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DISORDER AND INTERACTION: GROUND STATE PROPERTIES of the DISORDERED HUBBARD MODEL

Maria Elisabetta Pezzoli

Rutgers University

work done in SISSA - Trieste

In collaboration with : Prof. Michele Fabrizio and Dr. Federico Becca

OUTLINE

- AIM: interplay of disorder and interaction
  in 2 D Hubbard model

- METHOD: variational wave function within VMC

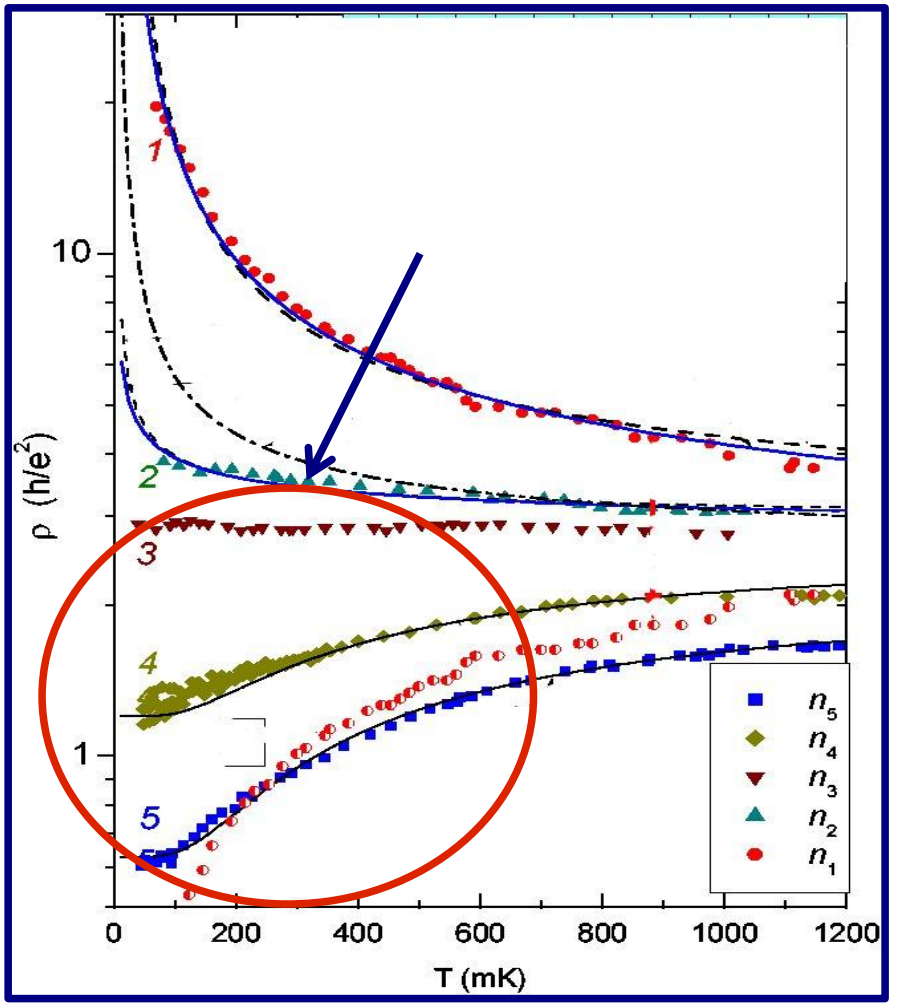
- RESULTS:
  transition from Anderson to Mott Insulator

  paramagnetic and magnetic phase diagram

WHY DISORDER AND INTERACTION ?

METAL-INSULATOR TRANSITION IN 2D

CAN INTERACTION CREATE AN EXTENDED STATE IN 2D ?



Kravchenko et al., Phys. Rev. Lett. ***84****, 2909*

Punnoose et al. Science ***310****, 289 (2005)*

ANDERSON LOCALIZATION in COLD ATOMS

COLD ATOMS IN OPTICAL LATTICES ARE A UNIQUE TOOL FOR HIGLY CONTROLLED INVESTIGATIONS OF MANY BODY SYSTEMS

Direct observation of Anderson localization of matter waves in a controlled disorder

Juliette Billy[1], Vincent Josse[1], Zhanchun Zuo[1], Alain Bernard[1], Ben Hambrecht[1], Pierre Lugan[1], David Clément[1], Laurent Sanchez-Palencia[1], Philippe Bouyer[1] & Alain Aspect[1]

Nature, **453**, 891 (2008)

