A Model for MR in SC Thin Films

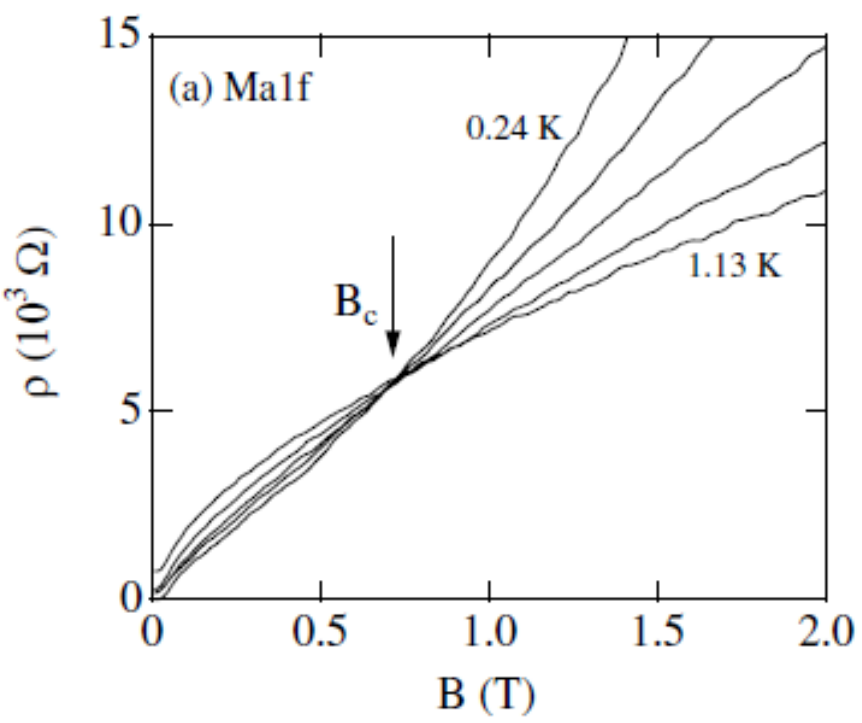
Elkana Porat

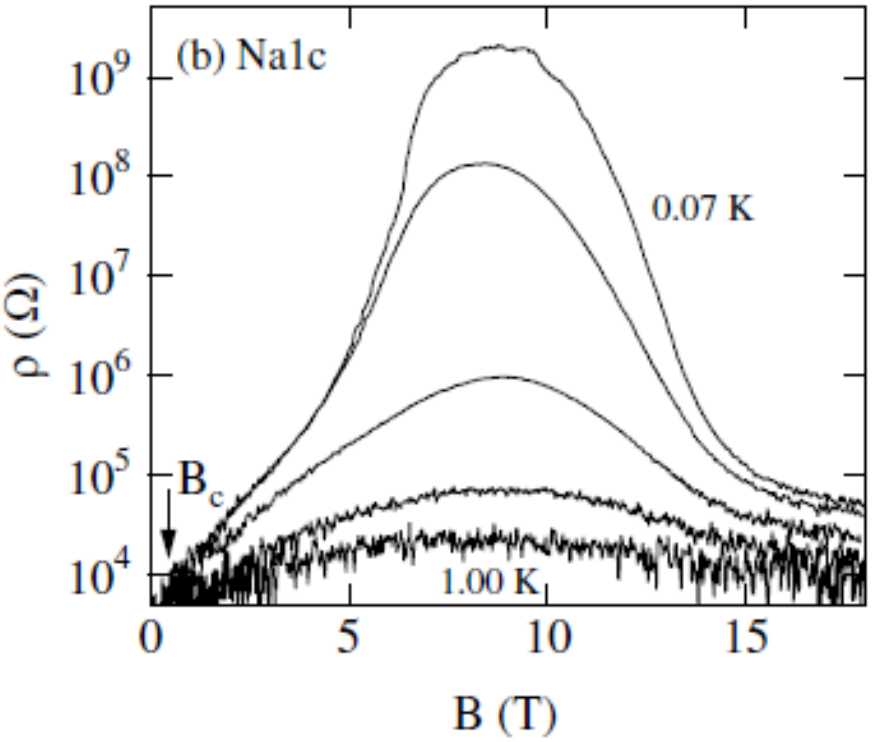
"Theory of the magneto resistance of disordered superconducting films" Y. Dubi, Y.Meir, Y.Avishay, PRB 73, 054509 (2006)

