Gaped and Gapless Phases of the Hubbard Model with Disorder

Krzysztof Byczuk

Institute of Physics, EKM, Augsburg University

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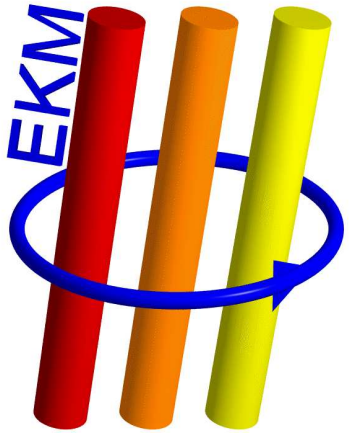
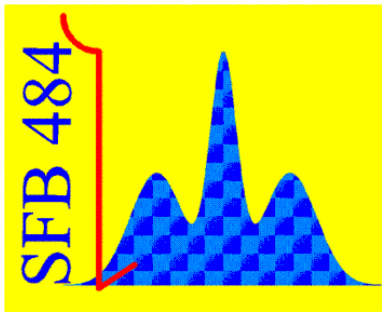


Collaboration

- Walter Hofstetter - Frankfurt, Germany
- Dieter Vollhardt - Augsburg, Germany

Phys. Rev. Lett. **94**, 056404 (2005); cond-mat/0403765
Physica B **359-361**, 651 (2005); cond-mat/0502257
Phys. Rev. B **71**, 205105 (2005); cond-mat/0412590

Support from SFB 484



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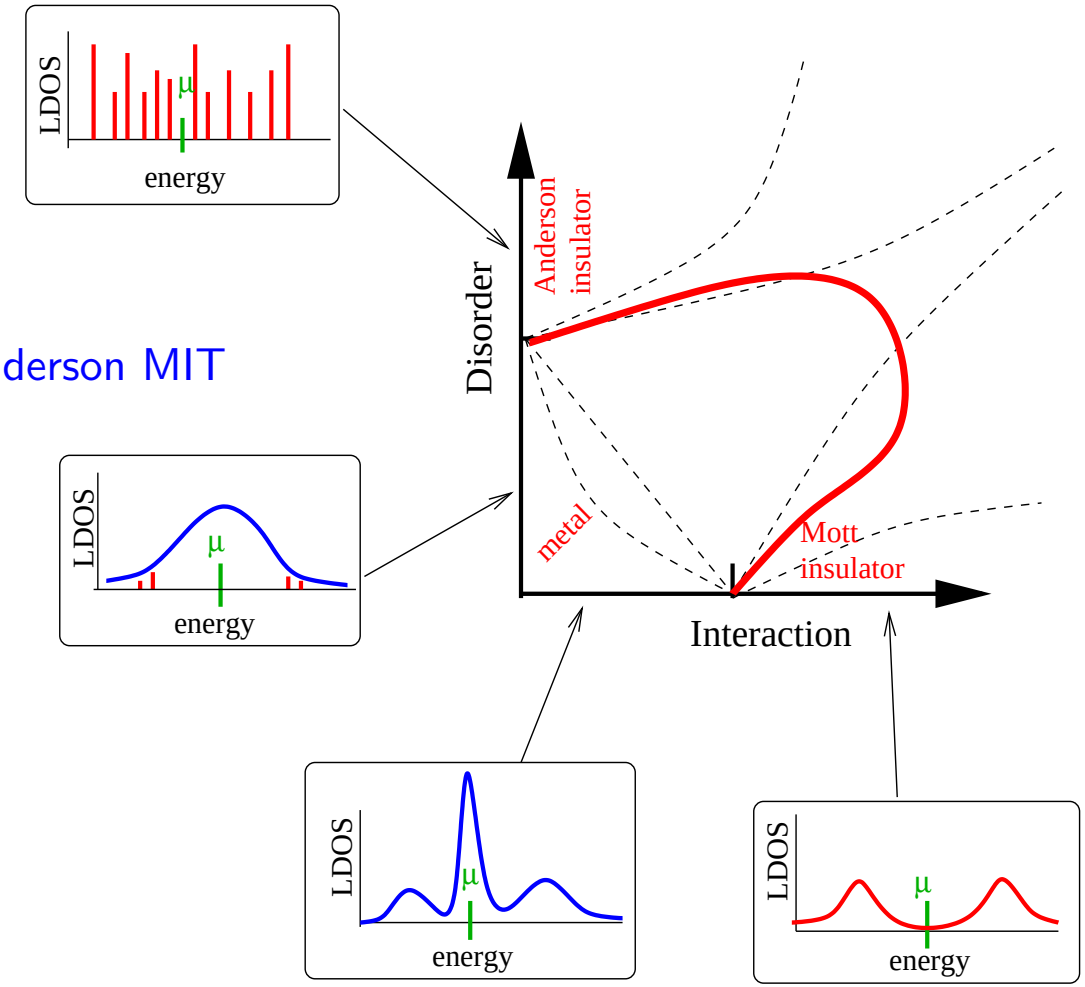


