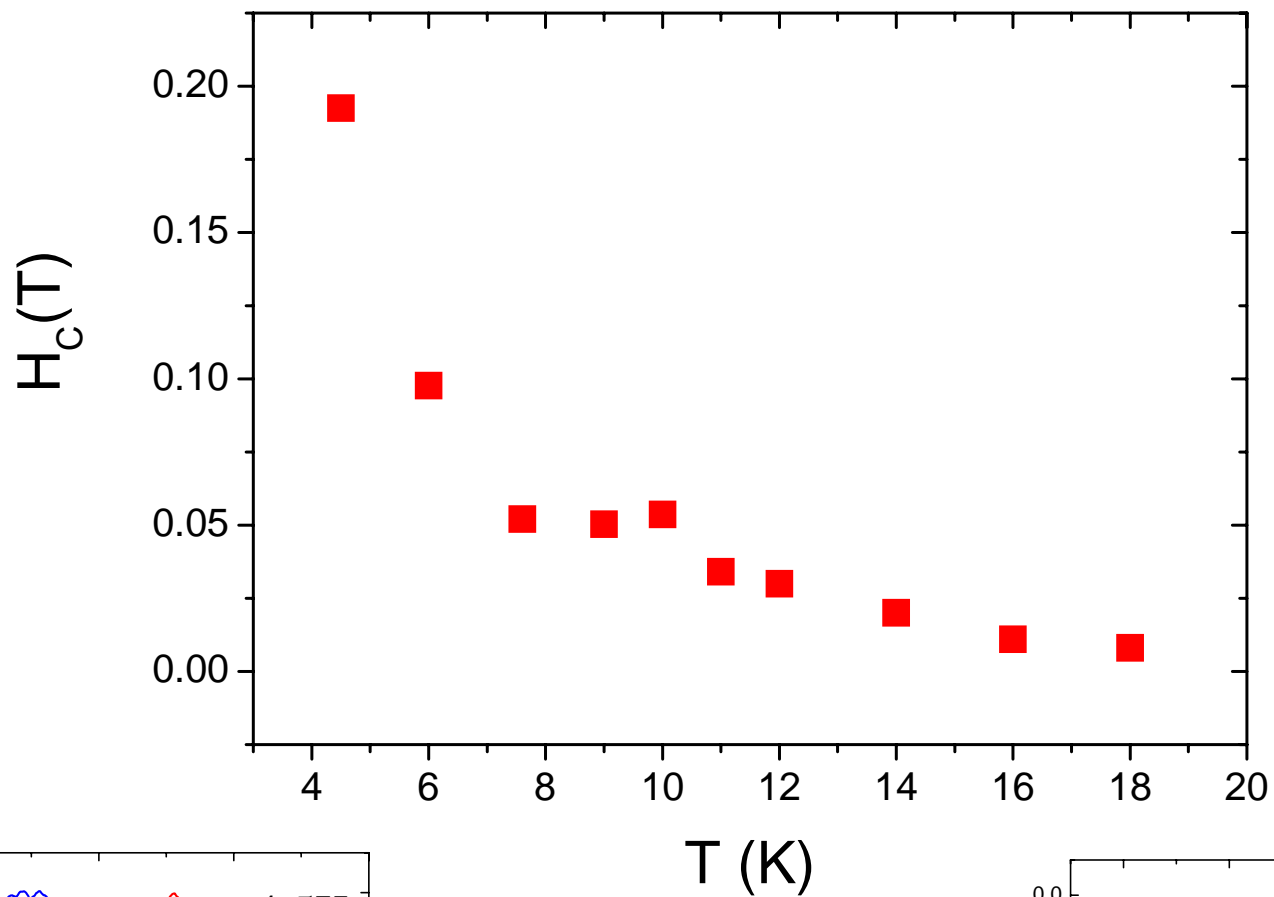


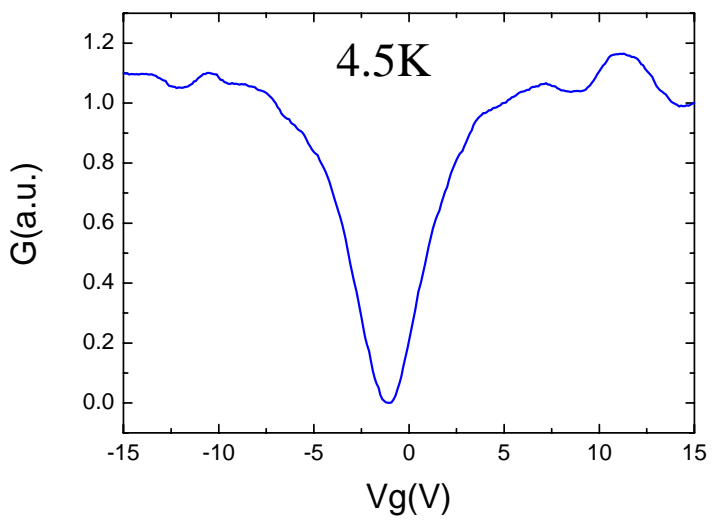
