Application of the Finite-Momentum Method

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1.1 Decorated Graphene Model

Critical Temperatures

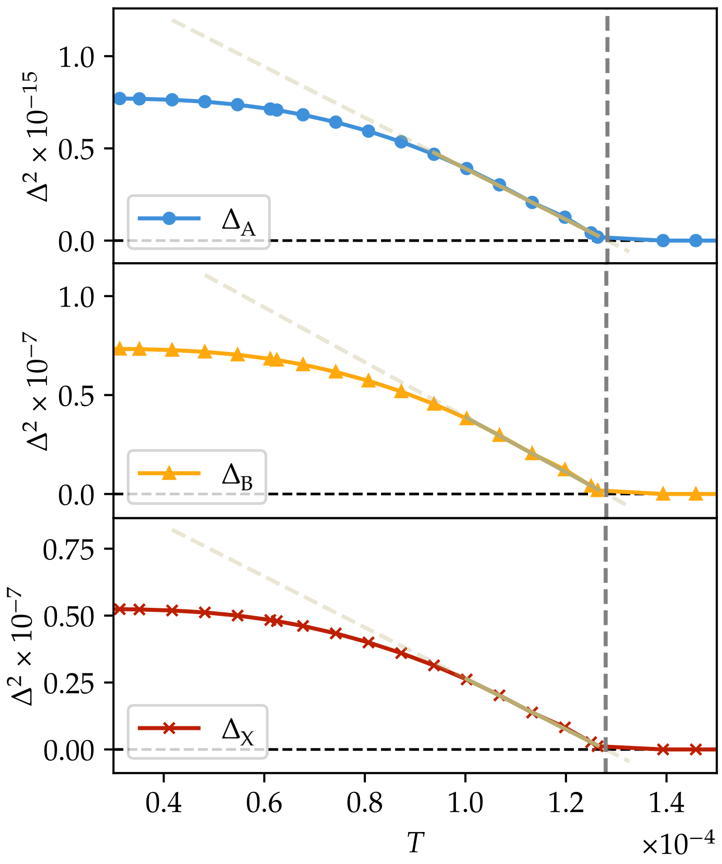

Figure 1.1 – Linear fit for extracting the critical temperature

Critical temperatures via **??**:

$$|\Psi|^2 \propto T_C - T\,. \tag{1.1}$$

Fit and corresponding T_C are shown in fig. 1.1. Notable:

- the gaps Δ_α have very different orders of magnitude, but fall in the same way, i.e. have the same critical temperature

Can plot critical temperatures against V and U.
Figure 1.2 shows T_C and gaps against V.

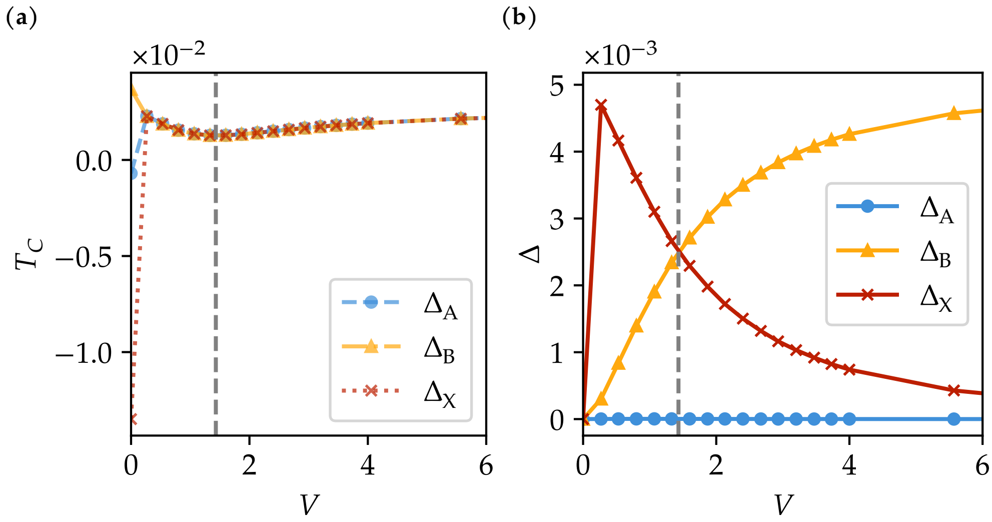

Figure 1.2 – **T** (**a**) Critical temperatures vs V. (**b**) Gaps vs V .

