Interaction Induced Collapse of a Section of the Fermi Sea in the Zig-Zag Hubbard Model

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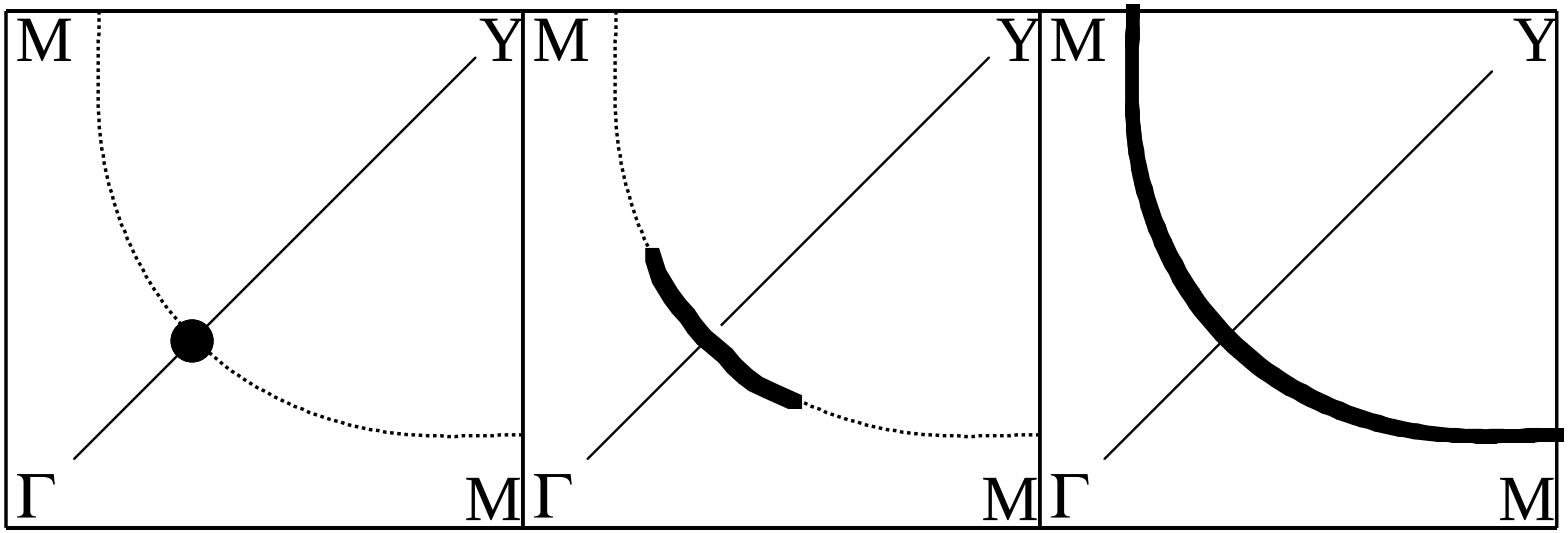
Phys. Rev. B (2001)
Phys. Rev. Lett. (2002)

- ◇ a short motivation
- ◇ analytical and numerical results
- ◇ further subjects

Fermi-surfaces of high-temperature superconductors

◇ example: $Bi_2Sr_2CaCu_2O_8$ (Bi2212, $T_c = 90\,K$)

$T < T_c$ $T \gtrsim T_c$ $T \gg T_c$



[ARPES]

Fermi-point Fermi-arc Fermi-surface

M.R. Norman *et al* Nature (1998)