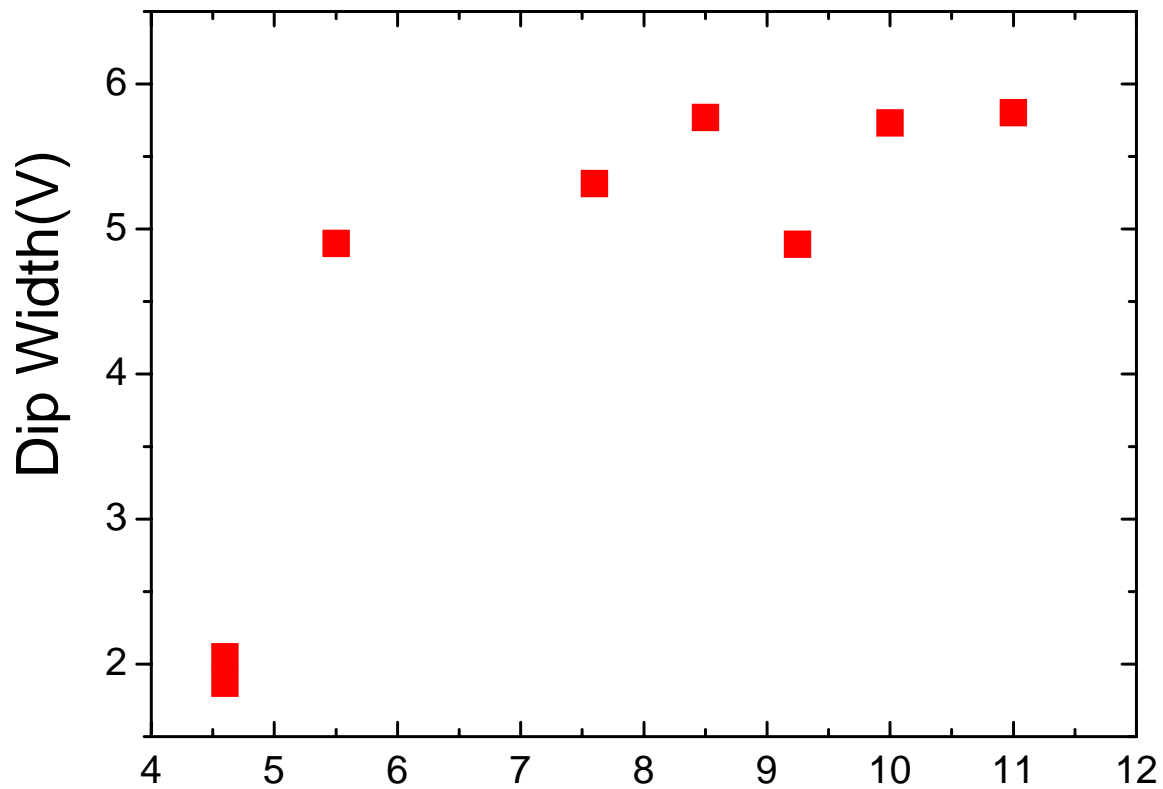


Why different from InO and Granular Al ?