Disordered SC Thin Films

- Manifestation of interplay between SC and disorder
- Superconductor-to-insulator quantum phase transition (SIT)
- On the insulator phase, peculiar magneto resistance was measured

Magneto Resistance in DSC films



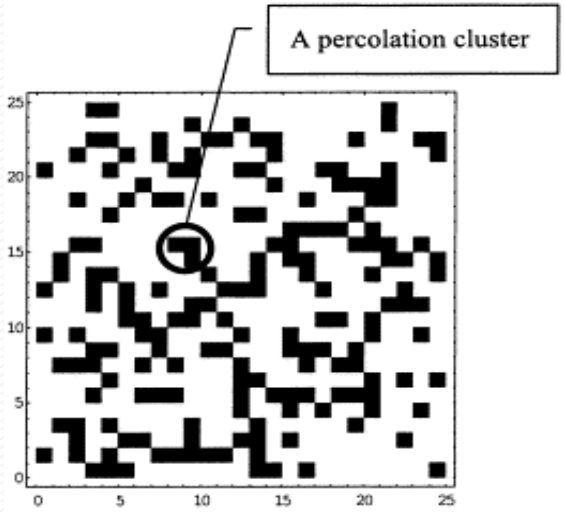


Sambandamurthy *et. al.*, PRL 92, 107005 (2004)

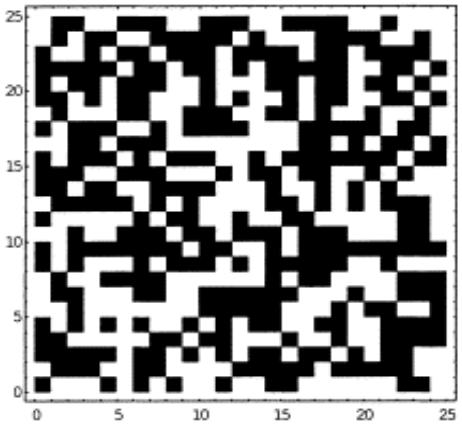
Magneto Resistance in DSC films

- Magnetic field driven SIT
- Resistance rise of several orders of magnitude
- Beyond some peak, a drop of again orders of magnitude before saturation.