Notable:

- Miminum of T_C and gaps at some $V = 1.43$, corresponds with metallic V in repulsive Hubbard model
- But no gap closure
- TC follows maximal gap
- What is happening at $V = 0$? New jobs This

Figure 1.3 shows T_C and gaps against U for different V.

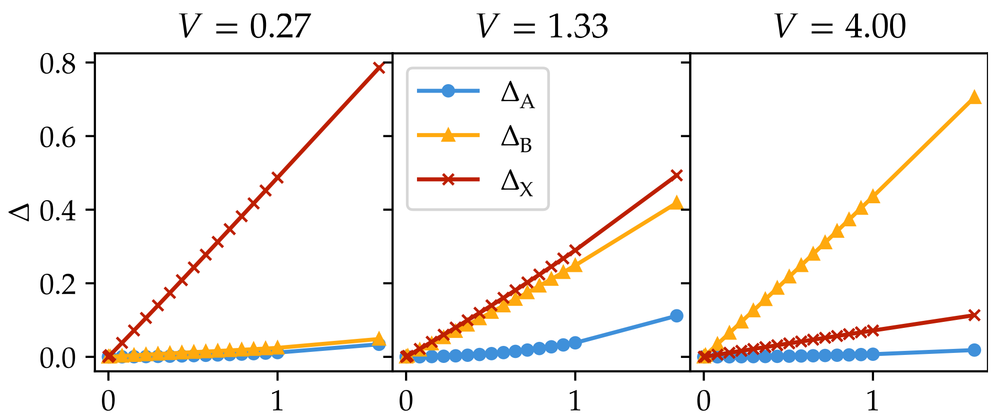

Figure 1.3 – Gaps vs U. for different V

Notable:

- Low V: flat band on X, high V: flat band on Graphene B, medium V: both
- Linear with interaction strength, typical for flat band in BCS (reference)
- mirrors the switchover seen in the gaps against V and the band structure

Extracting the Superconducting Length Scales

Plot two important gaps against q in fig. 1.4 for a medium V

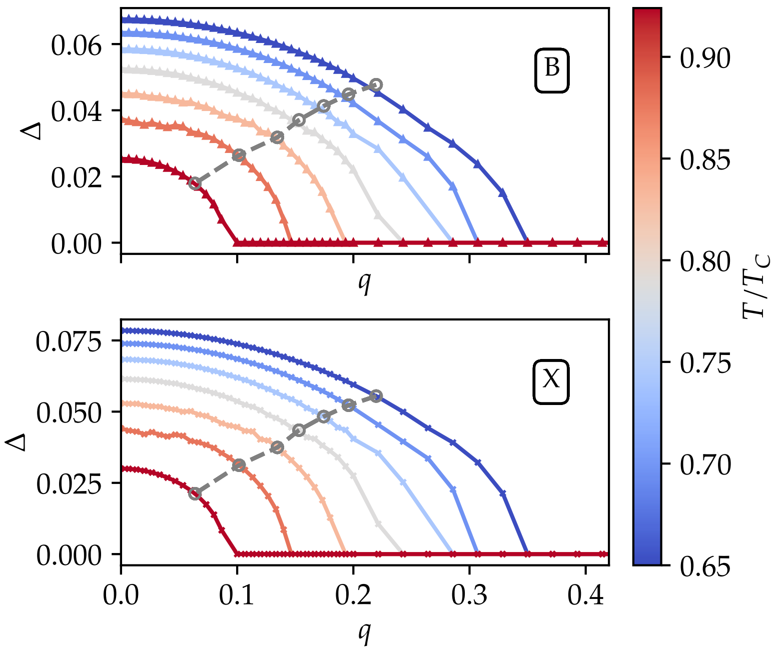

Figure 1.4 – Gap vs q

Notable:

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Plot two important gaps against q in fig. 1.5 for a high and low V

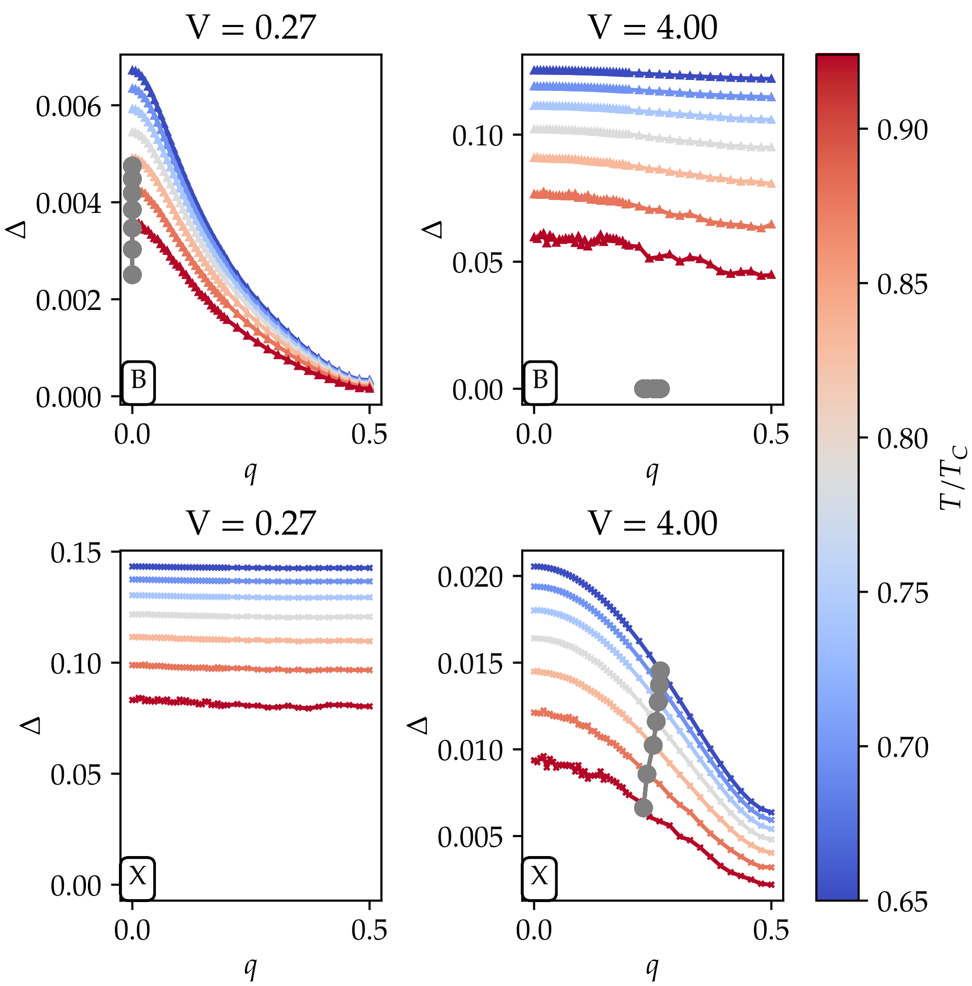

Figure 1.5 – Gap vs q

Notable:

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Take

$$\xi(T) = \frac{1}{\sqrt{2}|\mathbf{Q}|} \tag{1.2}$$

with **Q** such that

$$\left|\frac{\psi_{\mathbf{Q}}(T)}{\psi_0(T)}\right| = \frac{1}{\sqrt{2}} \tag{1.3}$$