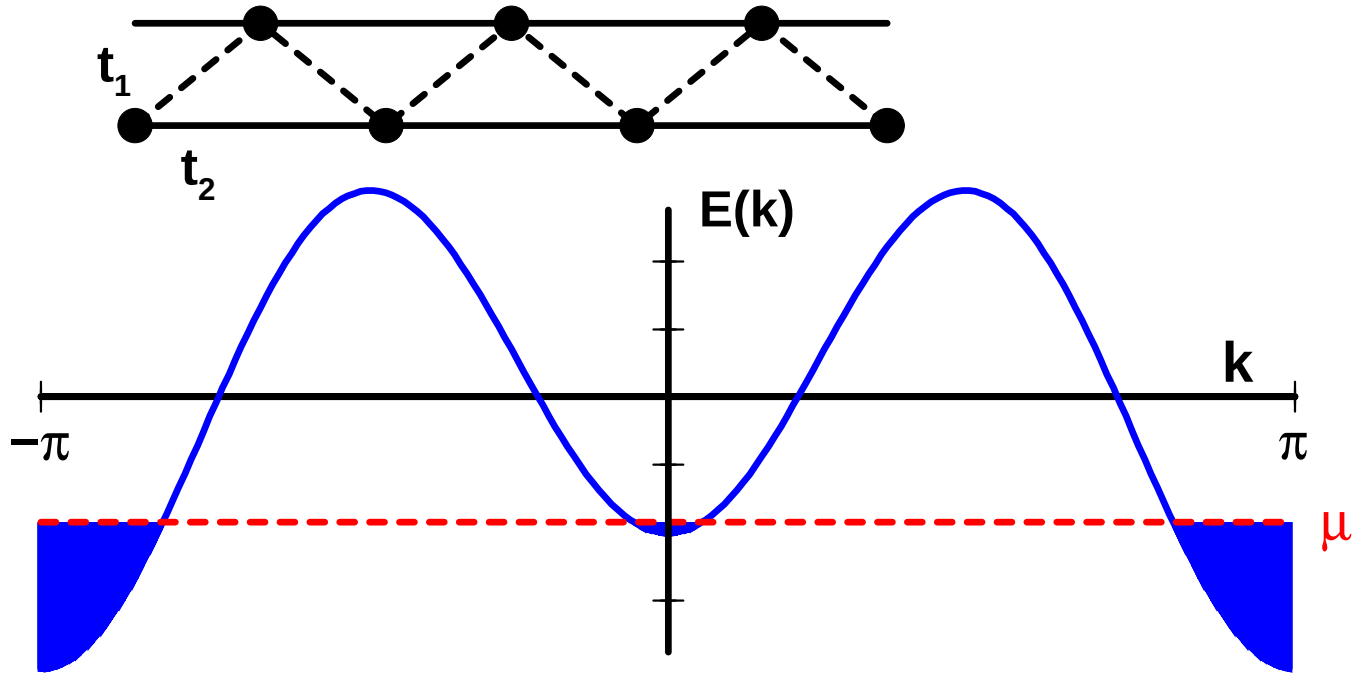
◇ part of the Fermi-surfaces disappears (pseudogap)

▷ smaller temperatures $\Longleftrightarrow$ bigger correlations

model: zig-zag ladder

$[t_1 - t_2$ model$]$

hopping-parameter: $t_1,\ t_2$ onsite-repulsion: U



big Fermi-sea v_2 small Fermi-sea v_1 big Fermi-sea v_2

different Fermi-velocities: $v_2 \gg v_1$

weak-coupling RG

[analytical]