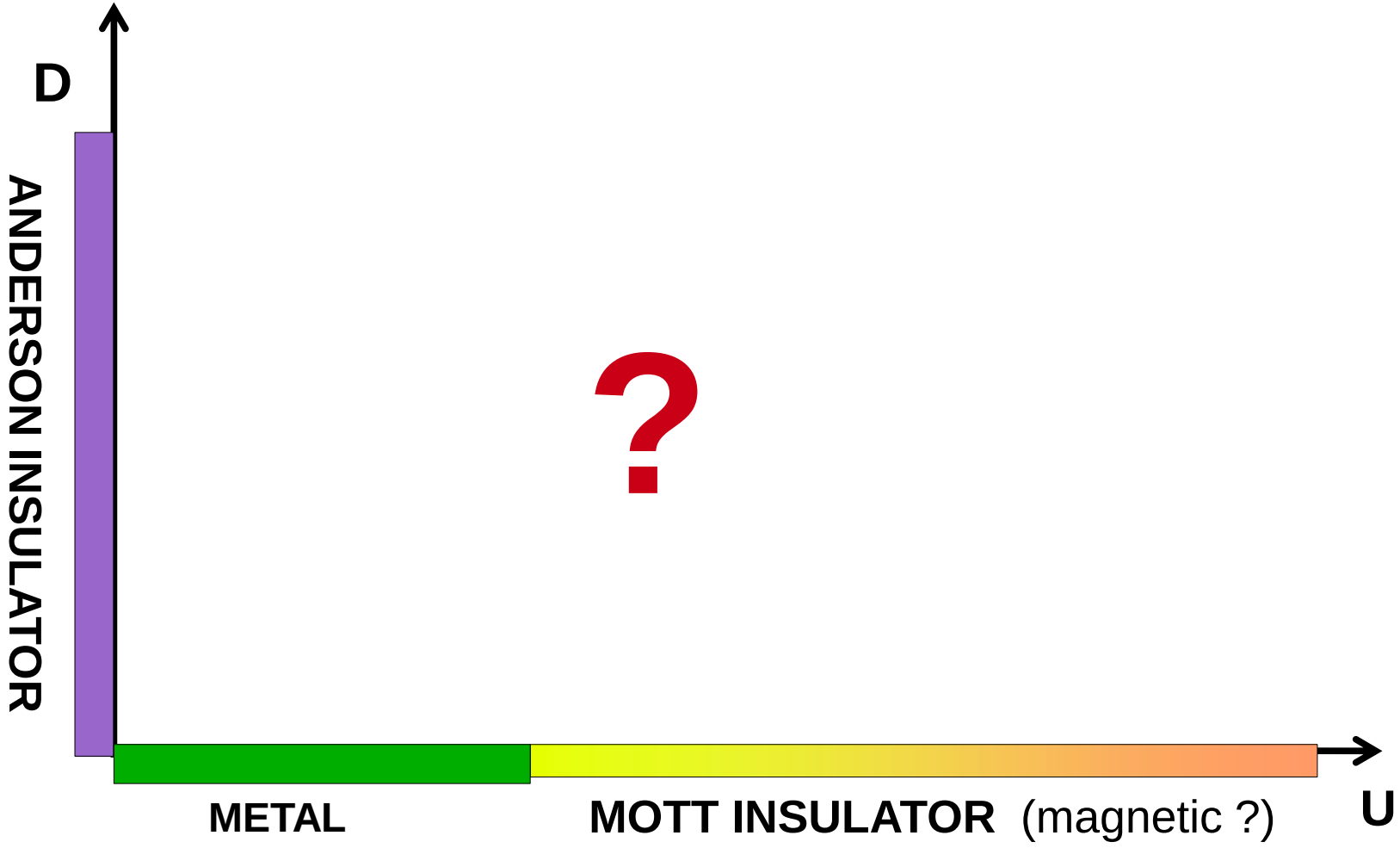
Anderson localization of a non-interacting Bose–Einstein condensate

Giacomo Roati[1,2], Chiara D'Errico[1,2], Leonardo Fallani[1,2], Marco Fattori[1,2,3], Chiara Fort[1,2], Matteo Zaccanti[1,2], Giovanni Modugno[1,2], Michele Modugno[1,4,5] & Massimo Inguscio[1,2]

Nature, **453**, 895 (2008)