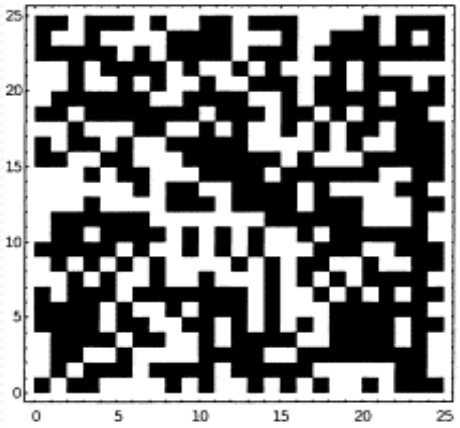
SIT as percolation problem



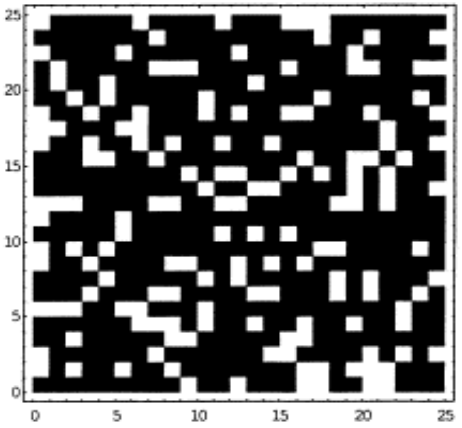
$f(p) = 0.35$



$f(p) = 0.50$



$f(p_c) = 0.59$



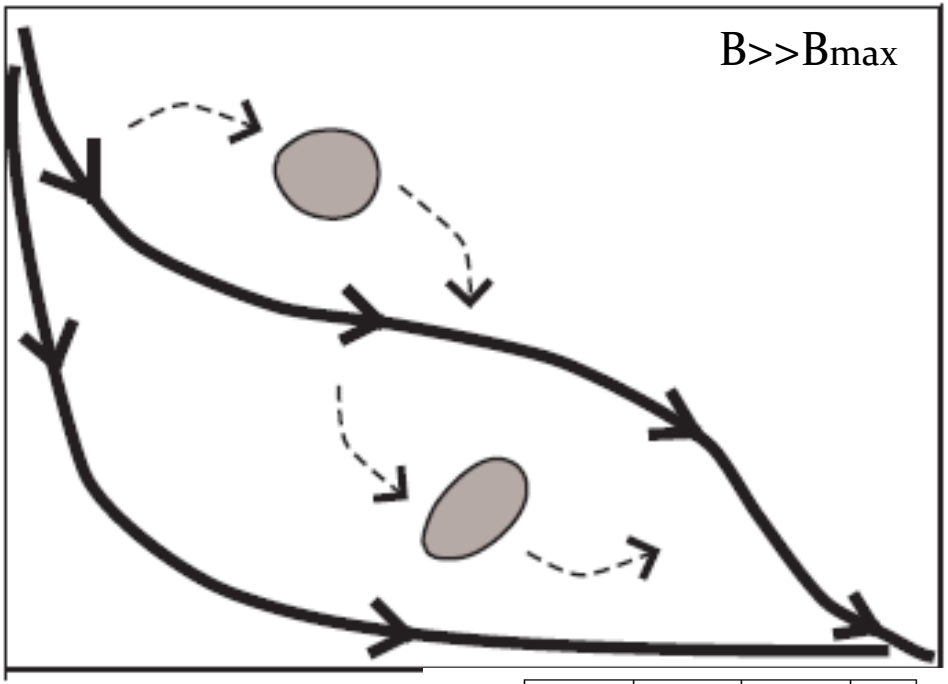
$f(p) = 0.76$

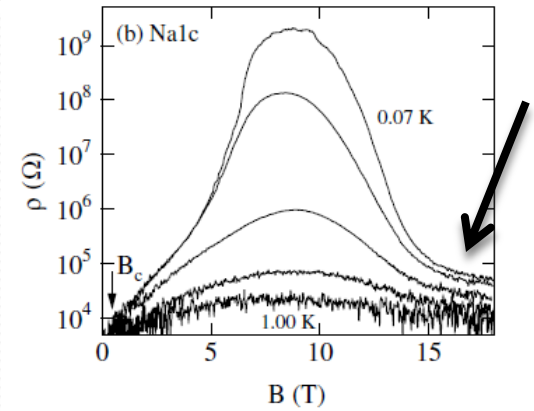
The Magneto Resistance Model

- Beyond the SIT, SC islands are formed
- The islands's size and concentration are reduced with increased magnetic field
- The islands have a charging energy, which blocks charge carriers from hopping in-and-out the islands

The Magneto Resistance Model

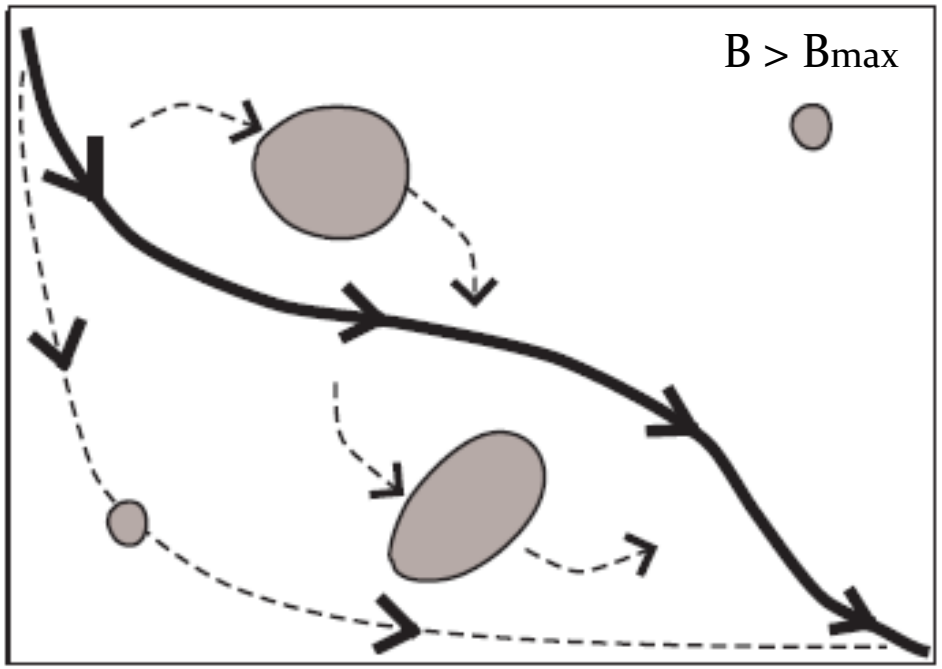
- At strong Magnetic fields, the islands are small and charging energy is high.
- The transport is dominated by normal paths.