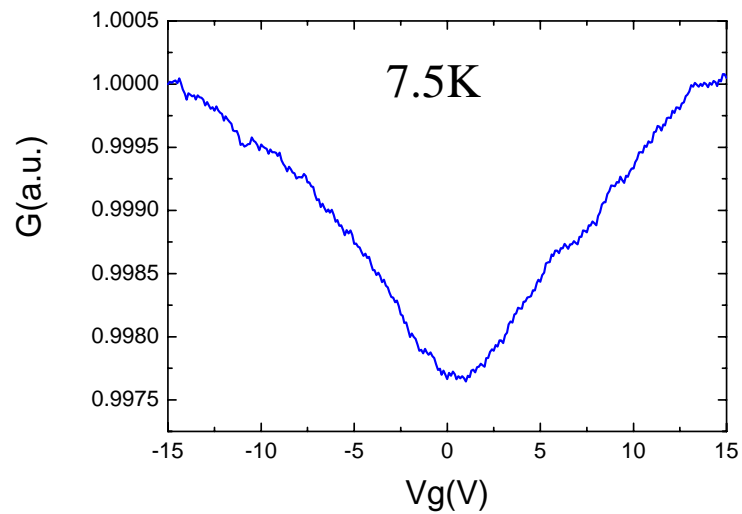


Hysteresis vrs T



