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NUMERICAL ATTEMPTS TO OBSERVE DECONFINED CRITICALITY

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Collaborators

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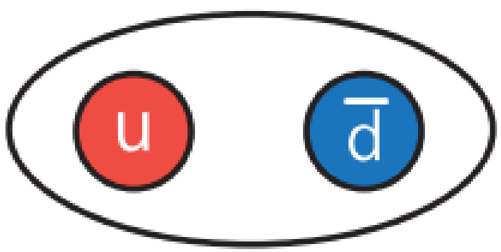
ISSP (Kobe): **Todo**, Sakashita
Fujitsu: Shitara

Special thanks to Matsuo (RIST)

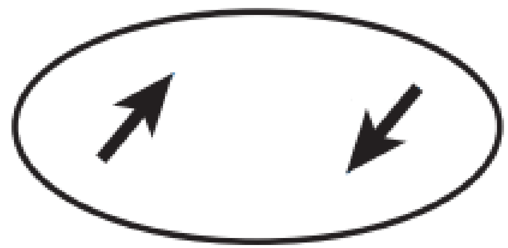
Confinement

Pion



~10^{-15} m

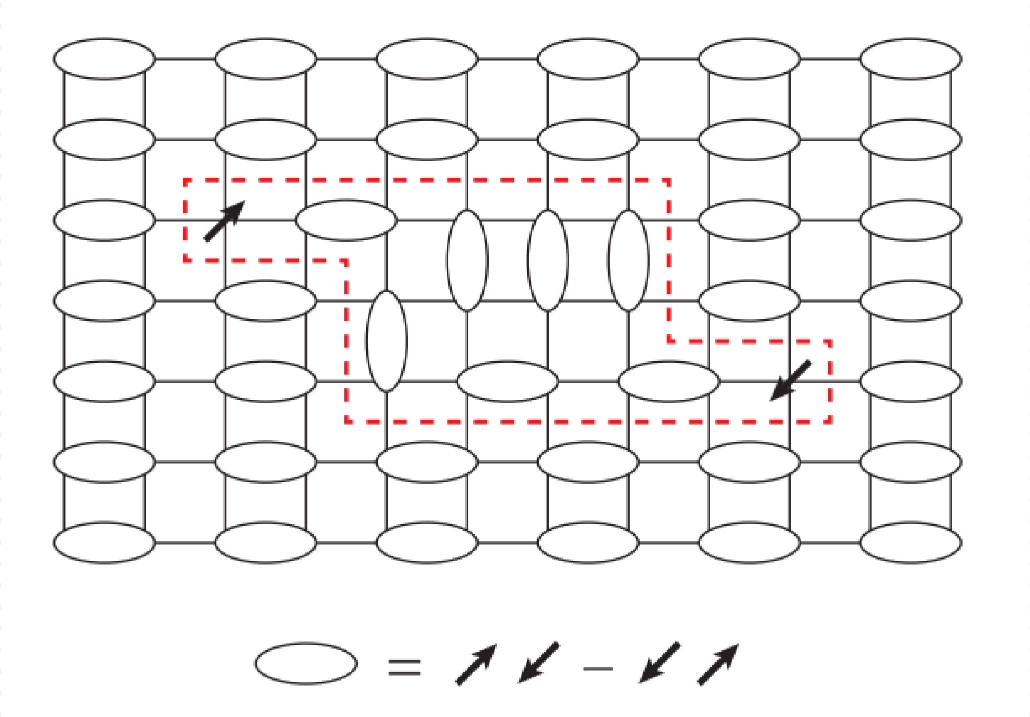
Singlet Pair



~10^{-10} m

Governed by a similar mechanism,
in spite of big difference in scale.