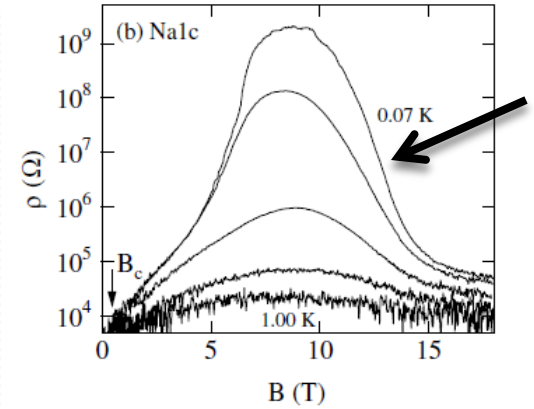




The Magneto Resistance Model

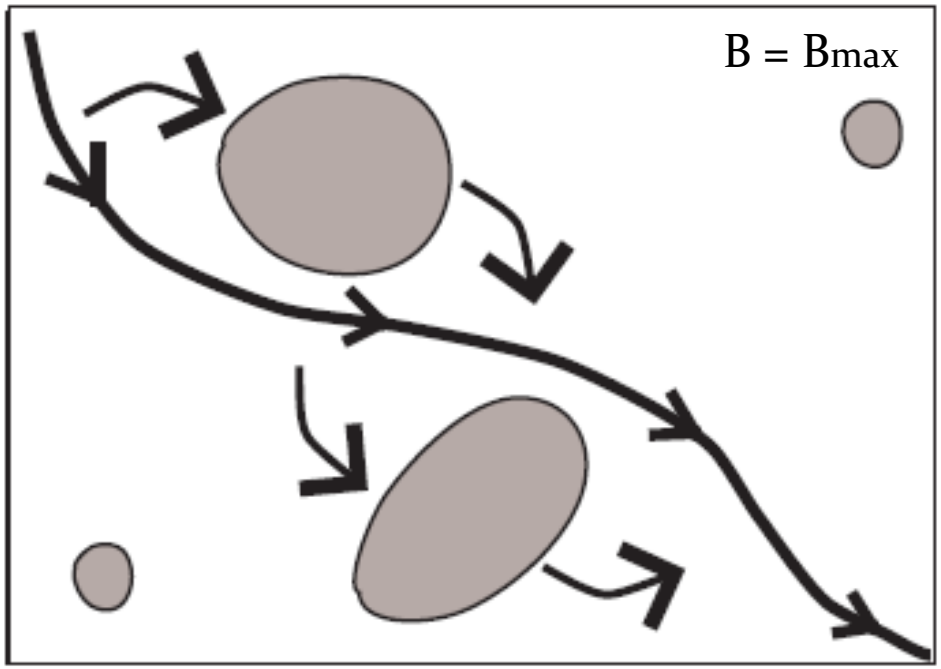
- As the external field is decreased, more SCIs appear.
- The SCIs block some of the available normal paths.
- This results with negative magnetoresistance.