Disorder ↔ Anderson MIT

Two insulators are continously connected

BUT

Interaction ↔ Mott-Hubbard MIT

Interaction and disorder compete with each other stabilizing the metallic phase against the occurring one of the insulators

Hubbard model with disorder

$$H = \sum_{i\sigma} \epsilon_i n_{i\sigma} + \sum_{ij\sigma} t_{ij}\ a^{\dagger}_{i\sigma} a_{j\sigma} + U \sum_{i} n_{i\uparrow} n_{i\downarrow}$$

- Interaction U.
- Randomness ϵ_i with box PDF

$$\mathcal{P}(\epsilon_i) = \frac{1}{\Delta} \quad \text{for} \quad |\epsilon_{\mathrm{i}}| < \frac{\Delta}{2}$$

  and zero otherwise.
- t_{ij} hopping on a lattice, used semielliptic bare DOS with $W = 1$.

- DMFT deals well with the interaction U
- CPA arithmetic averaging over ϵ_i does not describe Anderson localization

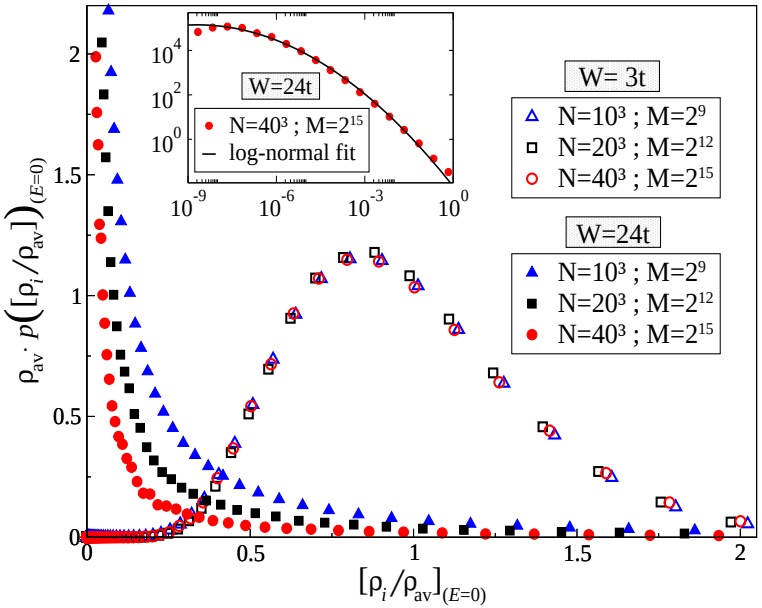
Typical behavior vs. geometric averaging

At large disorder:

- PDF of DOS is very broad with long tails
- Typical DOS is different from arithmetically averaged one
- PDF well fitted by log-normal distribution