Confinement of Spinons

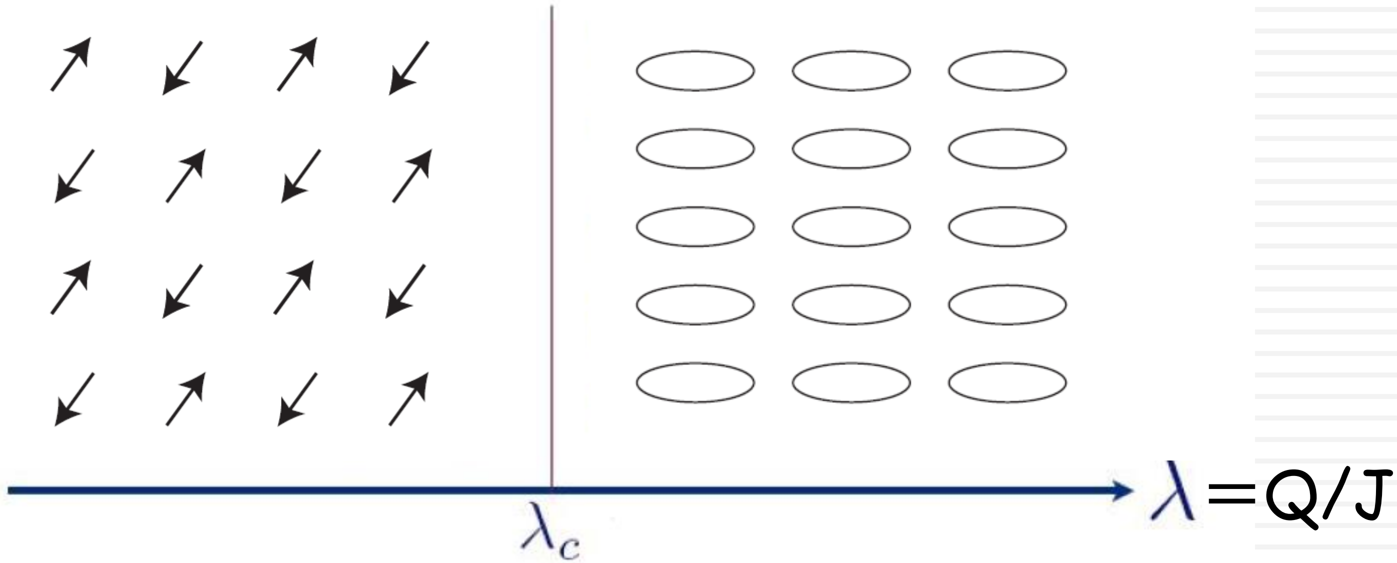


Breaking a singlet and creating two spinons cause the damage in the background texture proportional to the distance.

$\Rightarrow$ confinement potential

Magnetic/Non-Magnetic Transition

Symmetry-breaking may occur spontaneously.



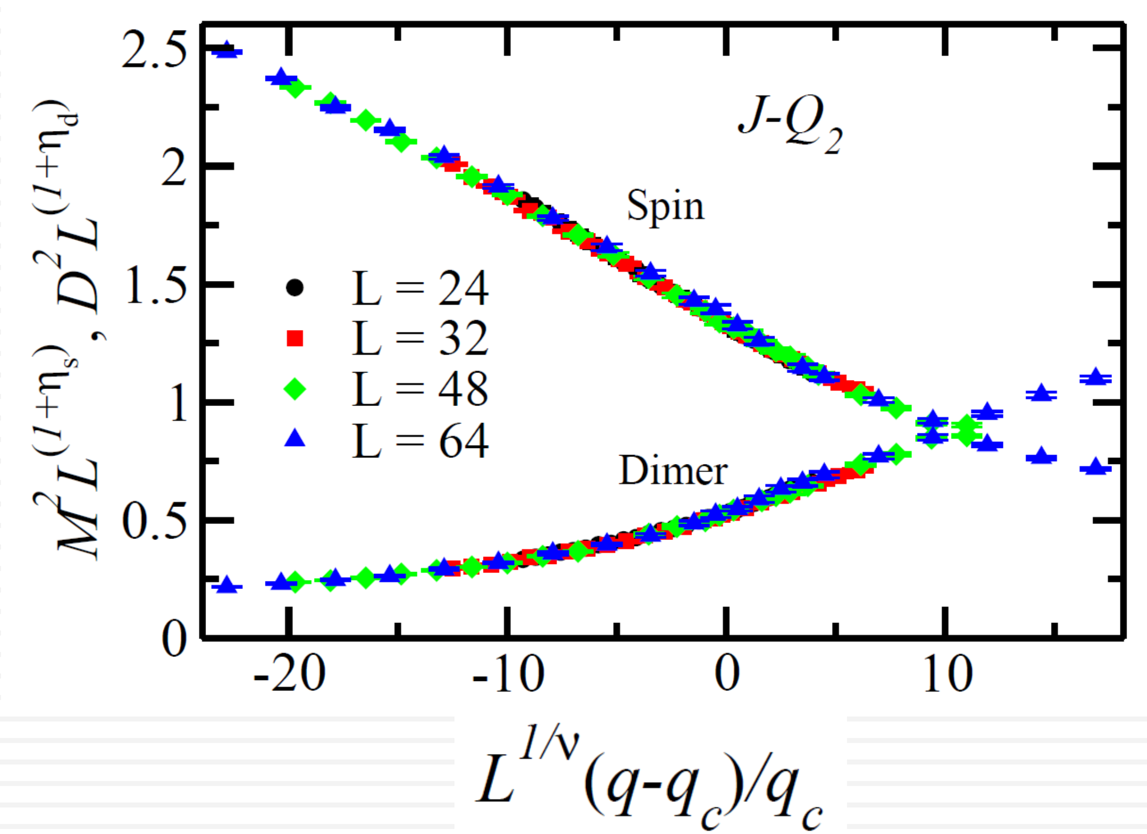
$$H = J\sum_{(ij)} S_i \cdot S_j - Q \sum_{p=(i,j,k,l)} \left(\frac{1}{4} - S_i \cdot S_j\right)\left(\frac{1}{4} - S_k \cdot S_l\right)$$