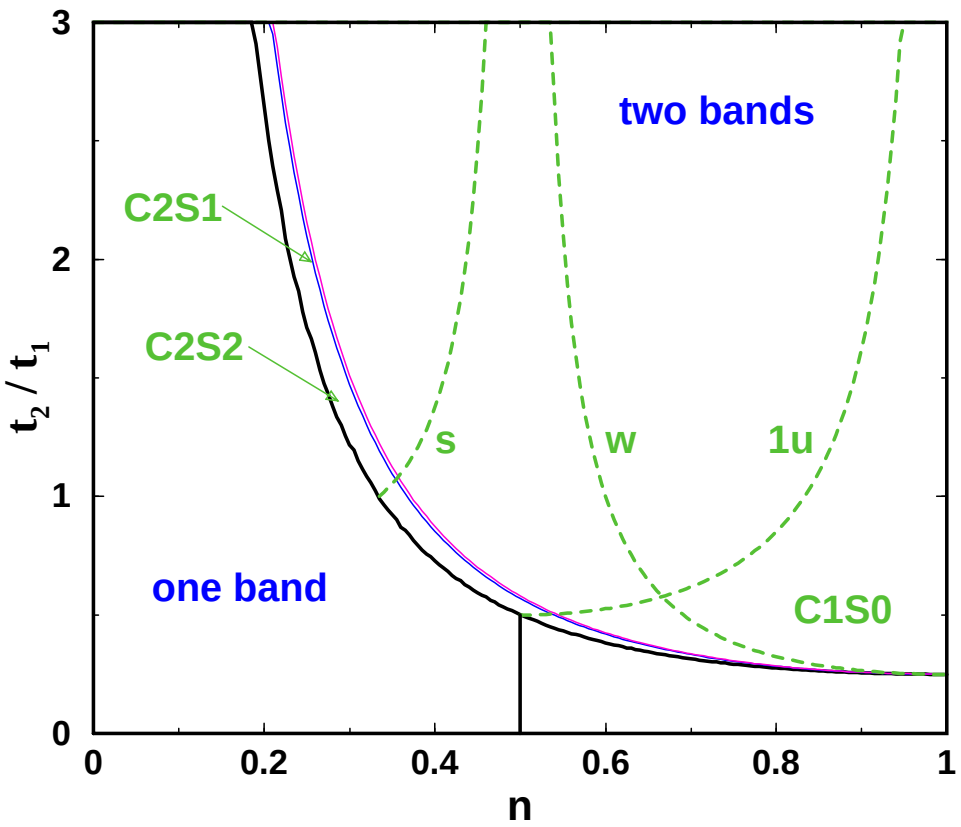
$$\frac{dU}{d\log\Lambda} \sim U^2$$

◇ coupling-constants at the Fermi-Surface: U $\longrightarrow$ g_1, g_2, ...