Plot also current against q fig. 1.6

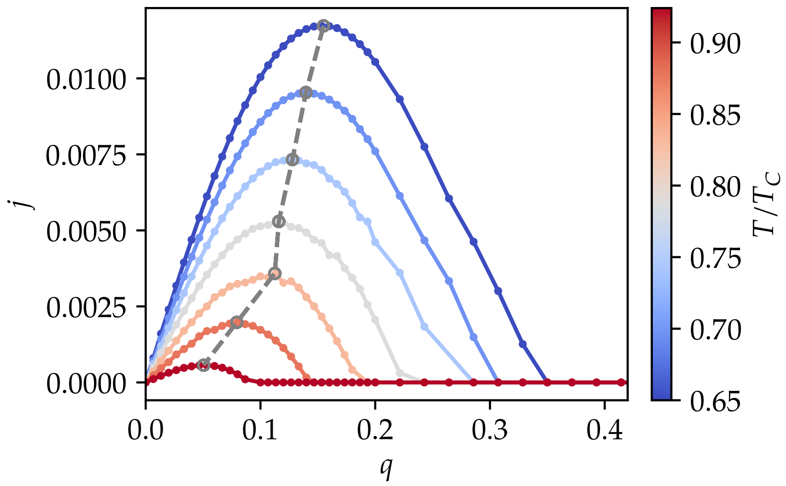

Figure 1.6 – Current against q

Notable:

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Calculate $\xi(T)$ and $\lambda_{\mathrm{L}}(T)$. Plot against T and fit to get $\xi_0, \lambda_{L,0}$.