(Sandvik, 2007)

--- What universality class?

Deconfined Critical Phenomena?

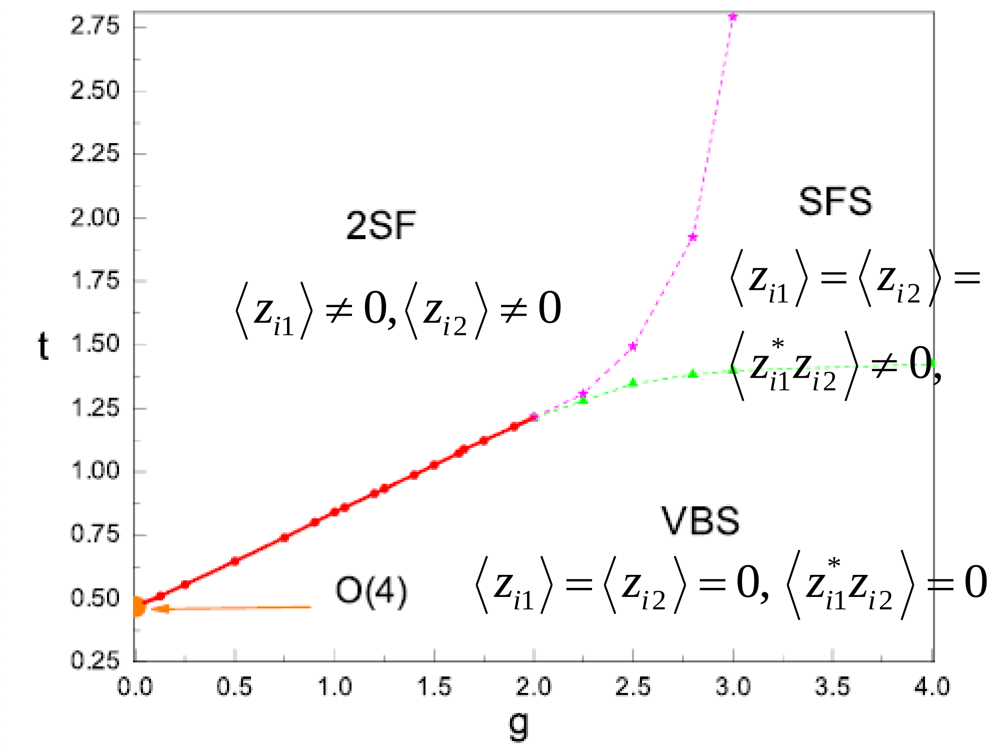
SU(2) J-Q Model

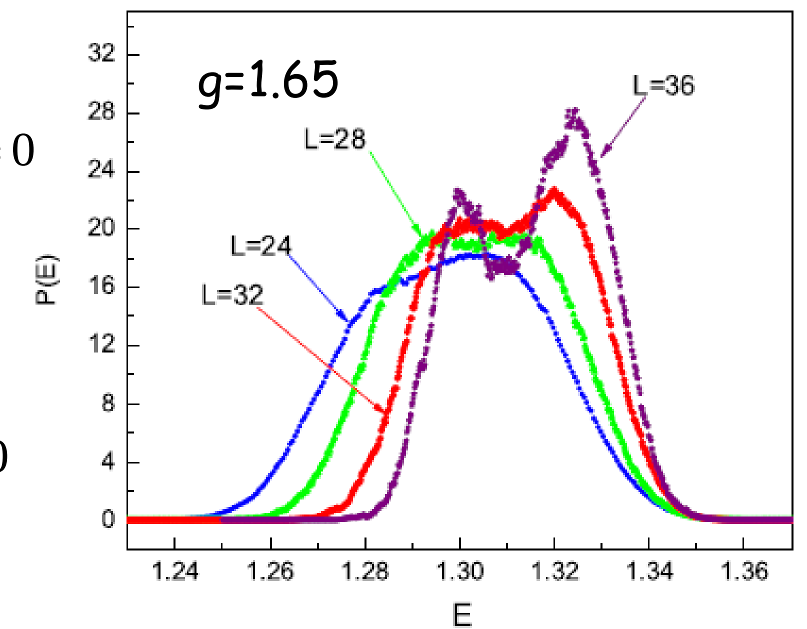


$q = Q_p/(J + Q_p)$

Scaling plot works beautifully.