phase-diagram

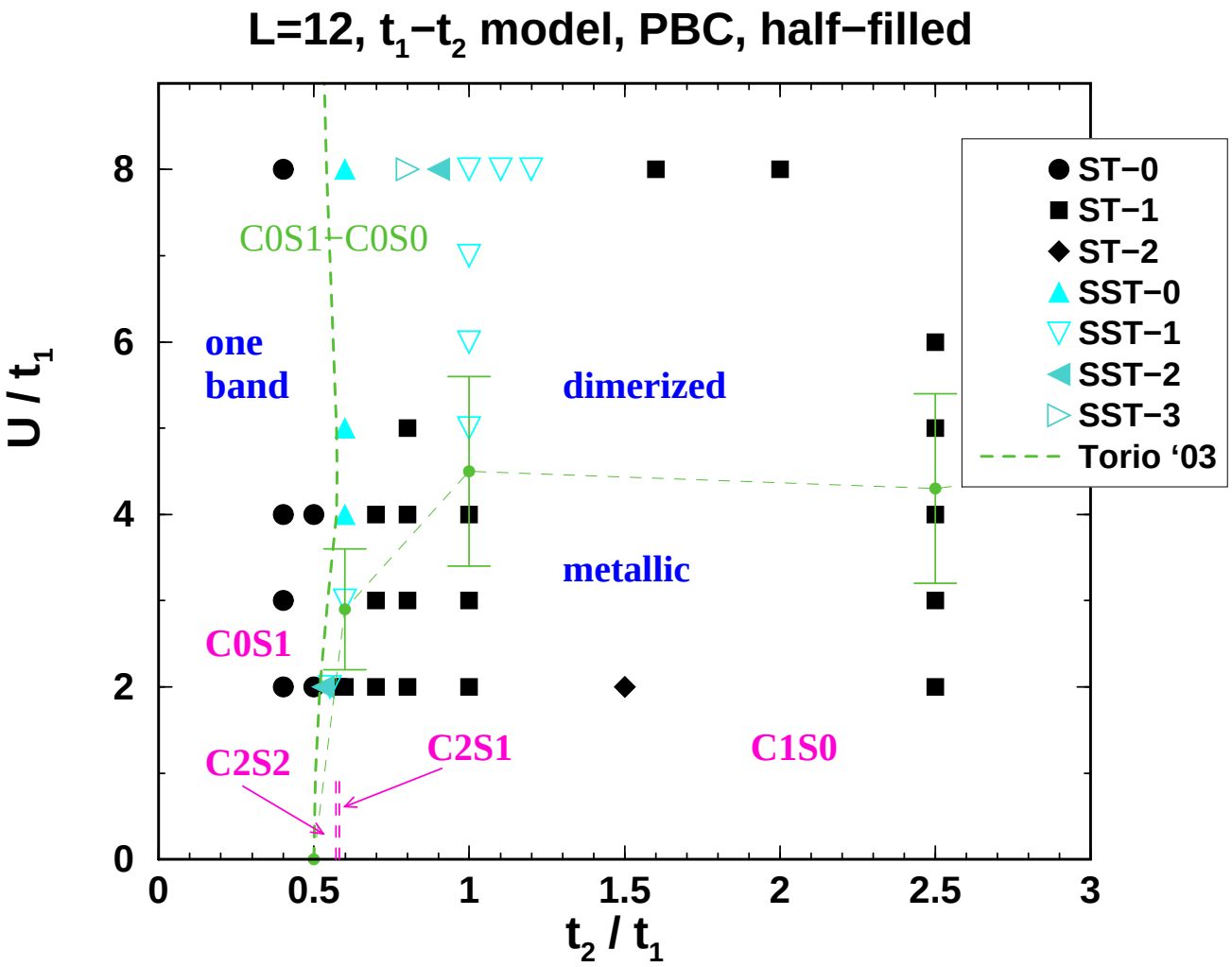
◇ CnSm-phase

n: gapless charge-modes
m: gapless spin-modes

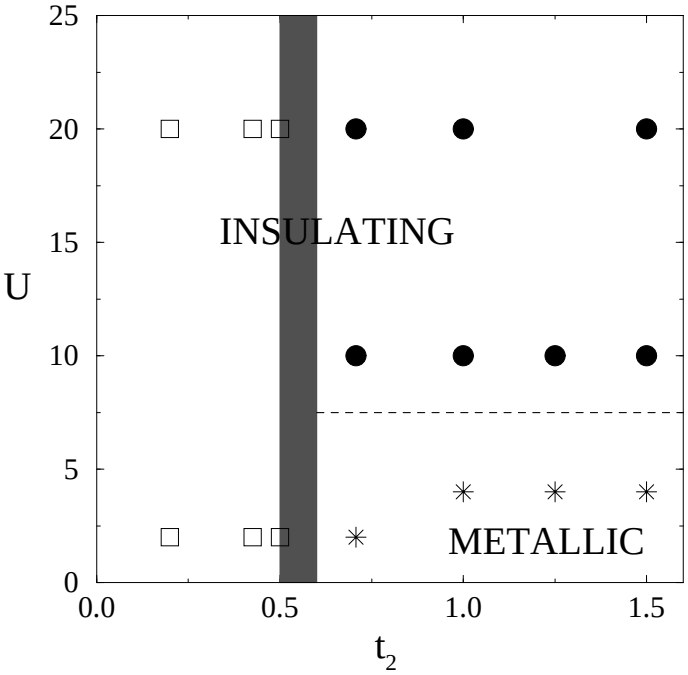


Balents & Fischer '96
Louis, Alvarez & Gros '01

work in progress



exact diagonalization, Gros *et al.* '03



DMRG, Daul & Noak '00

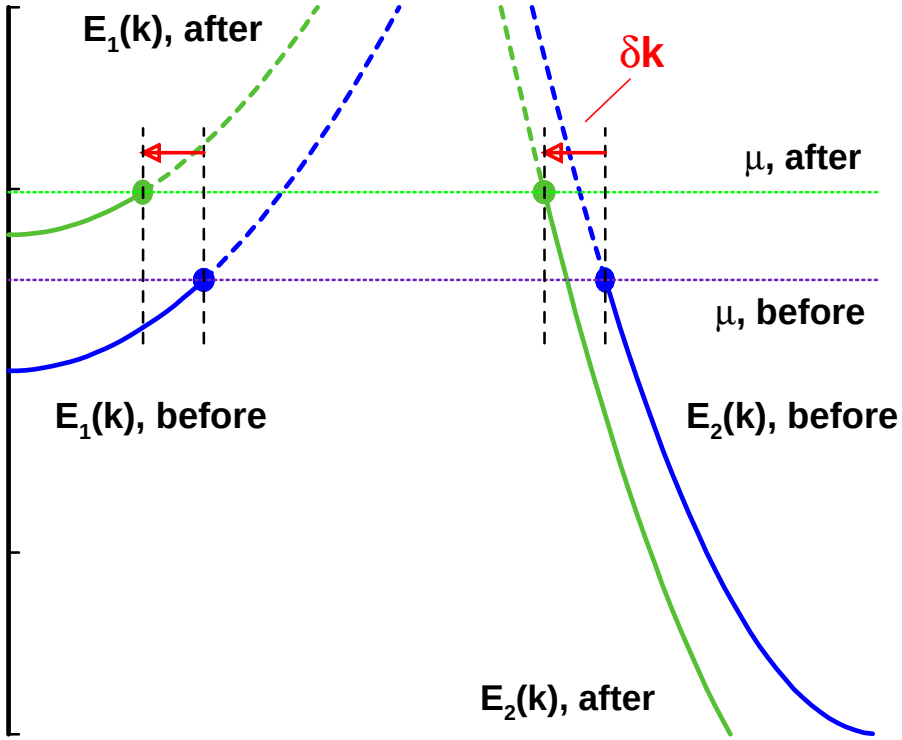
RG of bands

- ◇ Hartree-diagramm renormalizes both Fermi-seas differently
- ◇ RG-equations for Fermi-wavevector k_F

$$\frac{d\,k_F}{d\log\Lambda} = \frac{2\,\Lambda}{v_1+v_2}\left(g_{2\rho}-g_{1\rho}\right)$$