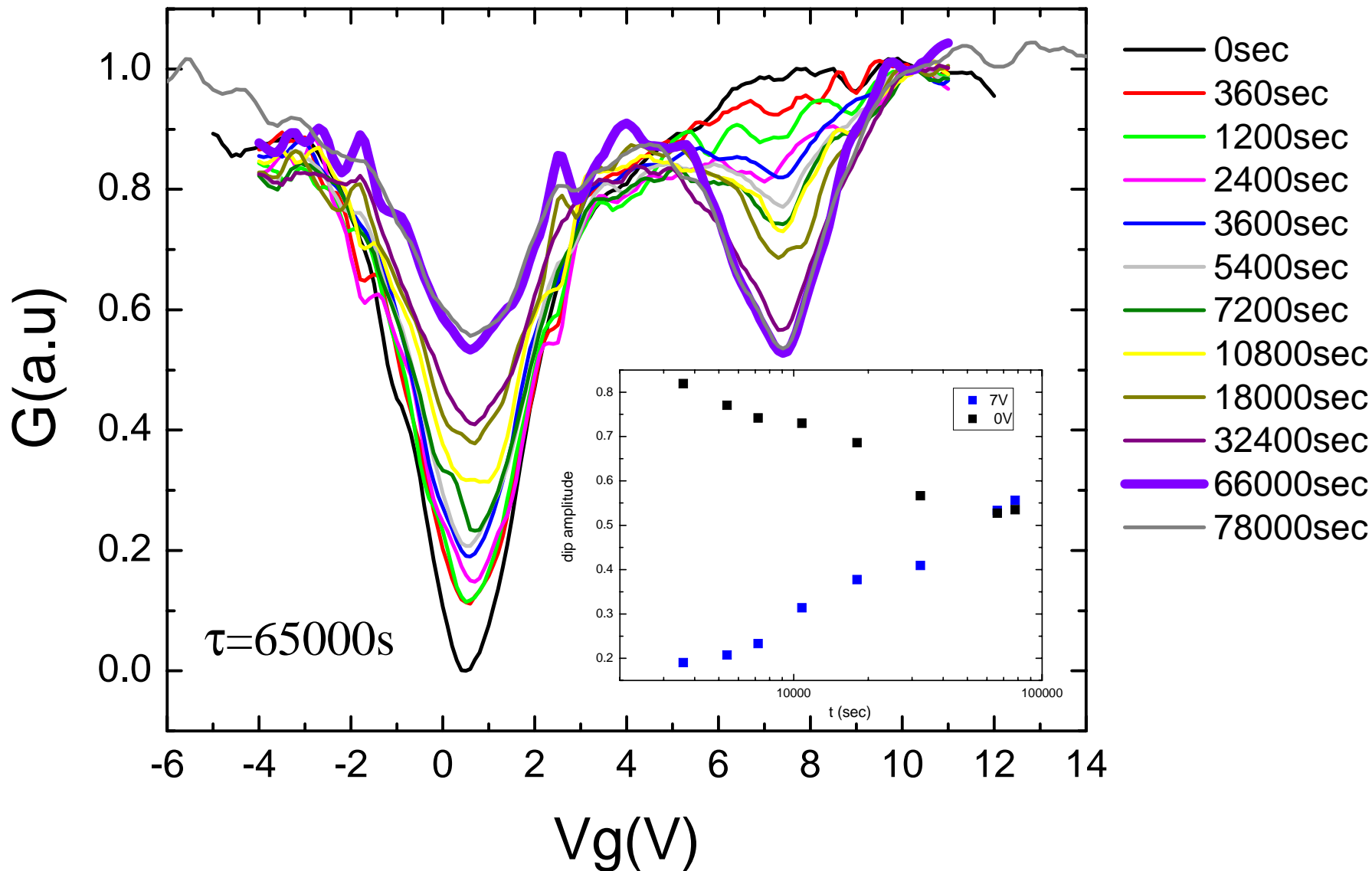


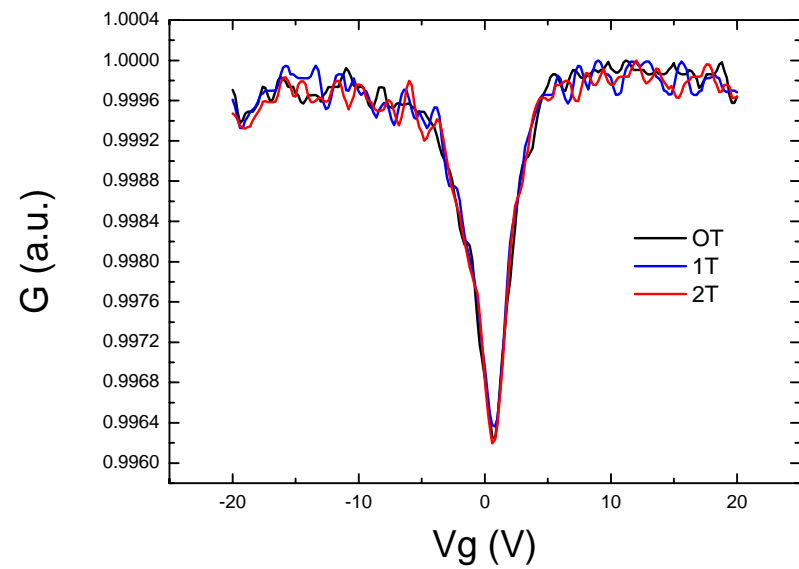