SU(2) Symmetric NCCP¹ Model



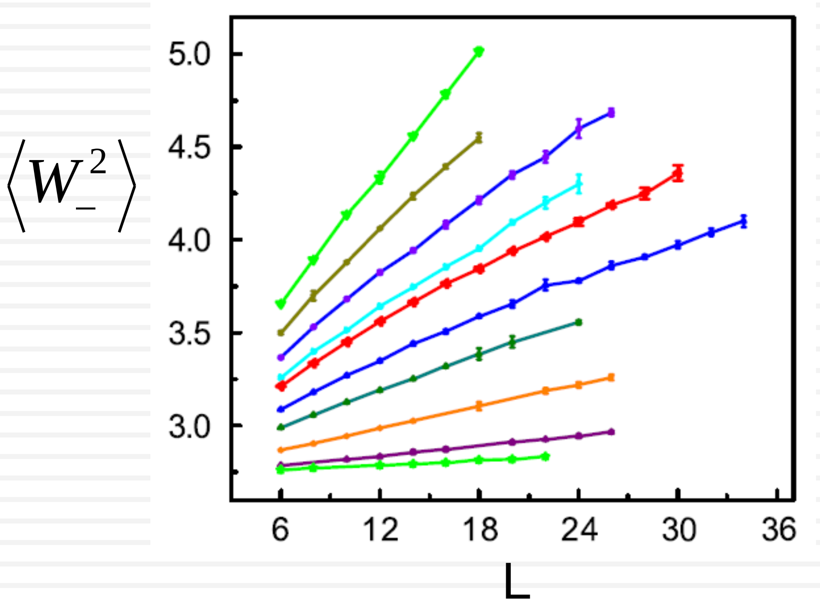


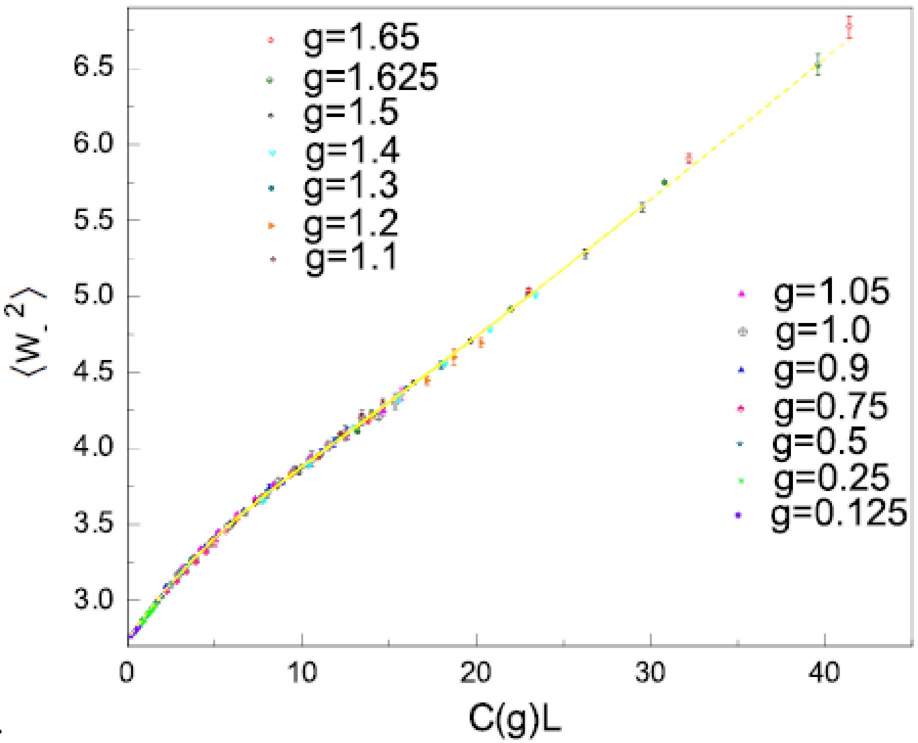
$$S = -t\sum_{(ij)}\sum_{\alpha=1,2}\left(z_{i\alpha}^{*} z_{j\alpha} e^{iA_{ij}} + \text{c.c.}\right) + \frac{1}{8g}\sum_{\square}(\nabla\times A)^2 \qquad \left(\sum_{\alpha=1,2}\left|z_{j\alpha}\right|^2 = 1\right)$$

Kuklov, Matsumoto, et al, PRL **101**, 050405 (2008)

Week First-Order Transition?

