Lecture IV	13 August 2019	(11:00 – 12:30)

Plan

1. Metal-insulator transitions in the 2D Hubbard model with CDMFT
   a) U-driven MIT
   b) δ-driven MIT
2. antiferromagnetism
3. superconductivity

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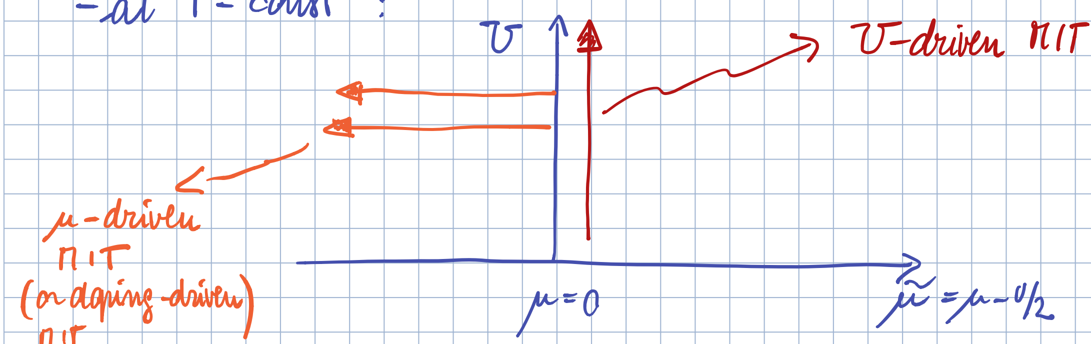
1. Metal insulator transitions in the 2D Hubbard model with CDMFT

– 3D parameter space to explore : U, μ, T

– at $T = \text{const}$:



a) U-driven MIT

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my discussion follows C. Walsh et al., PRB 2019 :

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.99.075122

(see, in particular, sections III, IV, and V)

I have discussed:

(i) T-U phase diagram

- double occupancy: first order transition, Widom line, Mott endpoint
- single occupancy and charge compressibility

[see Walsh et al., PRB 2019, section III:
https://journals.aps.org/prb/abstract/10.1103/PhysRevB.99.075122]

(ii) thermodynamic stability

[see Walsh et al., PRB 2019, section V:
https://journals.aps.org/prb/abstract/10.1103/PhysRevB.99.075122]

(iii) Density of states

[see H. Park et al., PRL 2008:
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.101.186403]

b) doping driven MIT

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(i) high temperature metal to Mott insulator crossover

- single occupancy and charge compressibility
- thermodynamic density fluctuations

[my discussion follows C. Walsh et al., PRB 2019

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.99.165151

(see, in particular, section III)]

- relevance for cold atom experiments

  see the following articles:

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.116.175301

  https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.117.135301

  https://science.sciencemag.org/content/353/6305/1260

(ii) lower temperatures

- $T-\mu$ phase diagram (or $T-\delta$ phase diagram)
- $U-\mu$ phase diagram
- single occupancy and charge compressibility: first-order transition at finite doping between a Fermi liquid and a pseudogap, Widom line
- phase characterisation: Mott insulator, pseudogap, Fermi liquid

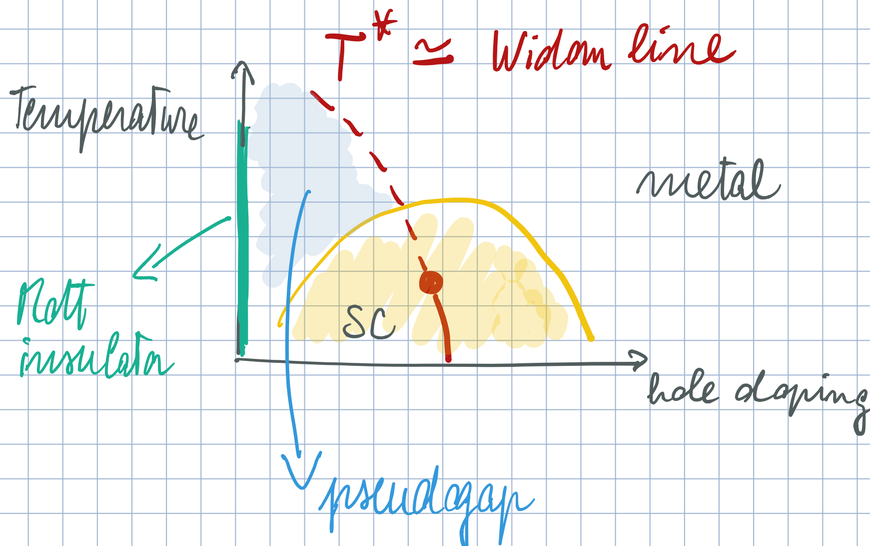
[my discussion follows G. Sordi et al., PRL 2010 / PRB 2011 / Sci. Rep. 2012:

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.104.226402

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.84.075161

https://www.nature.com/articles/srep00547]

- relevance for hole-doped phase diagram:
  onset of the pseudogap T^* ⟷ Widom line
  (pseudogap temperature as the Widom line)



[for further details, see
https://www.nature.com/articles/srep00547
https://journals.aps.org/prb/abstract/10.1103/PhysRevB.87.041101
https://www.sciencedirect.com/science/article/pii/S1631070514000267]

② antiferromagnetism (AF)

a) introduction

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i) Mott physics and AF

ii) Mott insulators and AF are often in close proximity in real systems

iii) AF can partially or completely hide the Mott transition

[for further details, see A.M. Tremblay :

https://www.cond-mat.de/events/correl13/manuscripts/tremblay.pdf

(see, in particular, section 3)]

b) AF in the 2D Hubbard model

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[for further details, see :

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.95.235109]

③ Superconductivity (SC)

a) introduction

⇝ see blackboard

i) Mott insulators and unconventional SC are often in close proximity in real systems

ii) why SC (attraction) from Hubbard U (repulsion)?

- large U
- small U

[for further details, see A.M. Tremblay :

https://www.cond-mat.de/events/correl13/manuscripts/tremblay.pdf

(see, in particular, section 4)]

b) SC in the 2D Hubbard model

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[for further details, see

https://www.cond-mat.de/events/correl13/manuscripts/tremblay.pdf

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.108.216401

https://www.nature.com/articles/srep22715]