TPSC: How it works

e-doped

TPSC: general ideas

- General philosophy
  - Drop diagrams
  - Impose constraints and sum rules
    - Conservation laws
    - Pauli principle ($\langle n_\sigma^2 \rangle = \langle n_\sigma \rangle$)
    - Local moment and local density sum-rules
- Get for free:
    - Mermin-Wagner theorem
    - Kanamori-Brückner screening
    - Consistency between one- and two-particle $\Sigma G = U \langle n_\sigma n_{-\sigma} \rangle$

Vilk, AMT J. Phys. I France, **7**, 1309 (1997);
Theoretical methods for strongly correlated electrons also (Mahan, 3rd)

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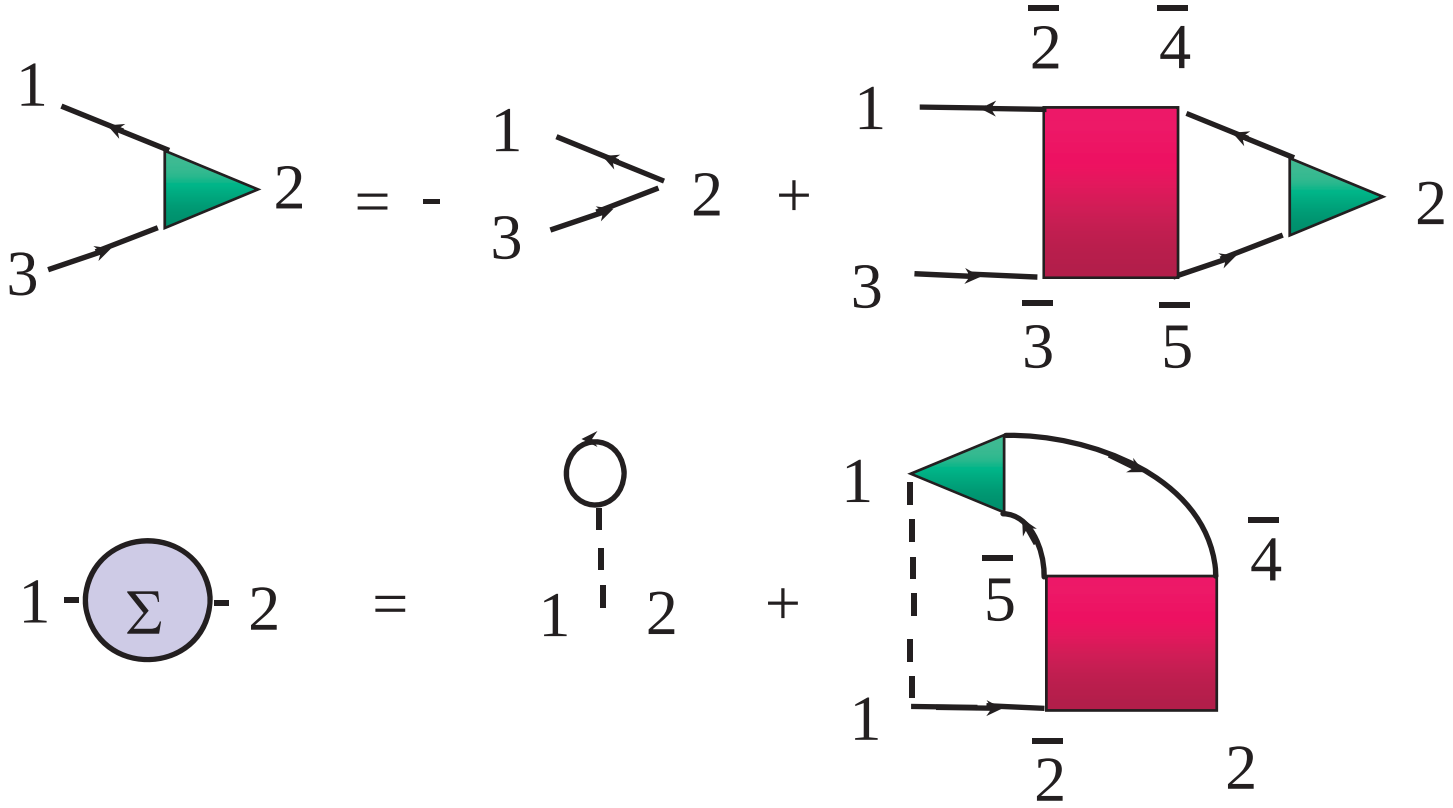
TPSC: Single-particle properties