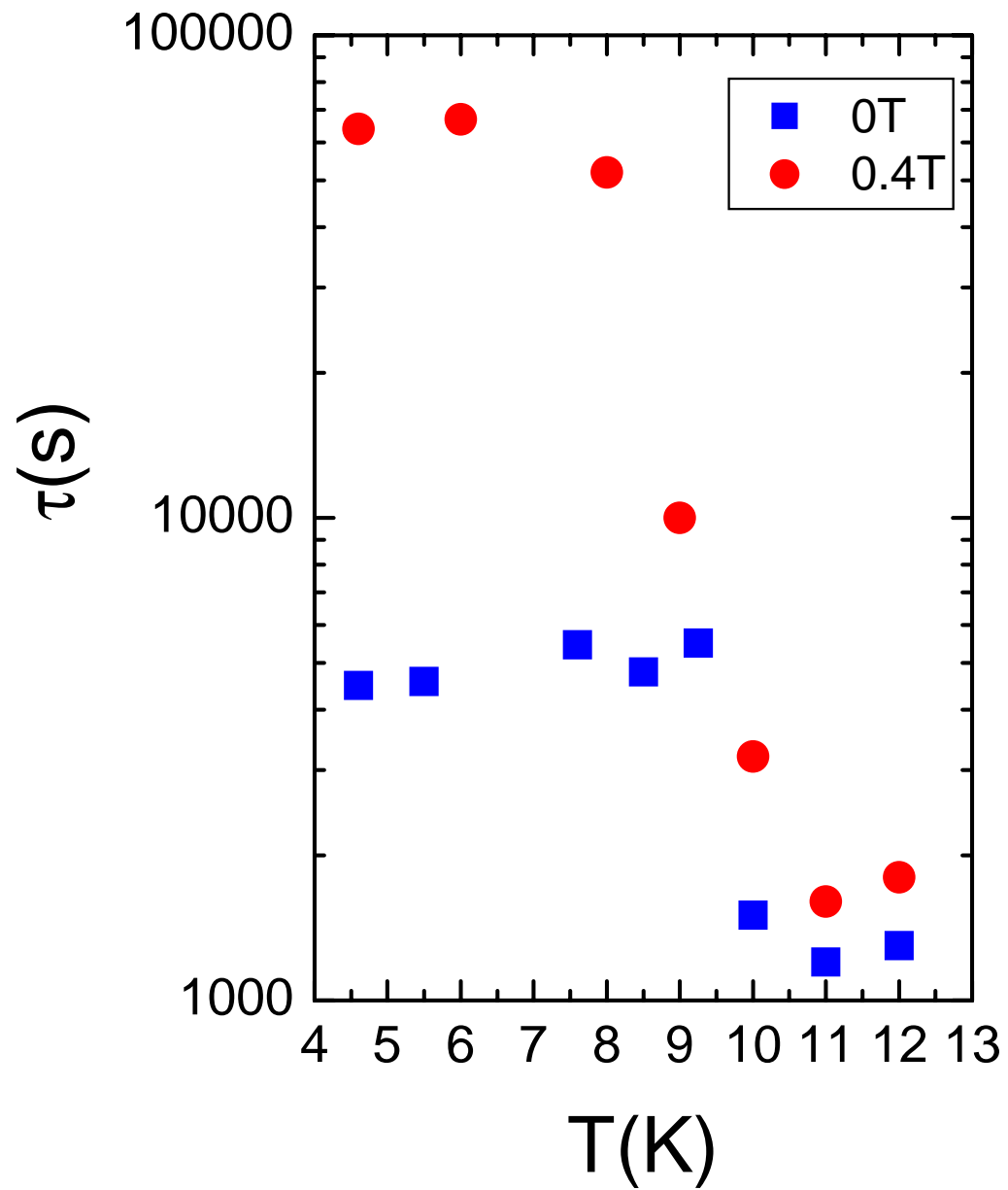
T (K)