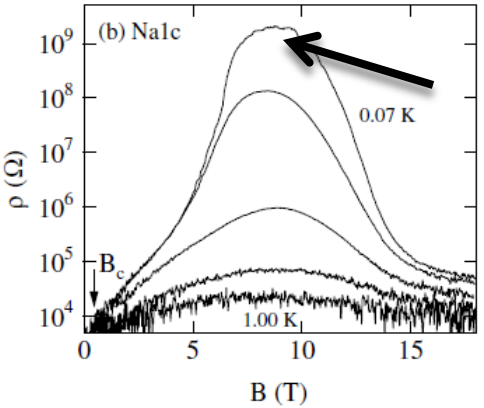




The Magneto Resistance Model

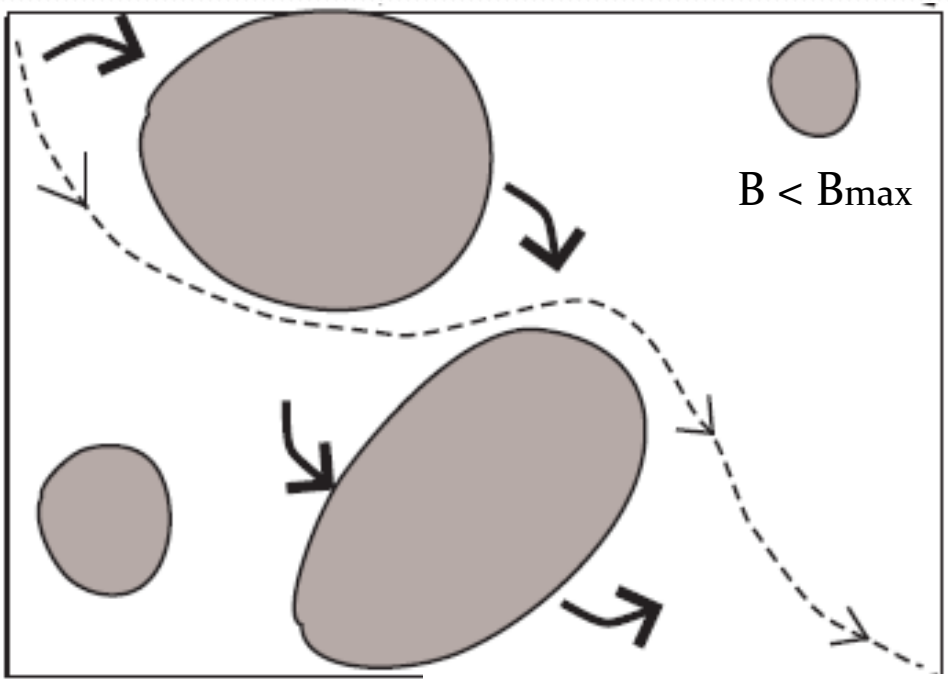
- At a certain field *Bmax*, the resistances of the normal and SC paths are comparable.
- That is the peak.

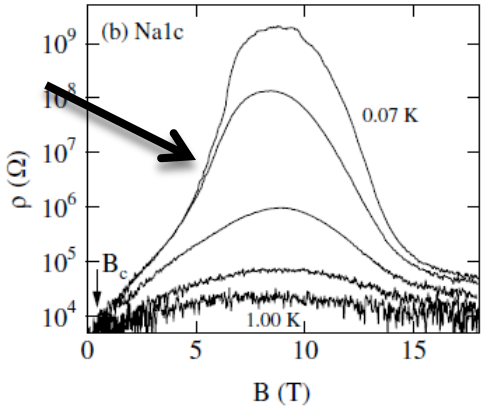




The Magneto Resistance Model

- For even lower magnetic field, the SC path are favorable.
- More and more SC paths apear, resulting with positive MR.
- Finally, percolation is achieved, and SIT occrus.