Plot also current for low and high V

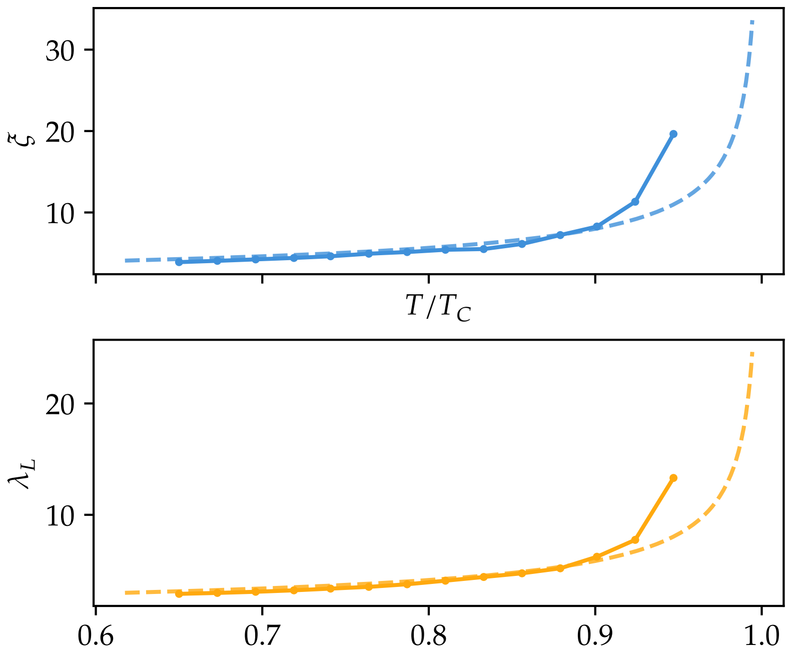

Figure 1.7 – Temperature fits for xi and lambda

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Length Scales

Plot SC length scales vs V, between different gaps

More data points for quantum metric, x axis

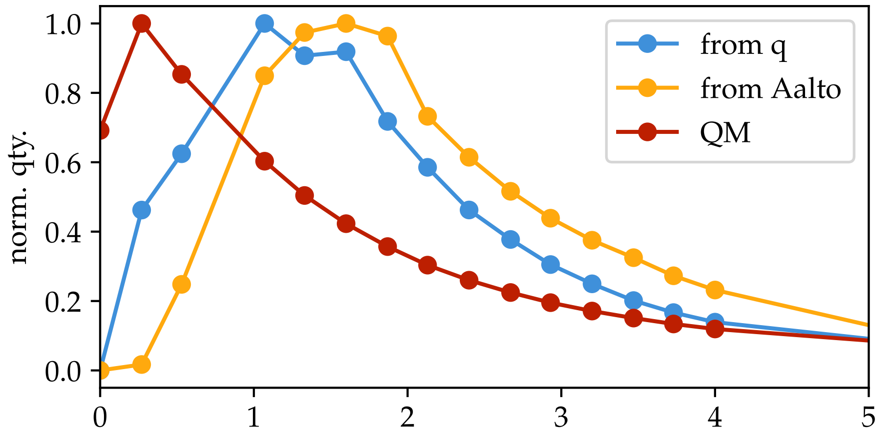

Figure 1.8 – DS

1.2 One-Band Hubbard Model on the Square Lattice

Can extract T_C same way as above. Plot it against U.

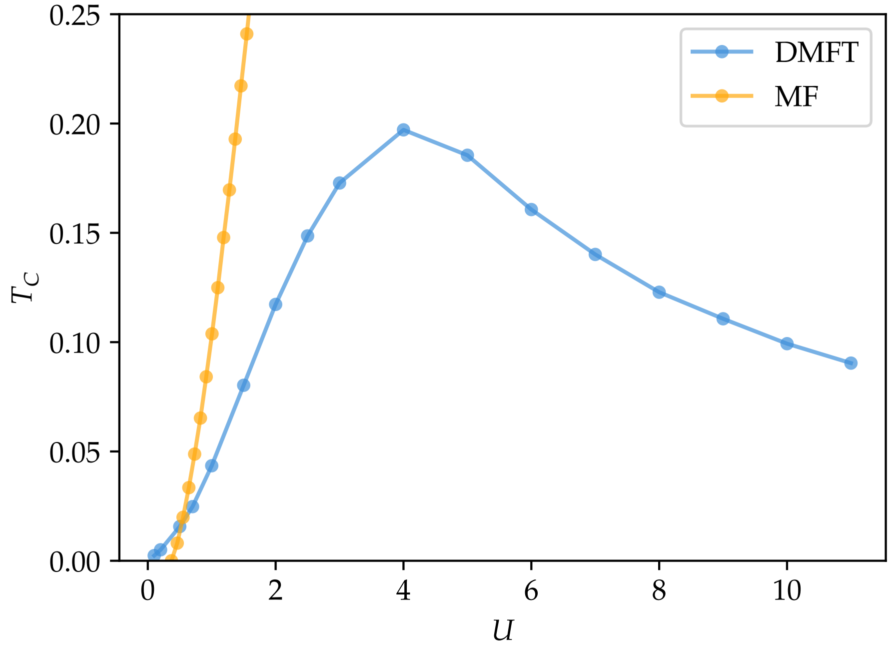

Figure 1.9 – TC against U (also mean field results)

Notable:

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Extracting Superconducting Length Scales

Extraction same as before, plot gap and current against q in section 1.2.