DISORDERED HUBBARD MODEL

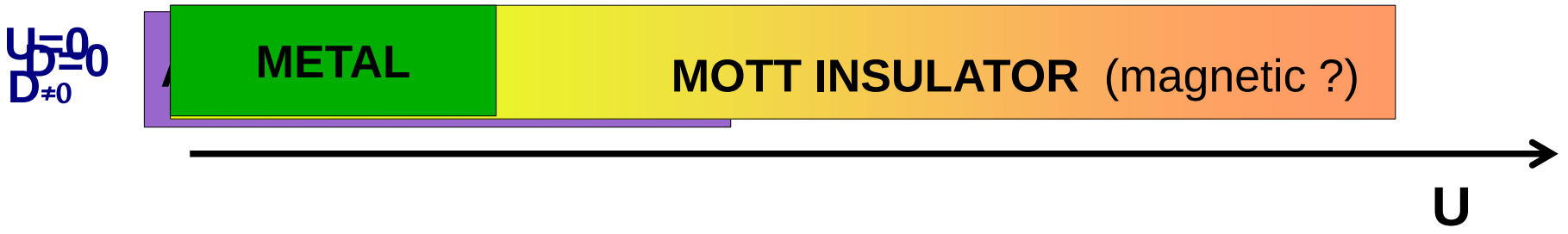
2 dimensions ***half filling***



VARIATIONAL WAVE FUNCTION

Disordered wave function with Jastrow correlation

DIAGONALIZE

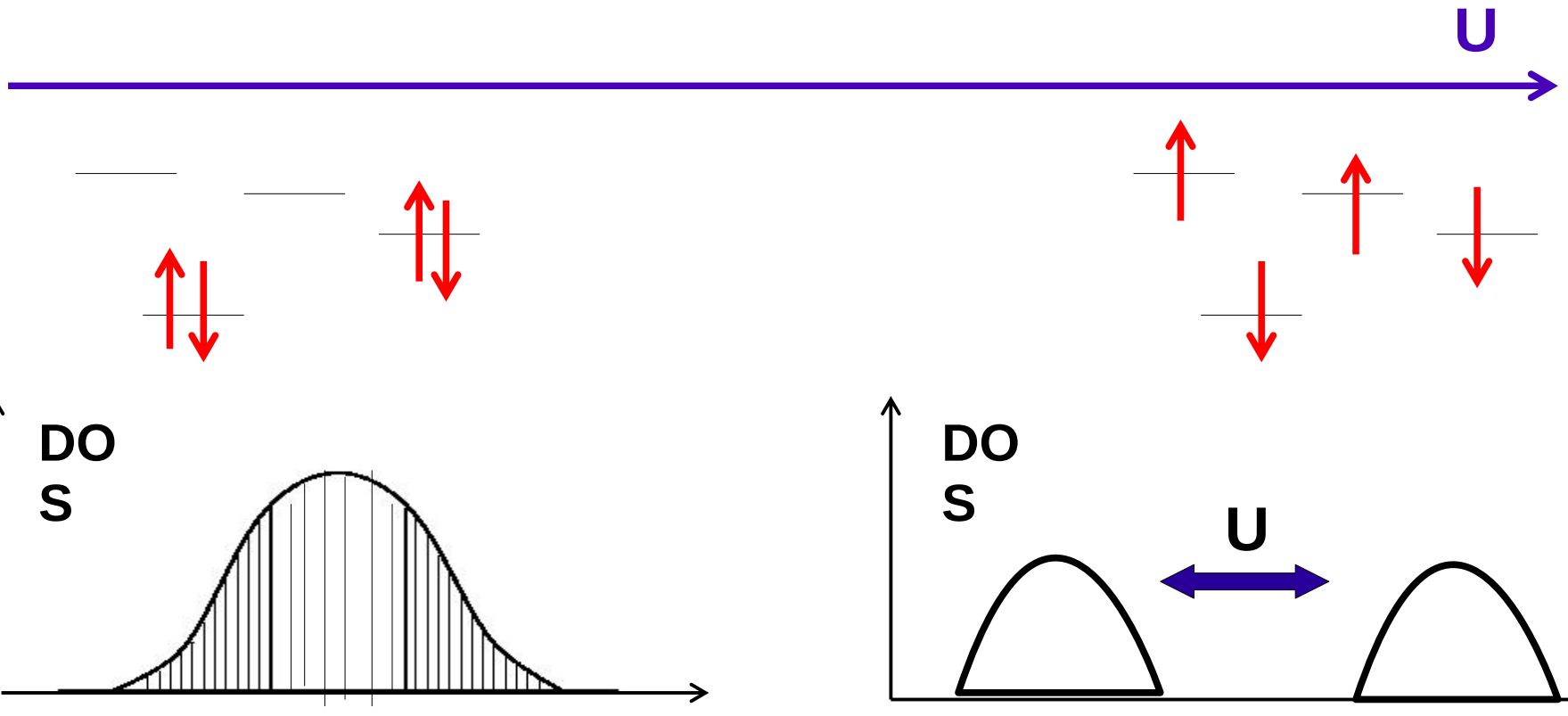


*M.Capello, et al. Phys. Rev. Lett **94** , 026406 (2005)*

ENERGY COMPETITION

ANDERSON INSULATOR

MOTT INSULATOR



HOW CAN WE DISTINGUISH BETWEEN A MOTT *AND AN* ANDERSON *INSULATOR ?*

The properties of excitations of a system are reflected in a different arrangement of the electrons in the ground state