- ▷ forward-scattering $g_{i,\rho}=g_{i,\rho}(\Lambda)$ in charge-channel, band = 1,2
- ▷ relevant: Λ-dependent

bands, before and after renormalization



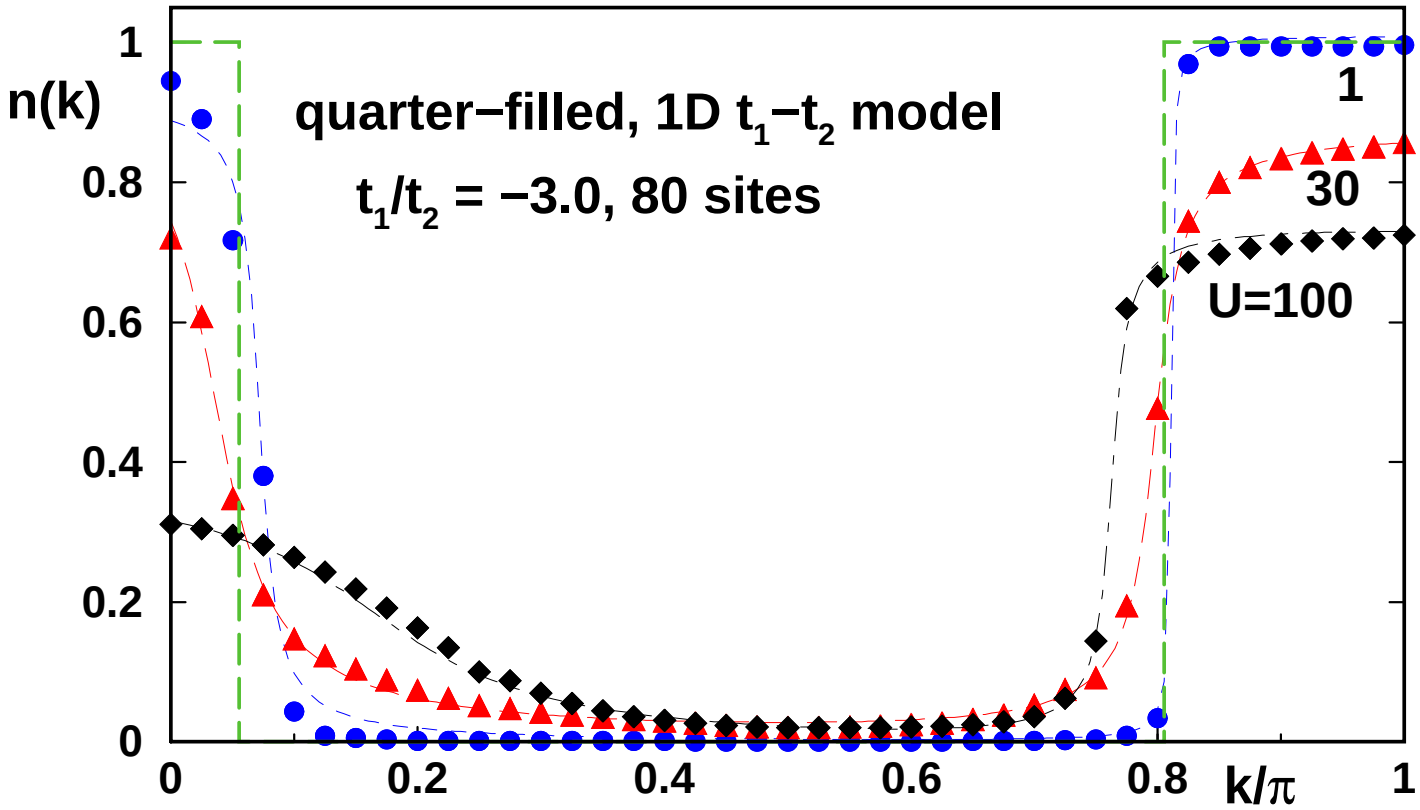
$\Longrightarrow$ time-integration:

$$\Delta k_{tot} = \frac{v_2-v_1}{(v_1+v_2)^2}\,\frac{\Lambda_0}{v_1 v_2}\,\frac{U^2}{\pi^2}$$

$U \to 0$

DMRG: n(k)

[momentum-distribution-function]