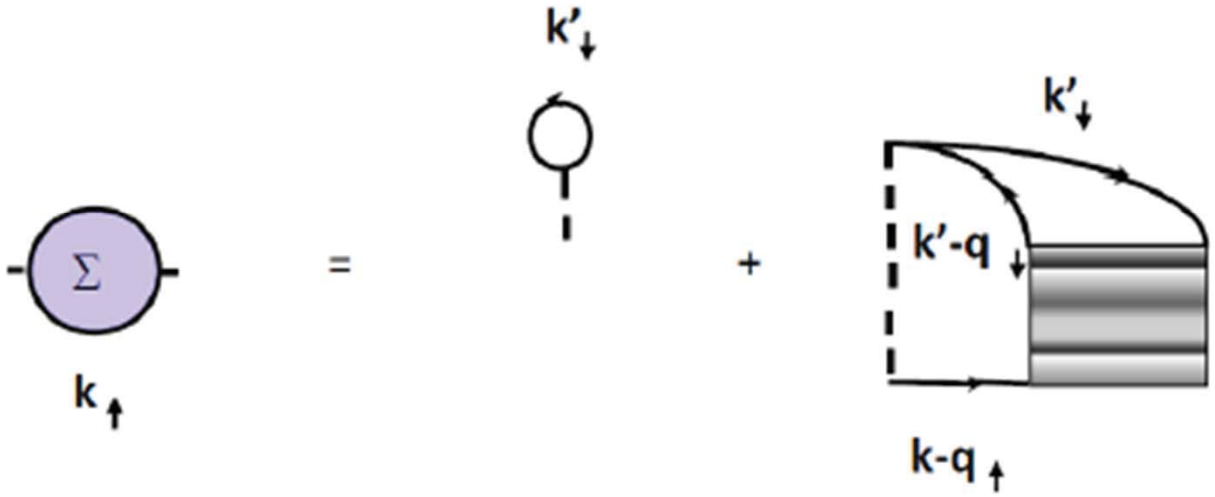
A better approximation for single-particle properties (Ruckenstein)



Y.M. Vilk and A.-M.S. Tremblay, J. Phys. Chem. Solids **56**, 1769 (1995).
Y.M. Vilk and A.-M.S. Tremblay, Europhys. Lett. **33**, 159 (1996);

N.B.: No Migdal theorem

Crossing symmetry



Self-energy in TPSC

$$\Sigma_\sigma^{(2)}(k) = U n_{\bar{\sigma}} + \frac{U}{8}\frac{T}{N}\sum_q \left[3U_{sp}\chi_{sp}^{(1)}(q) + U_{ch}\chi_{ch}^{(1)}(q)\right] G_\sigma^{(1)}(k+q)$$

Does not assume Migdal. Vertex at same level of approximation as G

$$\chi_{sp}^{(1)}(q) = \frac{\chi_0(q)}{1 - \frac{1}{2}U_{sp}\chi_0(q)}$$

$$\left\langle (n_\uparrow - n_\downarrow)^2 \right\rangle = \langle n_\uparrow \rangle + \langle n_\downarrow \rangle - 2\langle n_\uparrow n_\downarrow \rangle \qquad \frac{T}{N}\sum_q \chi_{sp}^{(1)}(q) = n - 2\langle n_\uparrow n_\downarrow \rangle$$

$$U_{sp} = U\frac{\langle n_\uparrow n_\downarrow \rangle}{\langle n_\uparrow \rangle \langle n_\downarrow \rangle}$$ Kanamori-Brückner screening