Kohn, Phys. Rev. ***133****, A171 (1964)*

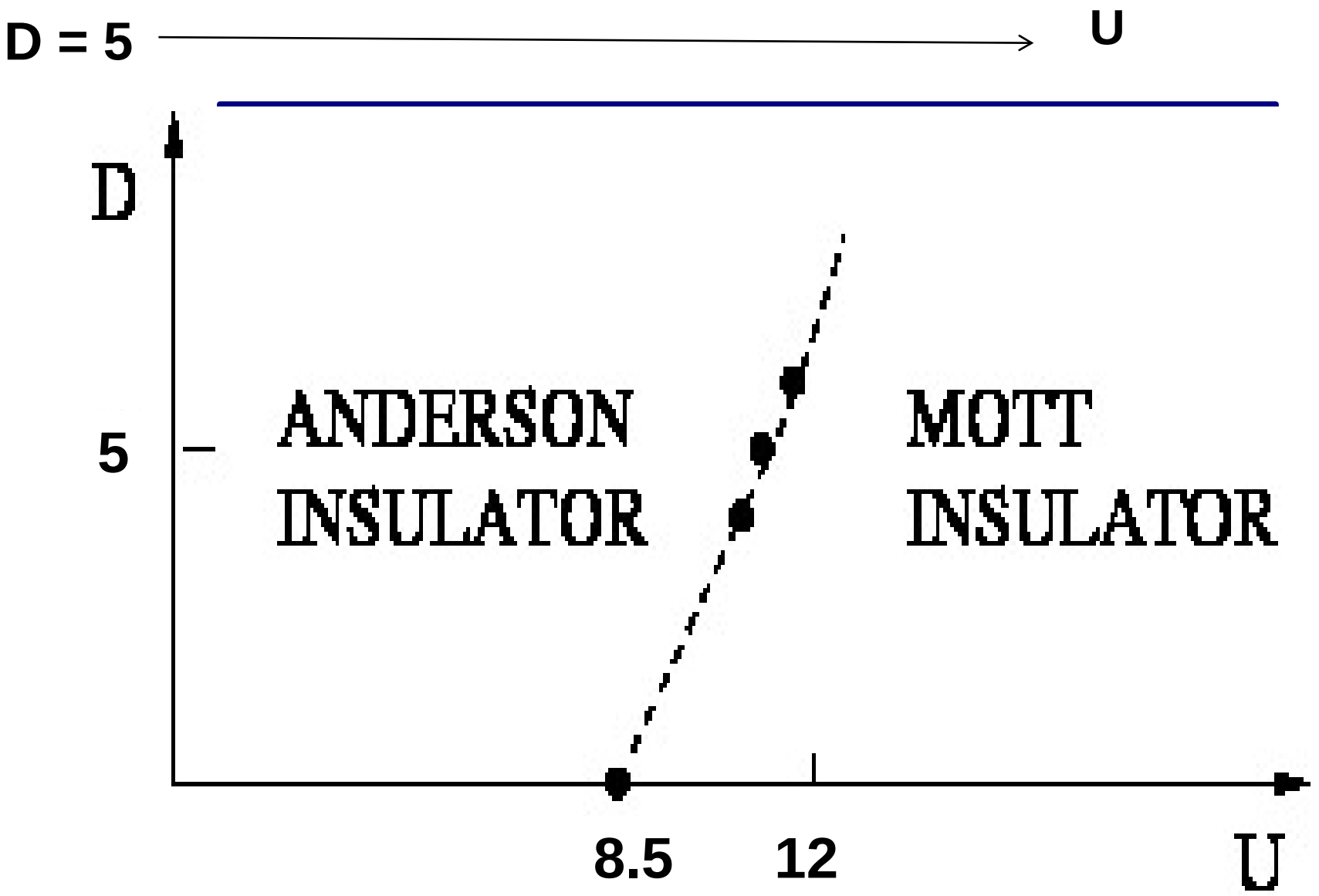
Static structure factor

charge gap = 0 **ANDERSON INSULATOR**

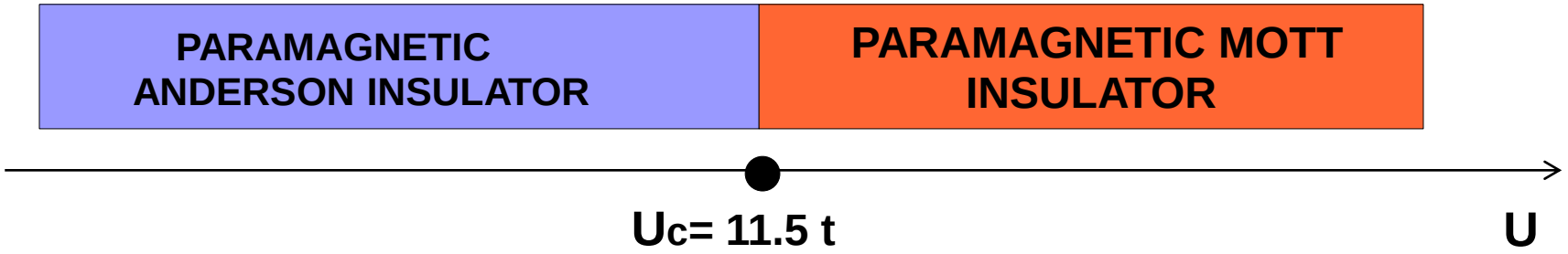
charge gap **0** **MOTT INSULATOR**

Average energy of an excitation : *(f-sum rule)*