Kuklov, Matsumoto, et al, PRL 101, 050405 (2008)





The coupling constant t is adjusted so that w>0 with the probability 0.75.

$$\langle W_-^2 \rangle = f\left(C(g)L\right)$$

$$C(g) \equiv \frac{e^{bg}-1}{e^{bg_0}-1} \quad (b=2.28,\ g_0=1.3)$$

✔Maybe too small to observe a turn around.
✔Just one particular model.

SU(3) and SU(4) J-Q2 Models

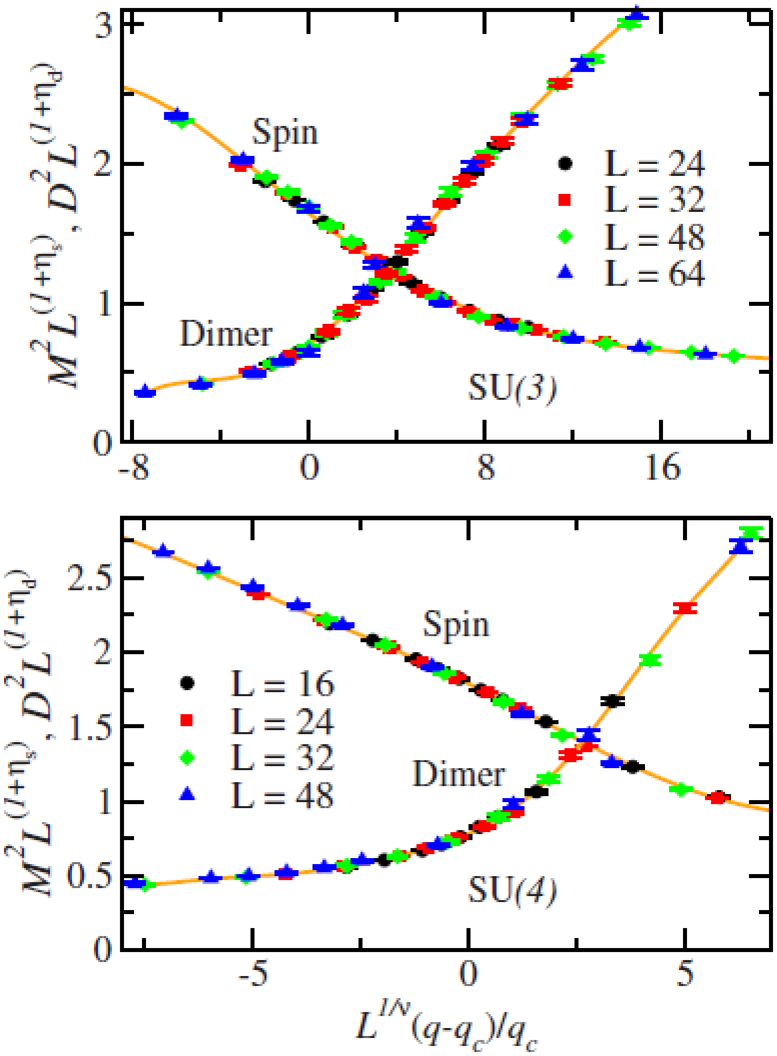
J. Lou, A. Sandvik, N.K (2009)

