An introduction to Anderson localization

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What is it about?

- Conduction in **NON-INTERACTING** systems with **DISORDER**
- Describes the role of **IMPURITIES**
- Completely different than the **Drude** model:

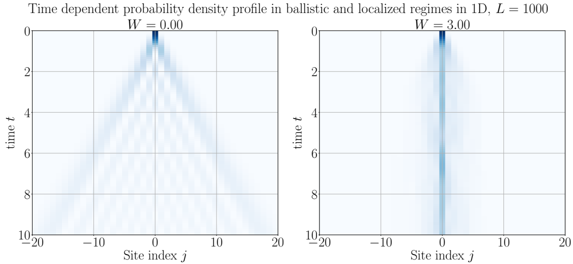
$$\sigma \propto l$$

What does it predict?

- for some disorder:

$$\sigma \to 0$$

- put forth by **P. W. Anderson (1958)**
- Nobel prize in **1977**



1D dynamics with no disorder and with strong disorder.

Why does it (still) matter?

What began in 1958 ...

PHYSICAL REVIEW VOLUME 109, NUMBER 5 MARCH 1, 1958

Absence of Diffusion in Certain Random Lattices

P. W. ANDERSON
Bell Telephone Laboratories, Murray Hill, New Jersey
(Received October 10, 1957)

... still remains relevant today

PHYSICAL REVIEW B **96**, 214201 (2017)

Anderson localization transitions with and without random potentials

Trithep Devakul and David A. Huse
Department of Physics, Princeton University, New Jersey 08544, USA
(Received 20 October 2017; published 6 December 2017)

- **Many-body localization (MBL)**
- includes **INTERACTIONS**
- not our today’s topic

Published in 2015:

Many-Body Localization and Thermalization in Quantum Statistical Mechanics

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672 citations as of April 2018 acc. to Google Scholar.

Outline

1. The basic concepts of the Anderson localization
2. Models of disorder
3. Numerical simulations
4. Conclusion

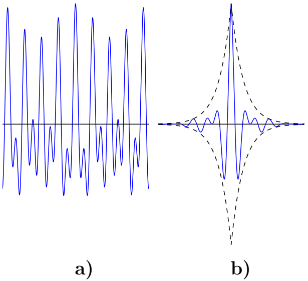
The basics

- **DISORDER** $\rightarrow$ states can localize
- A localized state:

$$|\psi(\mathbf{r})| \sim \exp\left(|\mathbf{r} - \mathbf{r}_0|/\xi\right)$$

- explains **vanishing** transport

Localization:



Extended and localized states.

The important keynotes

- An **interference** phenomenon
- Strong **dimensionality** dependence
- Energy dependence $\rightarrow$ the **mobility edge**

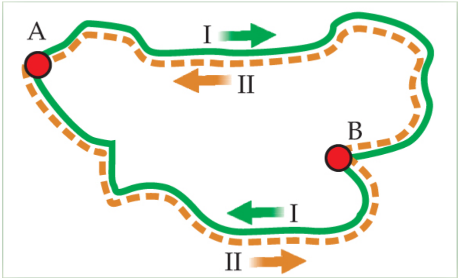
- calculation of the transition probability w

- any two paths:

$$w = |A_1 + A_2|^2 = w_{\mathrm{cl}} + w_{\mathrm{int}}$$

- time-reversed paths:

$$w = 4|A_1|^2 = 2w_{\mathrm{cl}}$$



Path from A to B back to A and its time-reverse

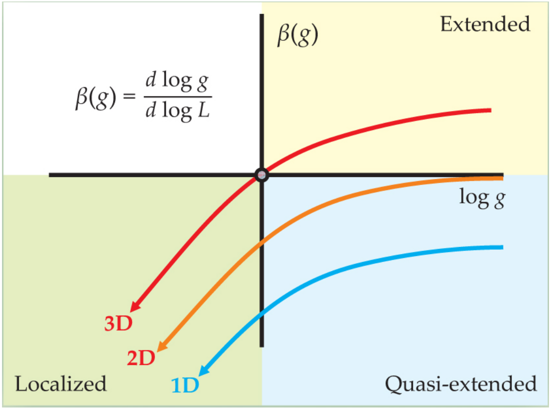
The scaling theory

- scaling of the **conductance** g
- **Ohmic** conductor:

$$g = \sigma L^{d-2}$$

- **Localized** regime:

$$g \propto \exp(-L)$$



Transition between ext. and loc. states is only possible in 3D.

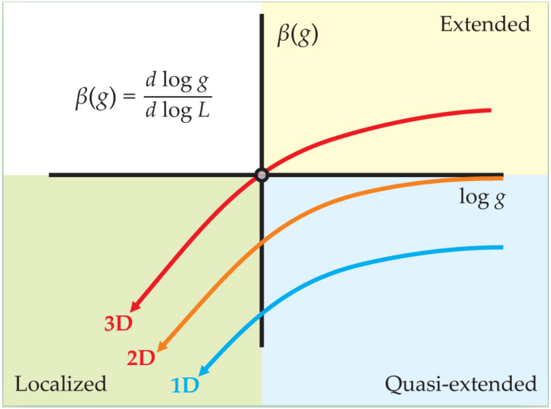
The scaling theory

1D, 2D

localization for any finite disorder

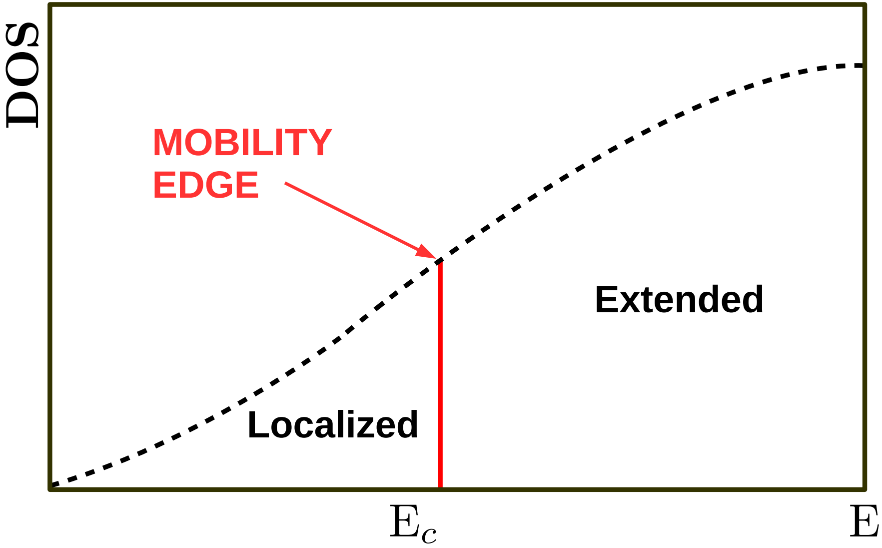
3D

localization for some critical disorder



Transition between ext. and loc. states is only possible in 3D.

3D, finite disorder



The models of disorder

A schematic of the cobalt niobate, $CoNb_2O_6$

The neutron scattering experiments

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