THE PARAMAGNETIC PHASE DIAGRAM

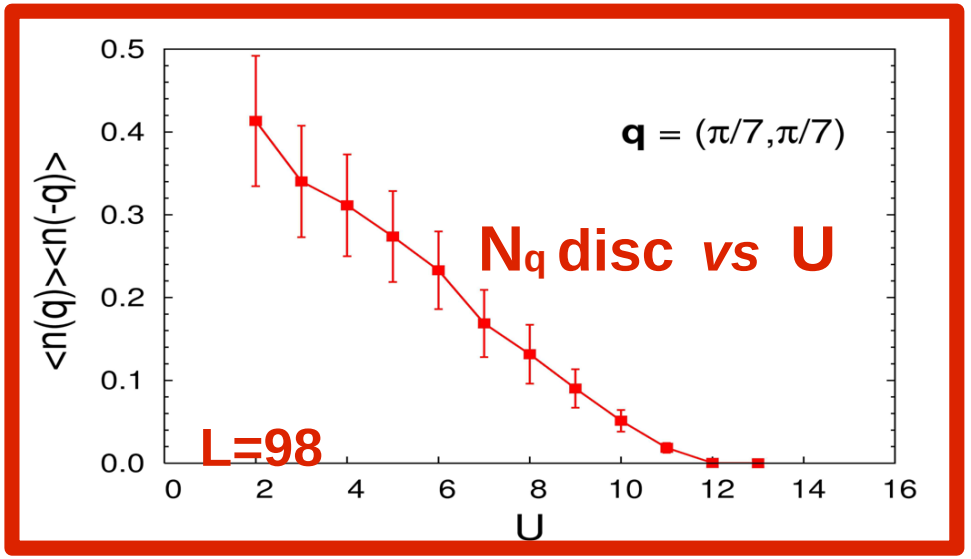


The Anderson–Mott transition



What is the behaviour of N_q disconnected ?

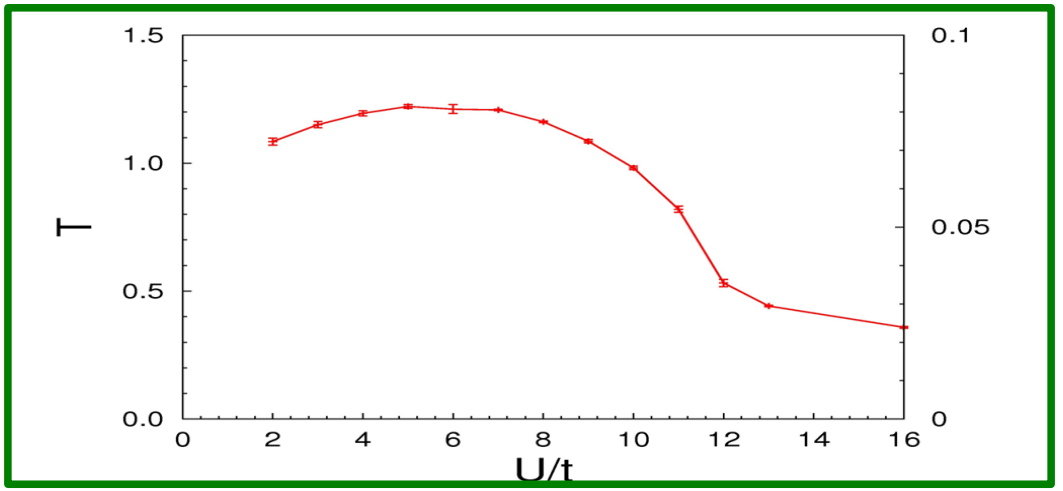
average over different disorder realizations