Typical LDOS is approximated by geometrical mean

$$\rho_{typ}(E) \approx \rho_{geom}(E) = e^{\langle \ln \rho_i(E) \rangle}$$



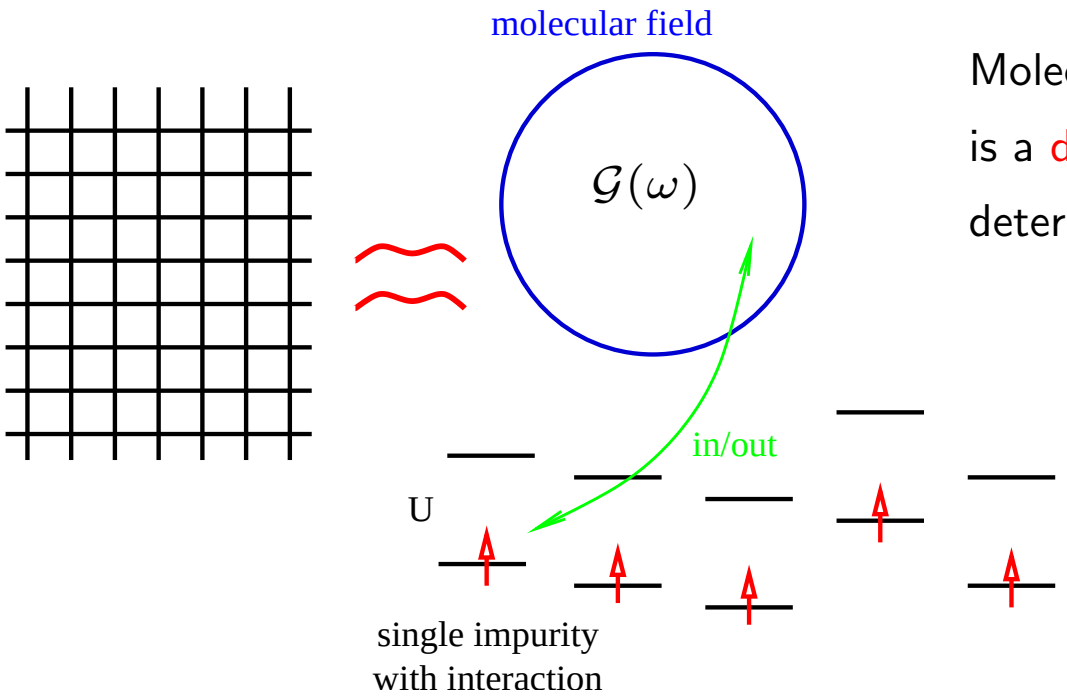
Schubert et al., cond-mat/0309015

Dynamical mean-field theory for U and Δ

Byczuk, Hofstetter, Vollhardt, Phys. Rev. Lett. **94**, 056404 (2005)
after idea from: Dobrosavljevic et al., Europhys. Lett. **62**, 76 (2003)

Lattice problem of interacting particles is mapped onto

an ensamble of single impurities (single atoms)



Molecular (Weiss) function $\mathcal{G}(\omega)$

is a dynamical quantity,

determined self-consistently

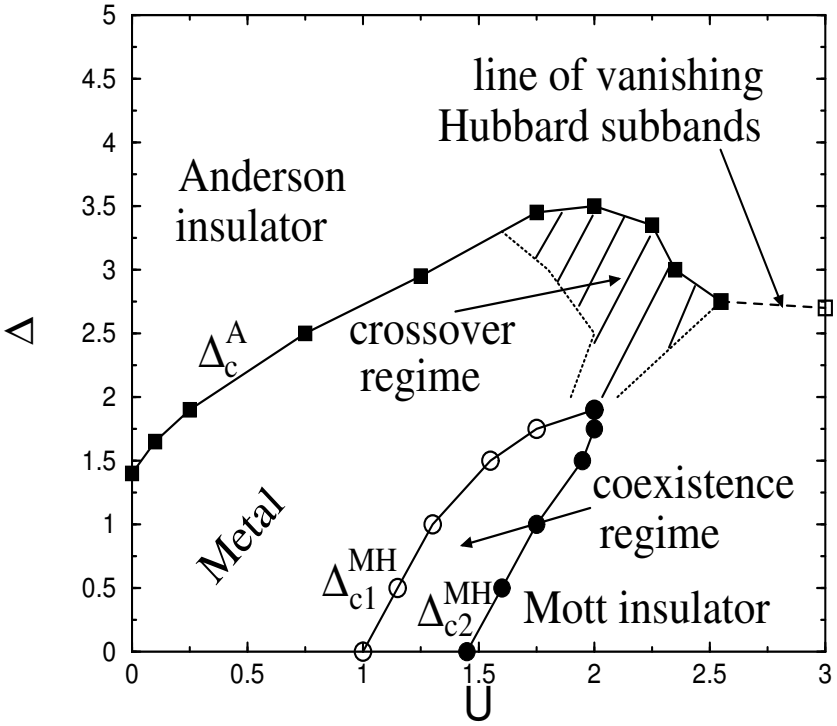
$$\rho_{typ}(E) = e^{\langle \ln \rho_i(E) \rangle}$$

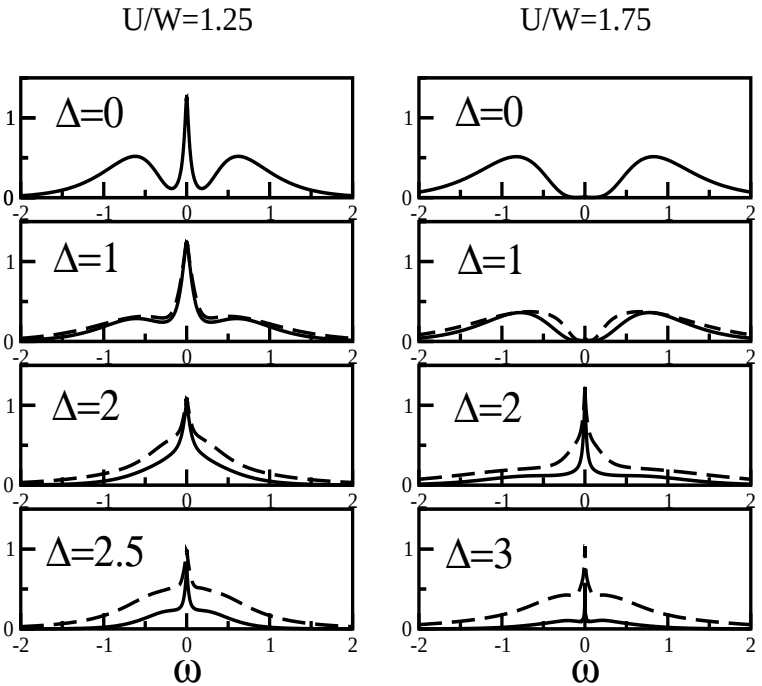
$$H = \sum_{i\sigma} \epsilon_i n_{i\sigma} + \sum_{ij\sigma} t_{ij}\ a^\dagger_{i\sigma} a_{j\sigma} + U \sum_i n_{i\uparrow} n_{i\downarrow}$$