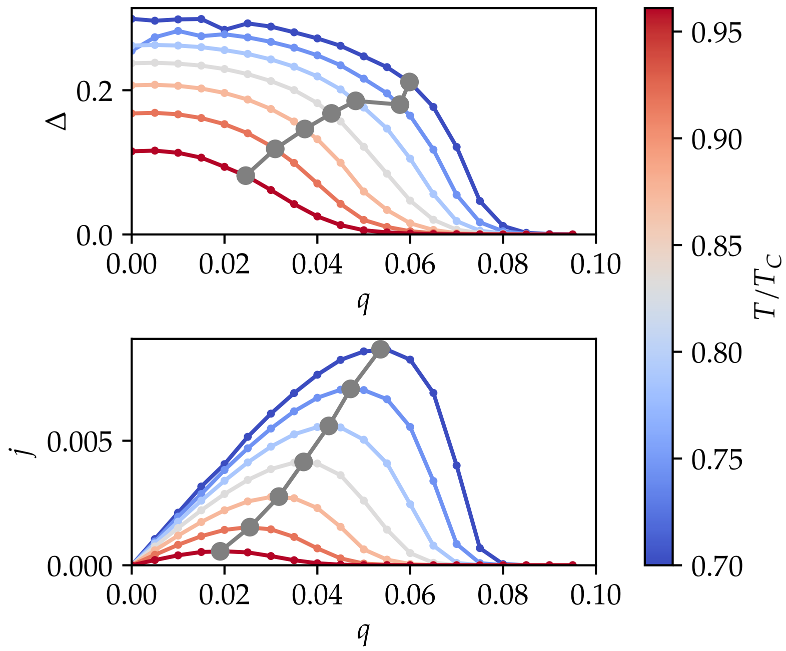

Figure 1.10 – Gap and current vs q.

Notable:

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Calculate $\xi(T)$ and $\lambda_{\mathrm{L}}(T)$. Plot against T and fit to get ξ_0, $\lambda_{L,0}$.