=

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Internal accuracy check

Internal accuracy check

$$\frac{1}{2}\mathrm{Tr}\left(\Sigma^{(2)}G^{(1)}\right) = U\left\langle n_\uparrow n_\downarrow\right\rangle \qquad \frac{1}{2}\mathrm{Tr}\left(\Sigma^{(2)}G^{(2)}\right)$$

f- sum rule (conservation law)

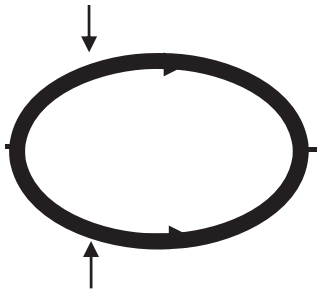
$$\int \frac{d\omega}{\pi}\omega\chi''_{ch,sp}\left(\mathbf{q},\omega\right) = \lim_{\eta\to 0} T\sum_{i\omega_n}\left(e^{-i\omega_n\eta} - e^{i\omega_n\eta}\right) i\omega_n\chi_{ch,sp}\left(\mathbf{q}, i\omega_n\right)$$

$$= \frac{1}{N}\sum_{\mathbf{k}\sigma}\left(\epsilon_{\mathbf{k}+\mathbf{q}} + \epsilon_{\mathbf{k}-\mathbf{q}} - 2\epsilon_{\mathbf{k}}\right) n_{\mathbf{k}\sigma}$$

TPSC superconductivity

Method

$$\chi_d = \frac{\delta G}{\delta \eta} =$$



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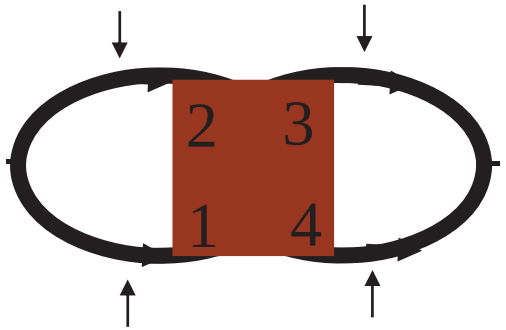
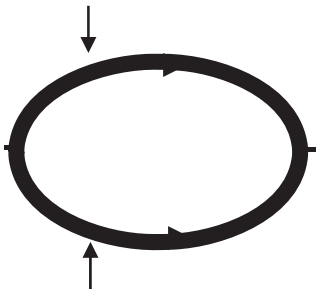


$$\frac{\delta G}{\delta \eta} = GG\left(1 + \frac{\delta \Sigma}{\delta \eta}\right)$$