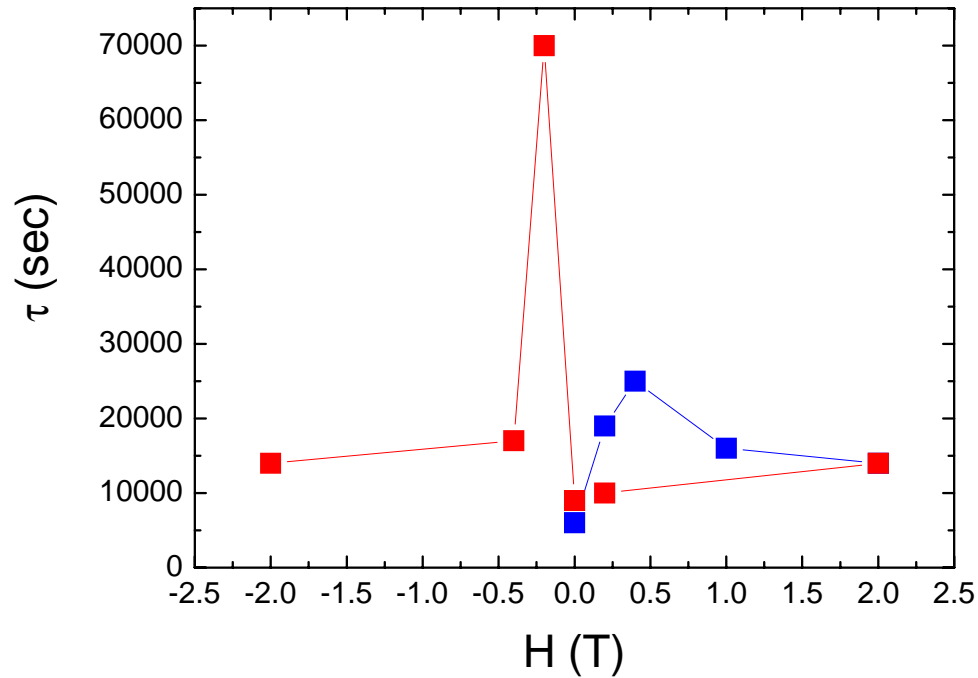
Finite magnetic field

$H=0.4T$

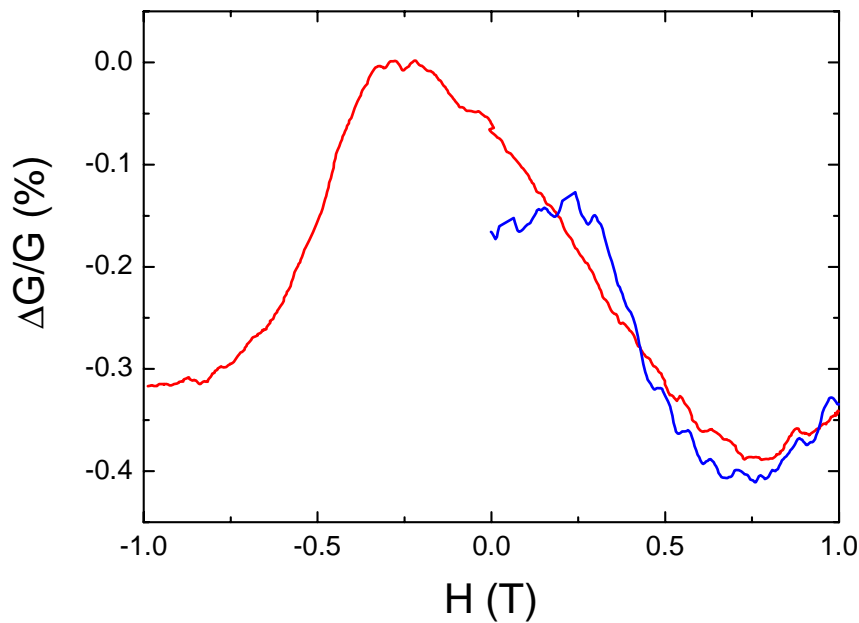




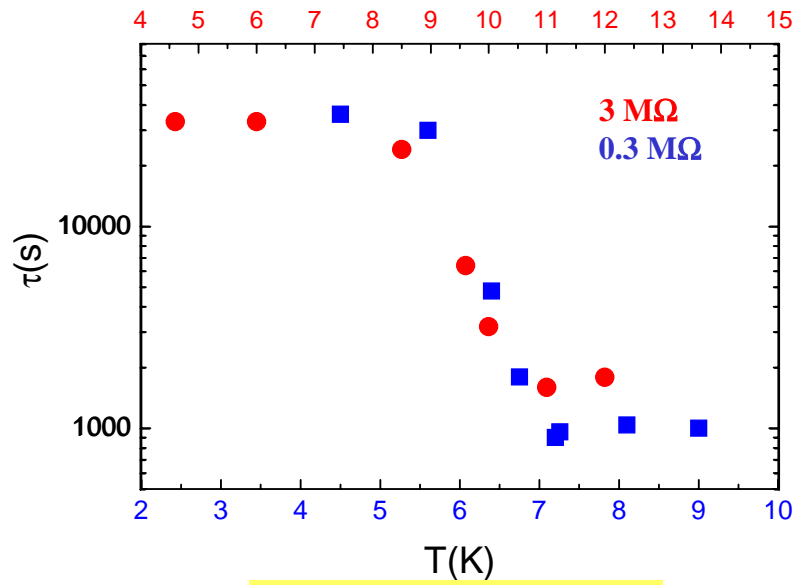
τ vrs H



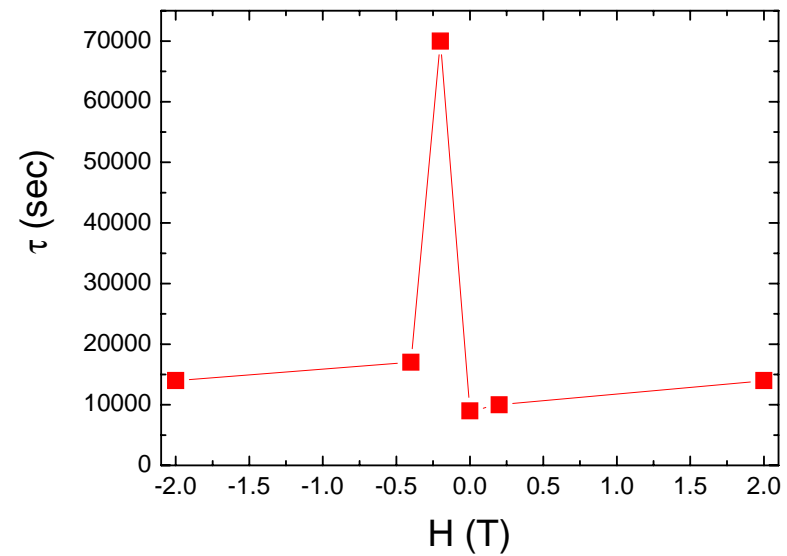
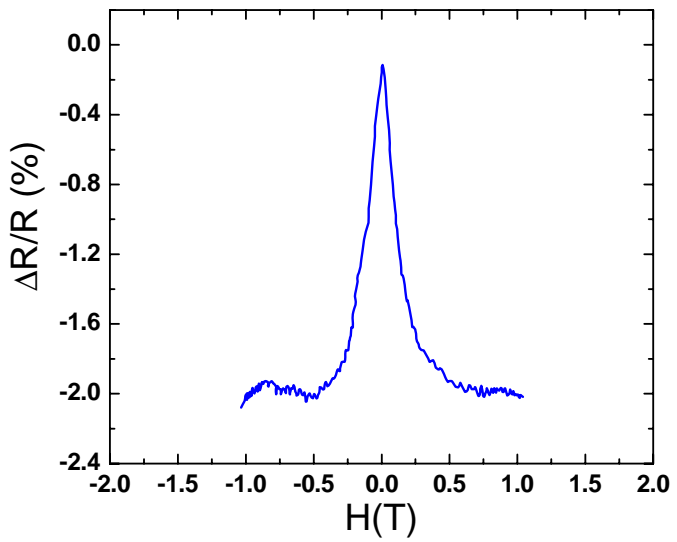
- Apply $H=0$
- Heat to 25k for 2 hours
- Cool down to 4.2k
- Establish memory dip (base line)
- Apply magnetic field
- 2 dip experiment



Disorder



Magnetic field



Summary

- Granular Ni shows slow relaxation and memory effects
- Very sharp increase of relaxation time upon cooling below ~10k
(Characteristic temperature lower than T_B)
- Applying a small magnetic field results in an increase of 1.5 orders of magnitude in τ
- Strong dependence on the history of magnetic field