The Magneto Resistance Model

Or in one sentence:

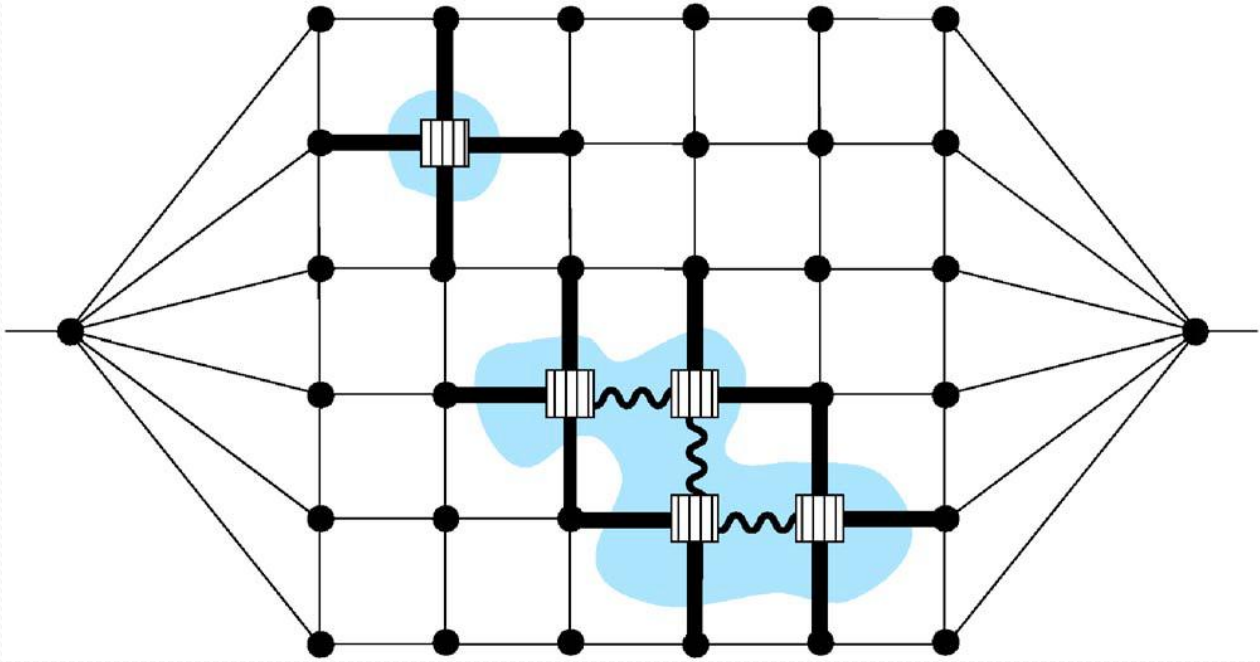
- The peak represents a crossover from dominant normal transport to dominant SC transport (through tunneling).