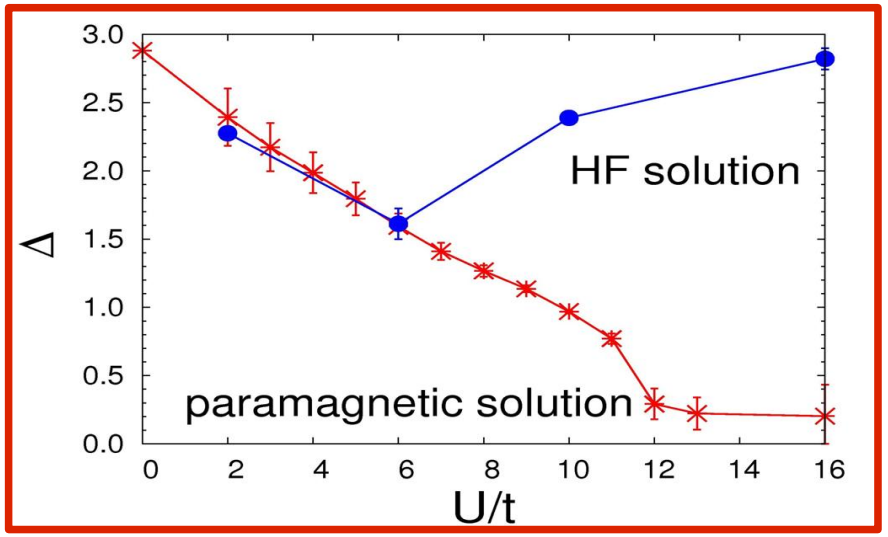


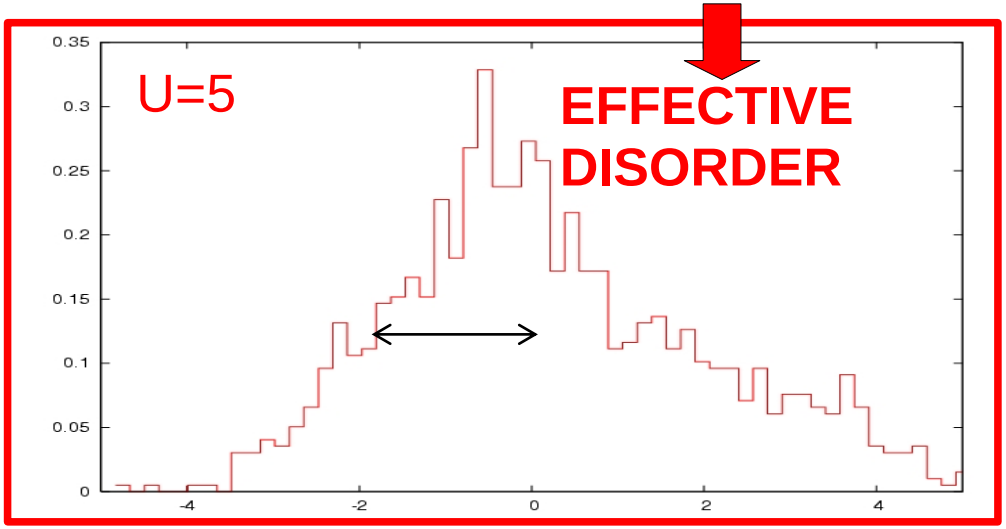
ORDER PARAMETER !!

compressibility fluctuations

INTERPLAY BETWEEN DISORDER AND INTERACTION (our results)