SU(3) J-Q2

$$\eta_s = 0.38(3), \;\; \nu = 0.65(3)$$

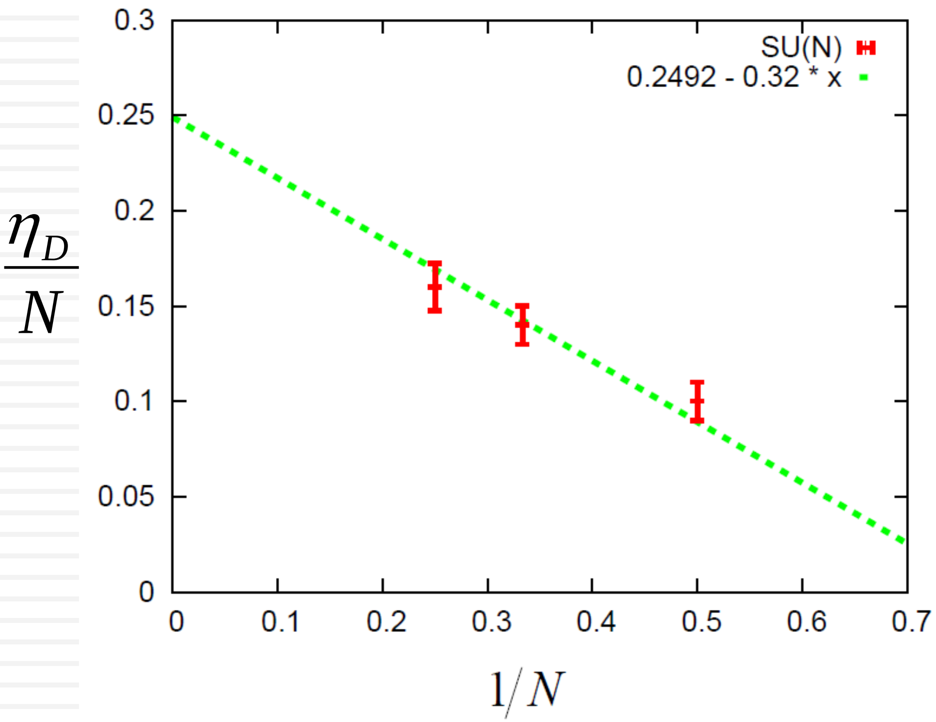
SU(4) J-Q2

$$\eta_s = 0.42(5), \;\; \nu = 0.70(2)$$



2D JQ-Model (Lou, Sandvik, N.K.)

Monopole Scaling Dimension up to $O(N^{-1})$



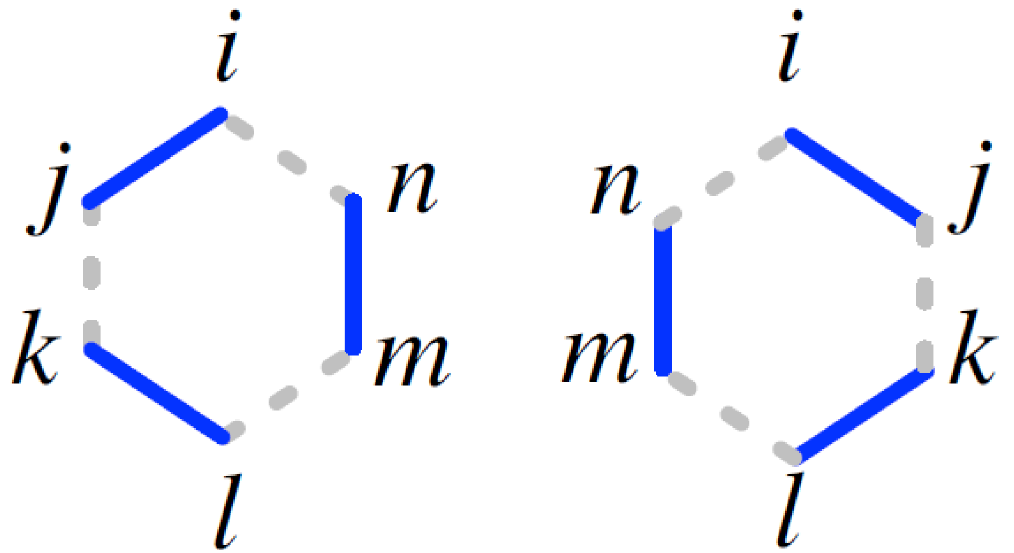
$$\frac{\eta_D}{N} = \frac{2x_\psi - 1}{N}$$