Numerical Calculations

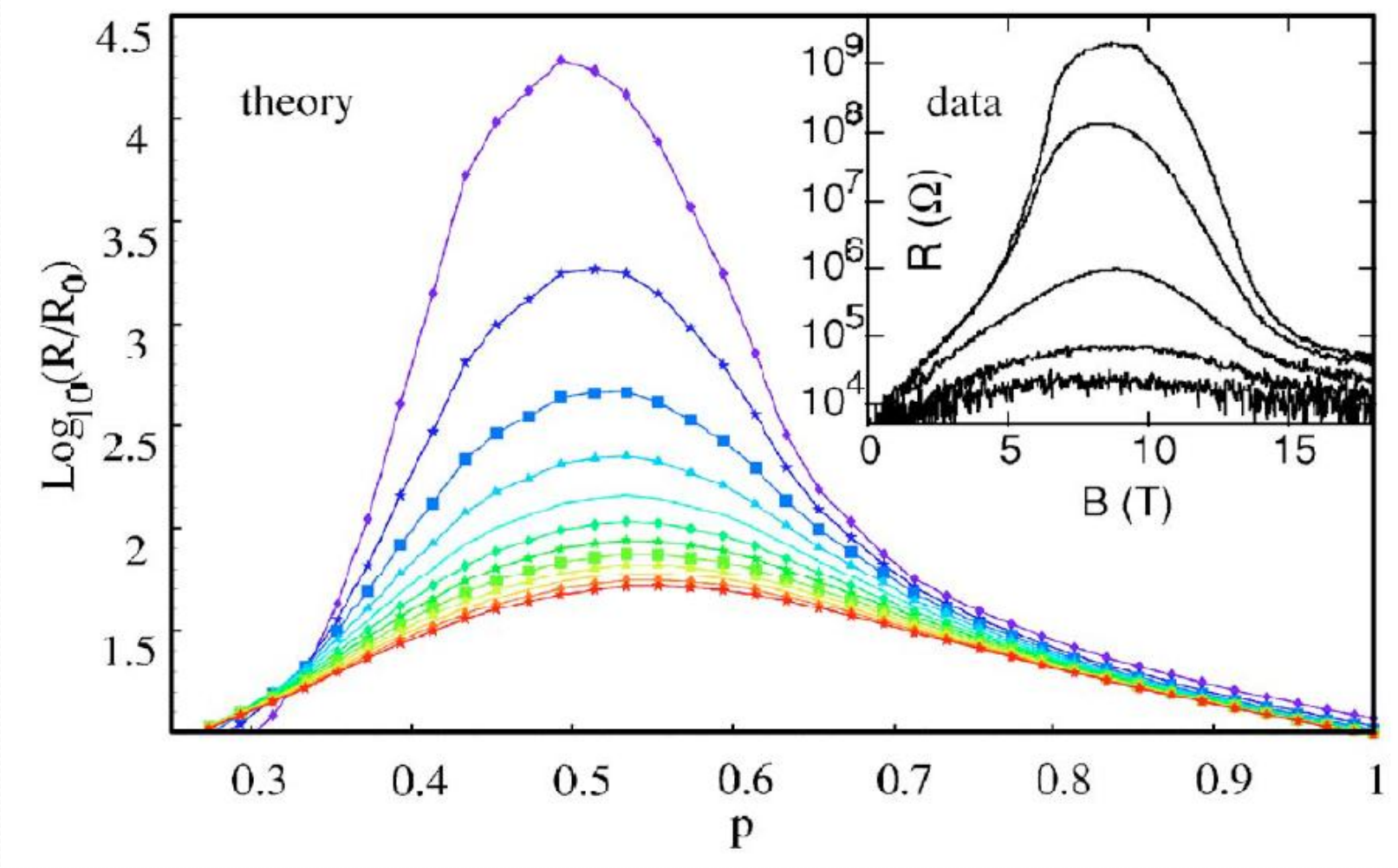
$$R_N \sim e^{(|\epsilon_i|+|\epsilon_j|+|\epsilon_i-\epsilon_j|)/T}$$