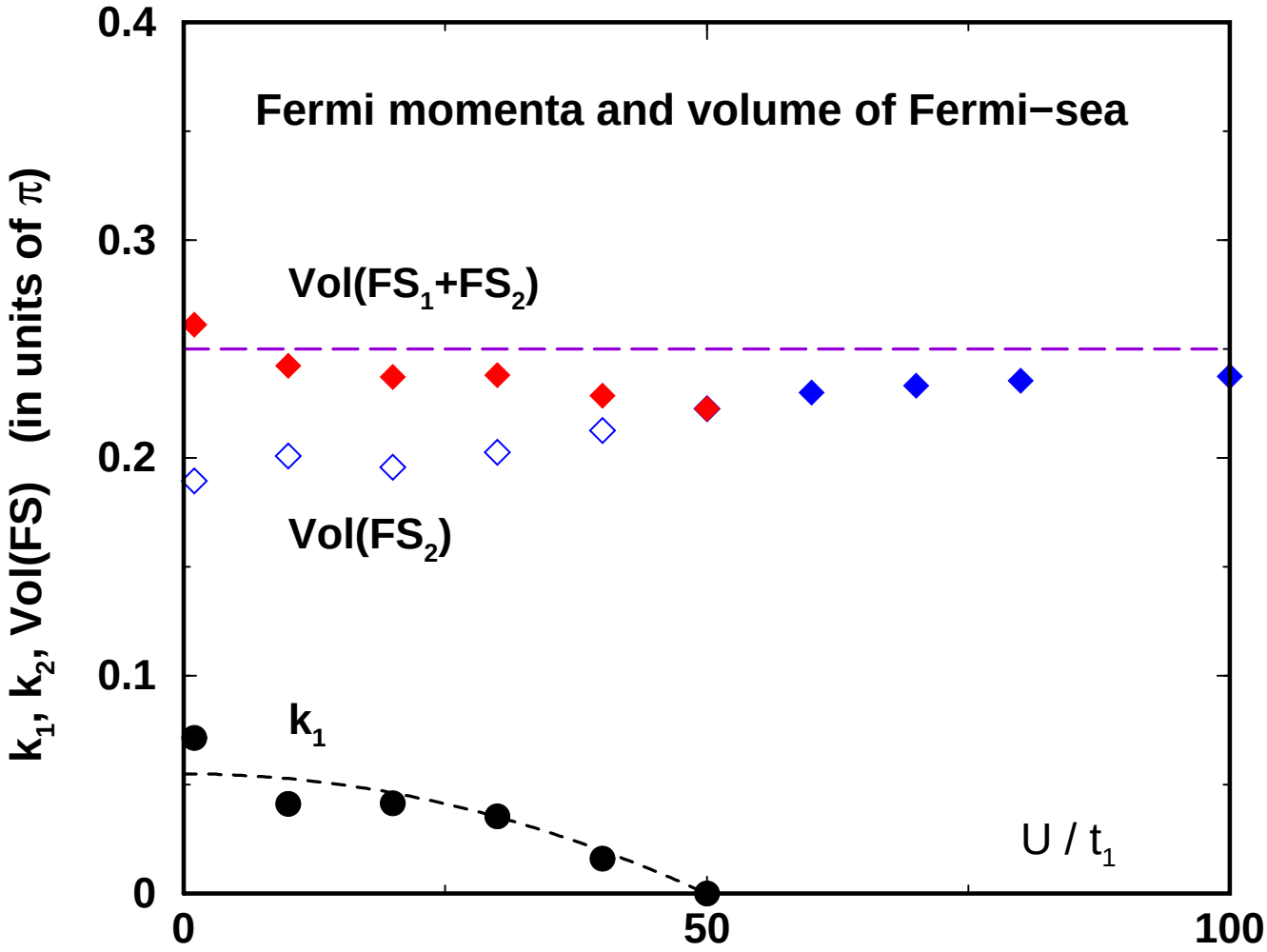
fit

$$n(k) \;=\; a_0 \;+\; a_1 \,\mathrm{atan}(b_1(k-k_1)) \;+\; a_2 \,\mathrm{atan}(b_2(k-k_2))$$

$\Longrightarrow$ Fermi-momenta $k_i(U)$

shift of the Fermi-edge

[DMRG]



▷ quantum-phase-transition: $U_c \approx 50\, t_1$ $\begin{cases} U < U_c & : \text{ two Fermi} - \text{seas} \\ U > U_c & : \text{ one Fermi} - \text{sea} \end{cases}$