$$= 0.2492 - 0.32\frac{1}{N} + O\left(\frac{1}{N^2}\right)$$

See Ribhu Kaul's talk for more discussions

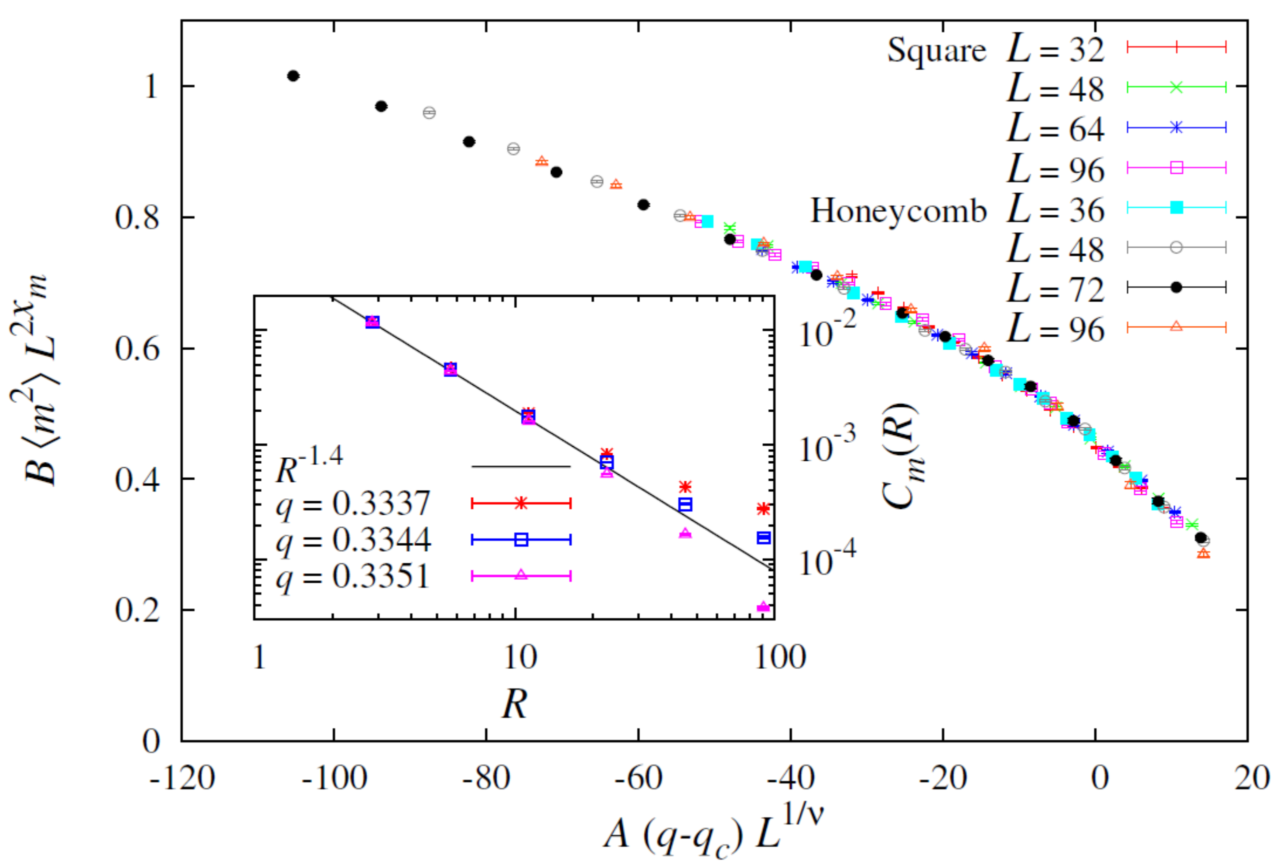
2D JQ-Model (Lou, Sandvik, N.K.)