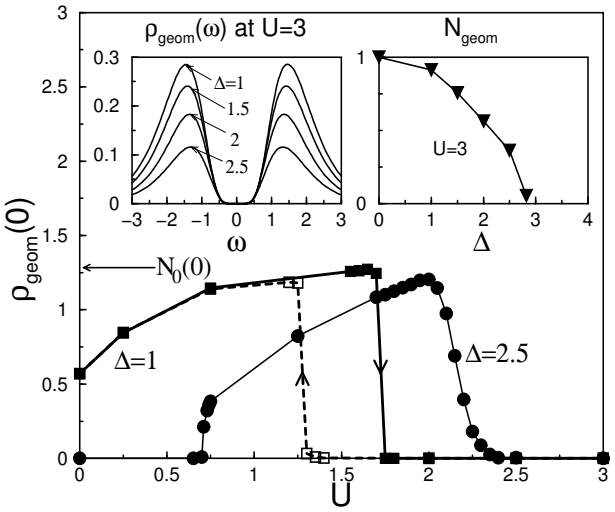
Phase diagram for disordered Hubbard model

(NRG solver, PM phase, $n = 1$, $T = 0$)

- Metallicity stabilized by U and Δ
- Mott gap closed by disorder, reentrant Mott-Hubbard MIT
- Anderson localization U-dependent (effective band-width)
- Luttinger (FL) due to U
- Hysteresis and crossover
- Insulators adiabatically connected



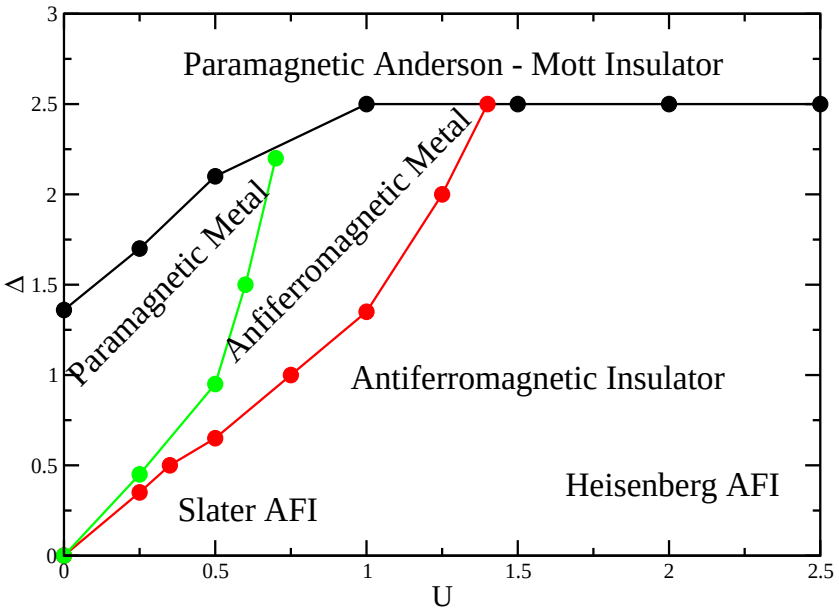




Phase diagram for disordered Hubbard model

(NRG solver, AFM phase, $n = 1$, $T = 0$)

- Metallicity stabilized by U and Δ
- Slater AFI - AF metal transition (small U)
- Heisenberg AFI stable (large U)
- Anderson localization U-dependent (effective band-width)



Conclusions and outlook

- Geometrical means used to study Anderson MIT in correlated electron system within DMFT
- Complete phase diagrams
- PM case: Two insulators connected continuously
- PM and AF cases: Interaction and disorder compete with each other stabilizing the metallic phase against the occurring one of the insulators
- AF case: AFI-AFM-PMM-PMAI transitions