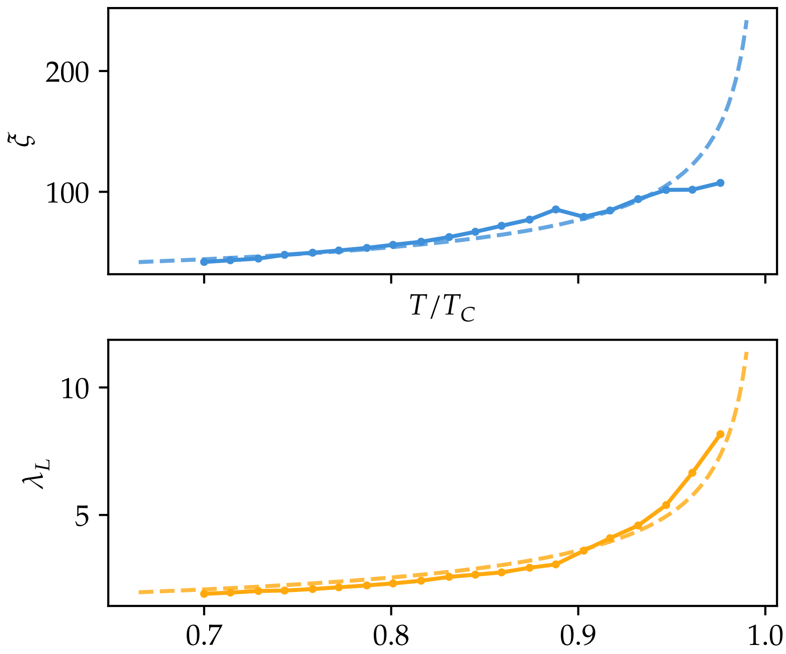

Figure 1.11 – Temperature fits for xi and lambda

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BCS-BEC Crossover

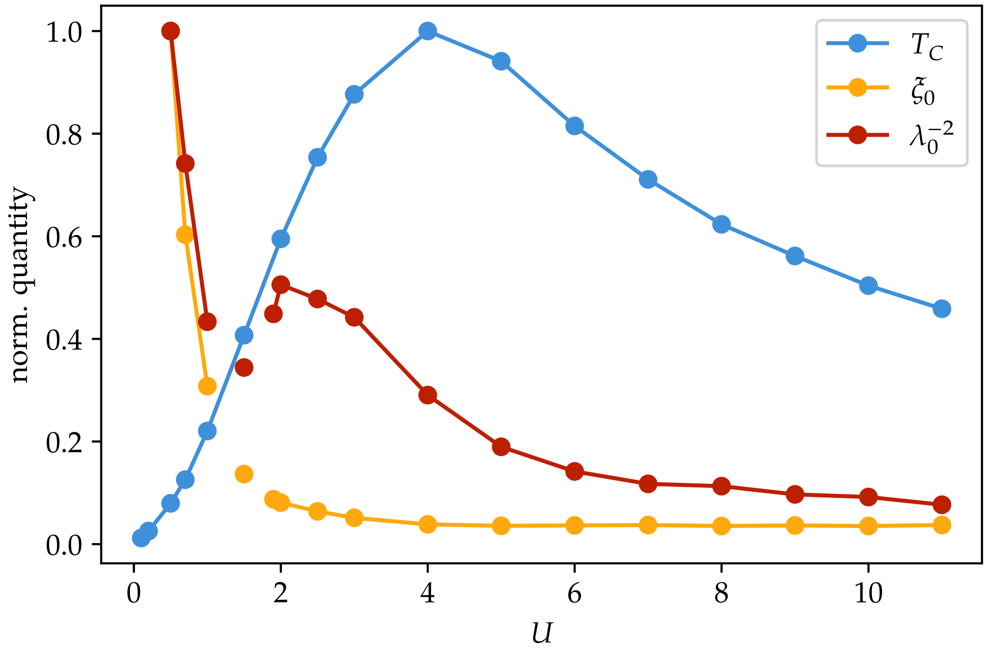

Figure 1.12 – Normalized TC/xi/DS against U (to show BCS-BEC crossover)

Comparison of MF and DMFT Data

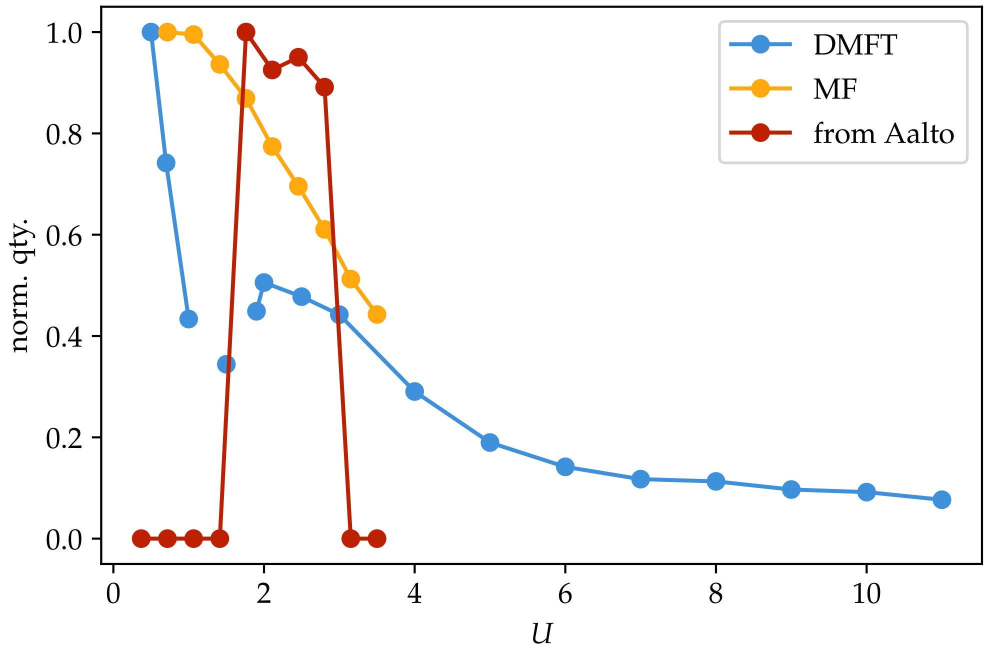

Figure 1.13

Plot MF and DMFT xi and lambda against U