$$R_b \sim e^{E_c/T}$$

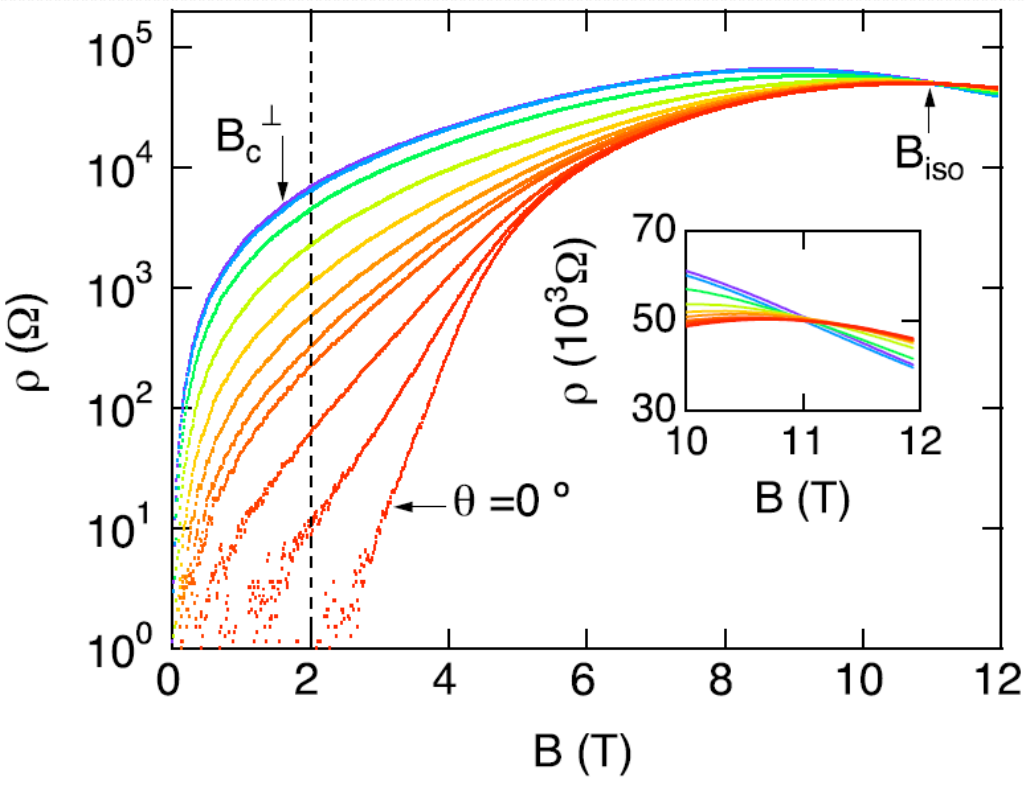
$$R_{SC} \ll R_N$$

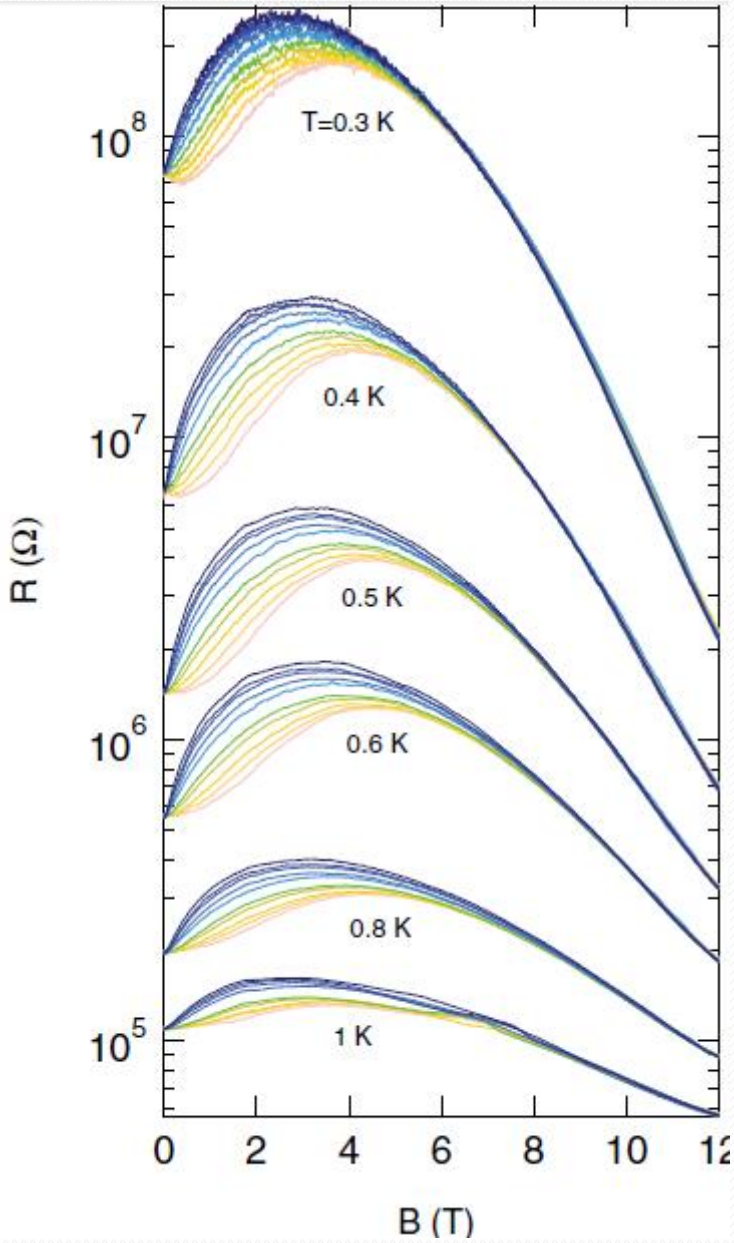


Numerical Calculations



New Experiments





Johansson *et. al.*, *Sol.* Stat. Comm. 151(9), 743 (2011)

Shammass *et. al.*, PRB 85, 140507 (2012)

New Results…

"Percolation model for directional effects of MR in SC thin films"

Elkana Porat

Condensed Matter Theory Seminar,

wednesday 03/04/2013

Thank you for listening