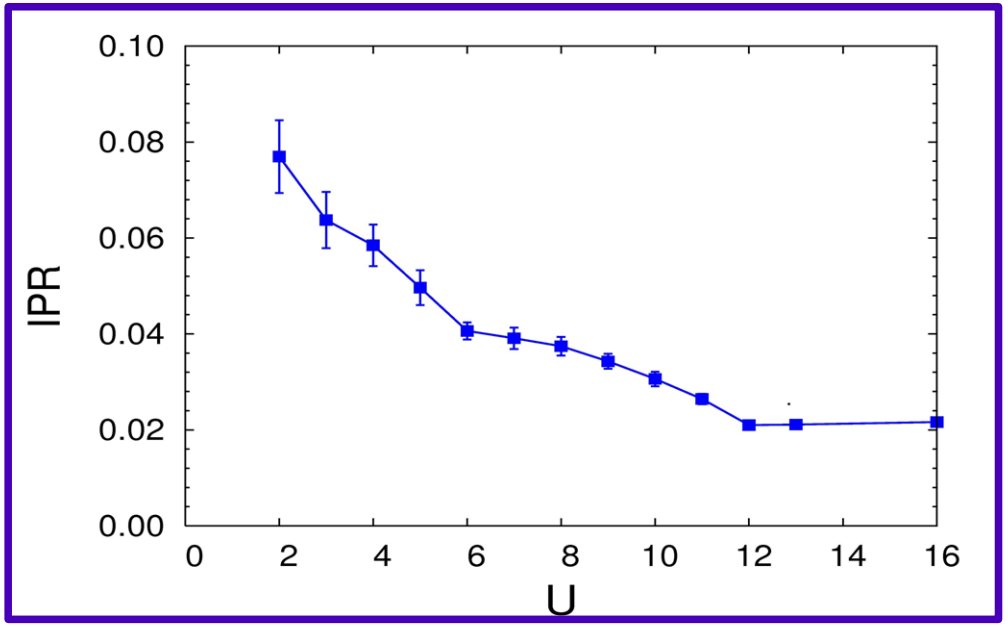


INTERPLAY BETWEEN DISORDER AND INTERACTION (our results)

Single particle wave function

COMPLETELY LOCALIZED STATE:

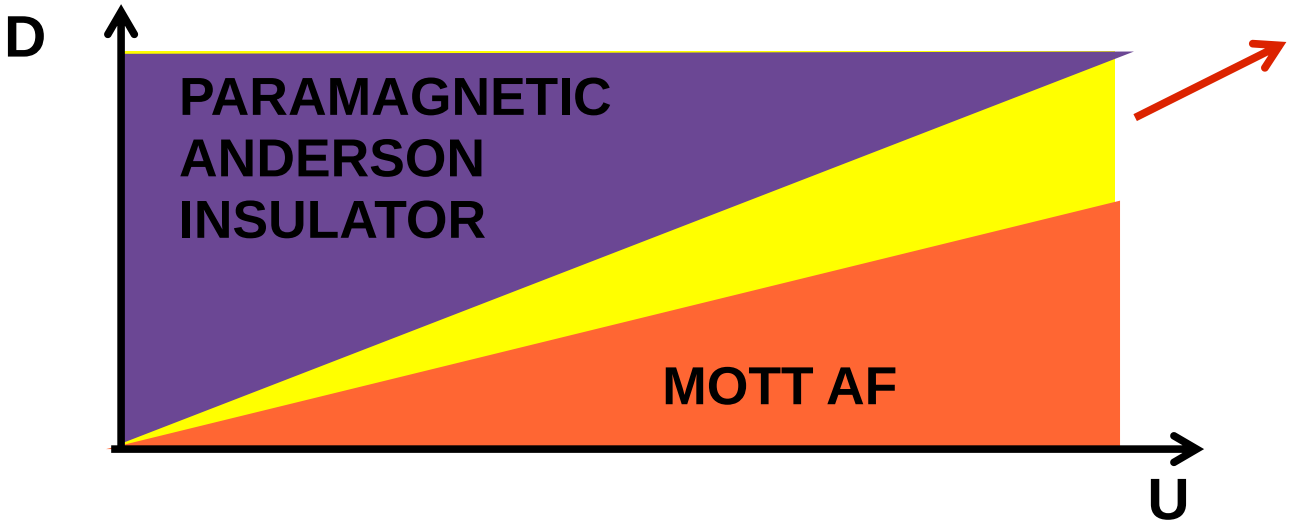
PLANE WAVE:



MAGNETIC PHASE DIAGRAM

ANDERSON INSULATOR

MOTT INSULATOR



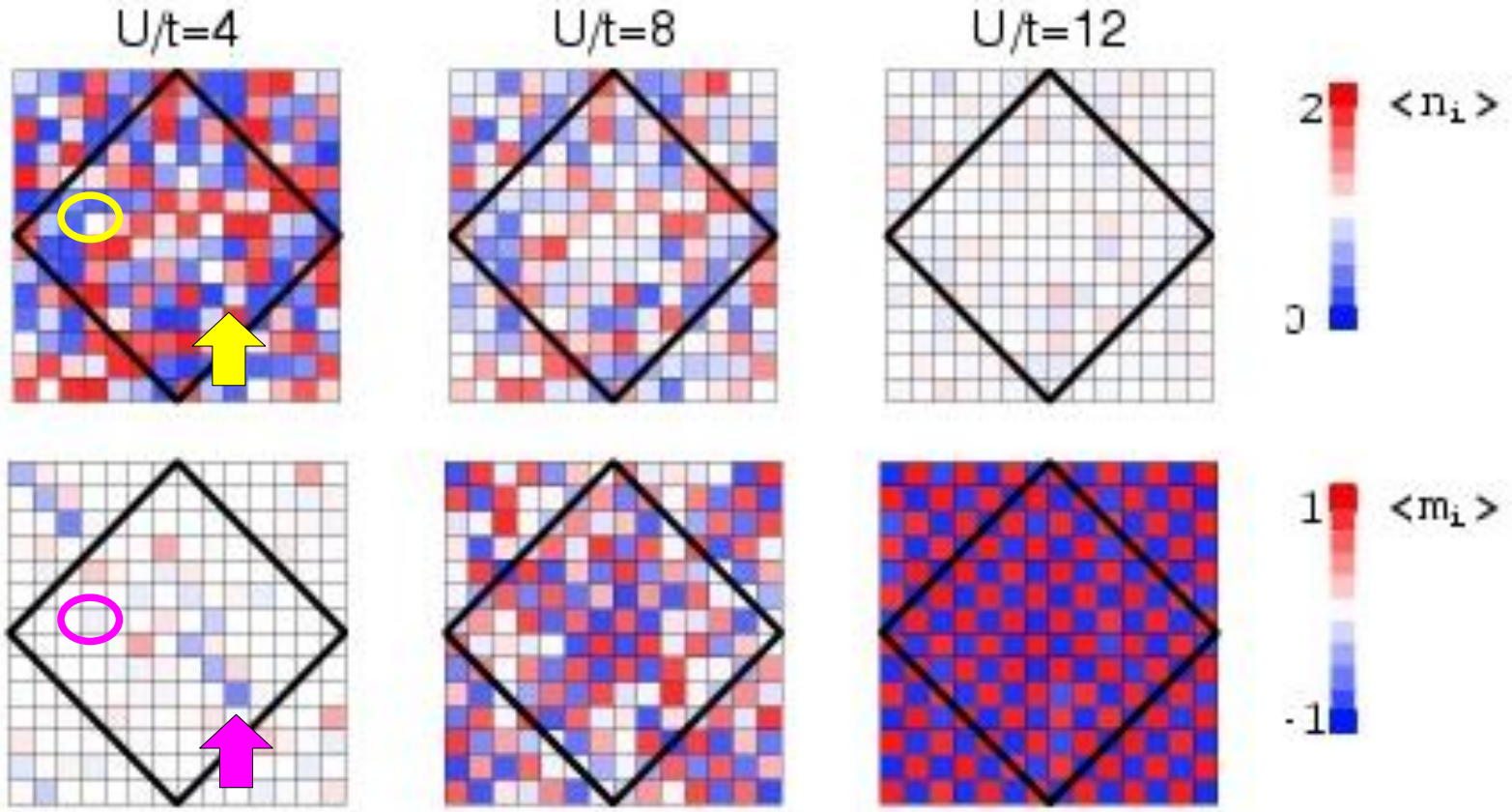
INTERMEDIATE PHASE

localized states

gap = 0

AF order

LOCAL MAGNETIC MOMENTS



Presence of local magnetic moments at T=0

Local magnetic moments appear before the onset of long-range order: rare events

For a review on quantum Griffiths effects: Thomas Vojta arXiv: 1005.2707v1

EXPERIMENTS on (Si:P)

Paalanen et al., Phys. Rev. Lett. ***57****, 2061*
Hirsch et al., Phys. Rev. Lett. ***68****, 1418*

FURTHER DEVELOPMENTS

What (and how) can we say about the full many body wave Function ?
Is it localized or extended?

Local moments: are they dominating the thermodynamics of the system?

Thank you