$$G = \frac{1}{G_0^{-1} - \eta - \Sigma}$$

$$\chi_d = \frac{\delta G}{\delta \eta} \sim$$



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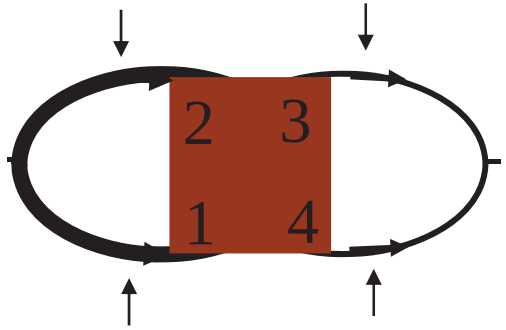
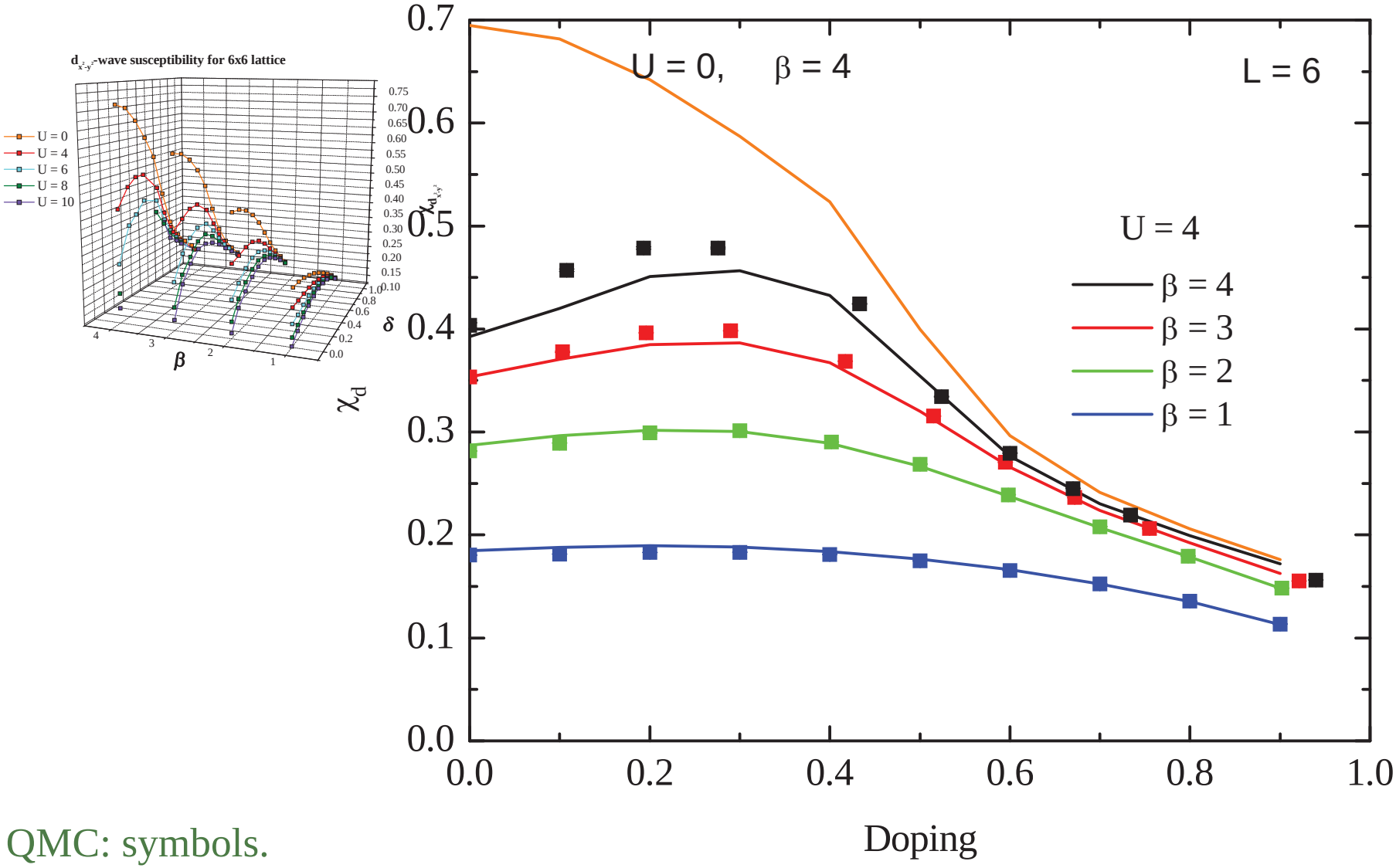


Σ for spin fluctuations, in the presence of off-diagonal source field



QMC: symbols.
Solid lines analytical.

Kyung, Landry, A.-M.S.T. PRB (2003)

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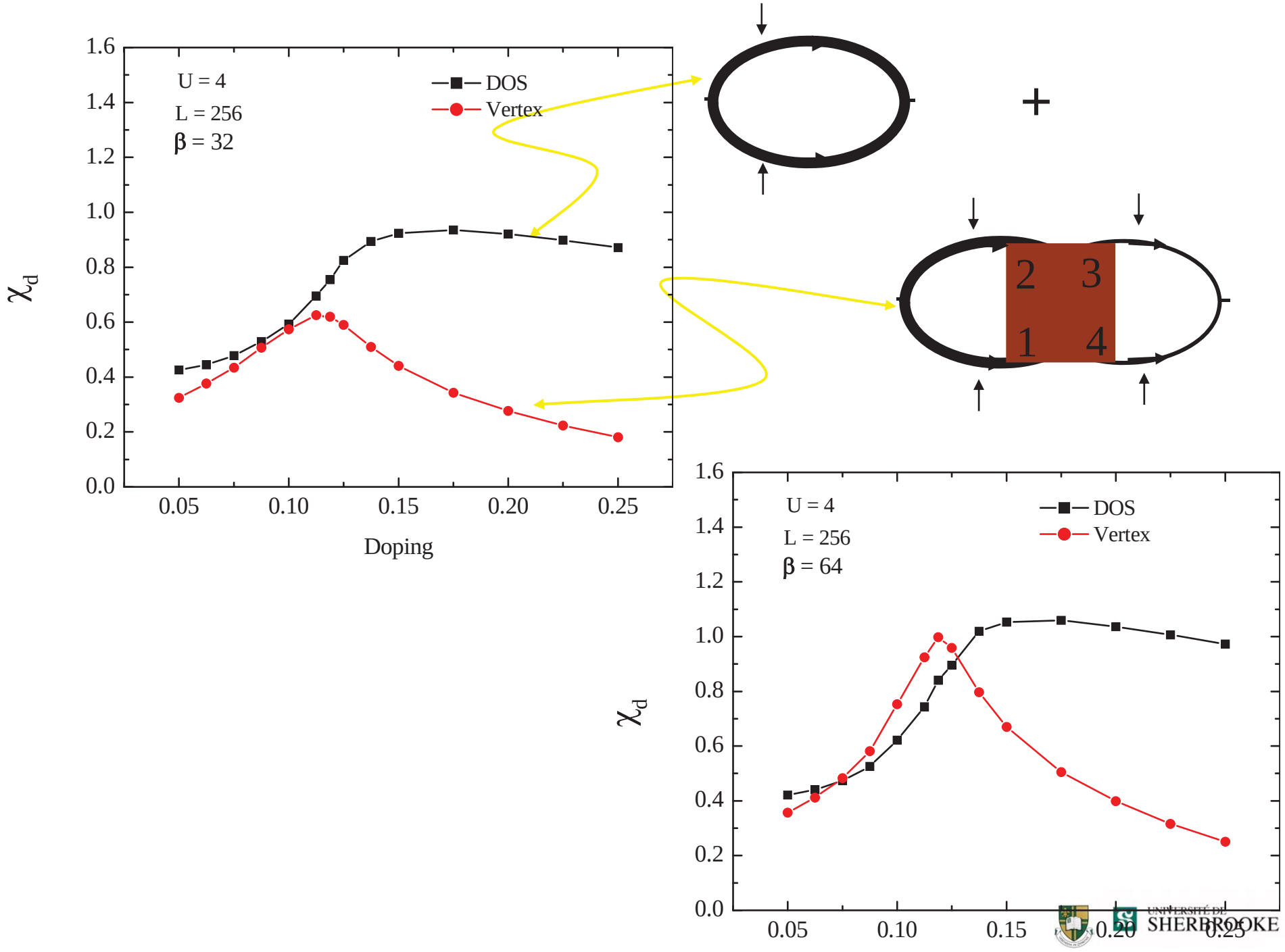
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
χ_d
U = 4
L = 256
β = 32
DOS
Vertex
0.05
0.10
0.15
0.20
0.25
Doping
+
2
3
1
4
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
χ_d
U = 4
L = 256
β = 64
DOS
Vertex
0.05
0.10
0.15
0.20
0.25

To do

- Calculate T_c for e-doped
- Include feedback of SC on AFM fluctuations
  - (explain correlation length near optimal doping)
- Take atomic limit as starting point to generalize to strong correlations?
- Generalize to broken symmetry states and multiband
- Generalize to longer range interaction
  - Davoudi, AMST PRB **74**, 035113 (2006); PRB **76**, (2007);


Merci
Thank you