Honeycomb Lattice



$$H = -J \sum_{(ij)} P_{ij} - Q \sum_{(ijklmn)} \left(P_{ij} P_{kl} P_{mn} + P_{jk} P_{lm} P_{ni} \right)$$

Magnetization



SU(3) JQ Model

$$\beta J = L$$

$2x_m = 1.40$

$y = 1.89$

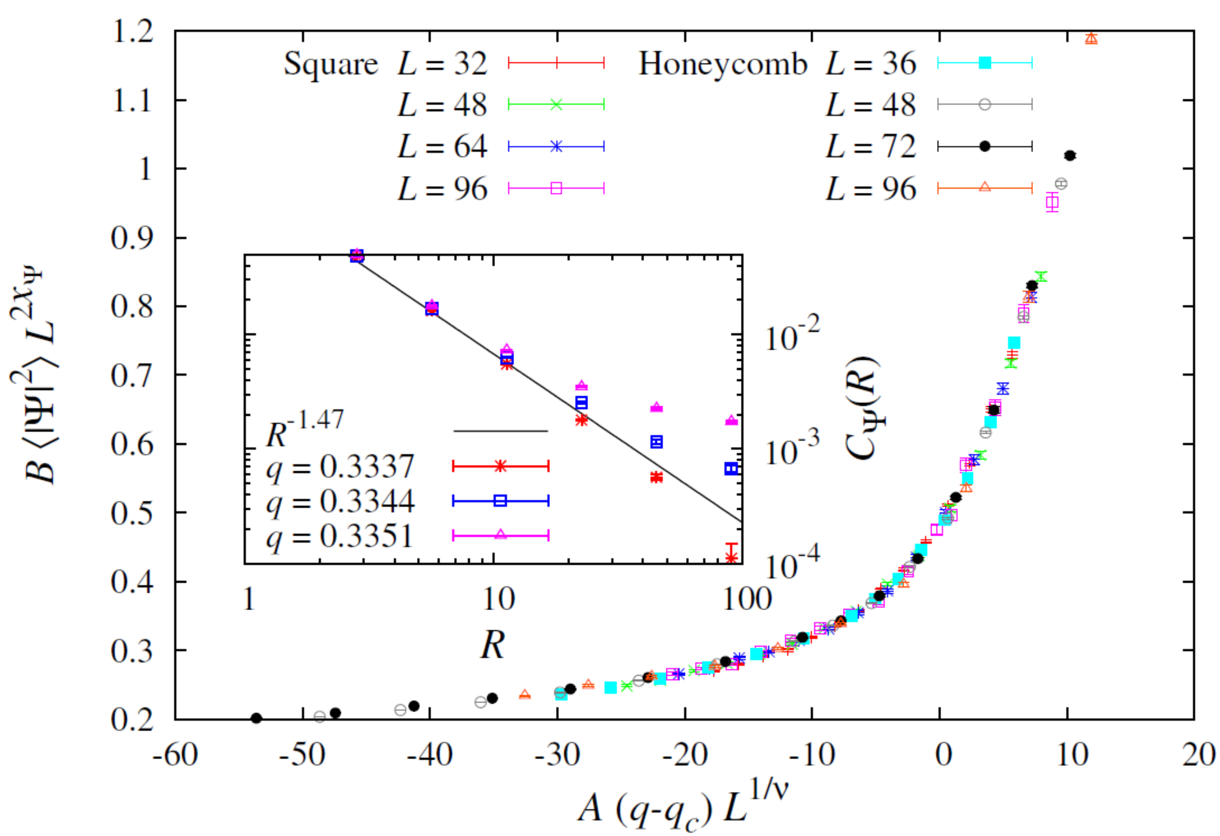
$q_c = 0.3354$ (sq)

$= 0.2036$ (hc)

Same exponents are assumed for both lattices

Harada et al PRB 88 220408 (2013)

New Data (Dimerization)



SU(3) JQ Model

$$\beta J = L$$

$$2x_\psi = 1.47$$

$$y = 1.73$$

$$q_c = 0.3339 \text{ (sq)}$$

$$= 0.2029 \text{ (hc)}$$

Same exponents are assumed for both lattices

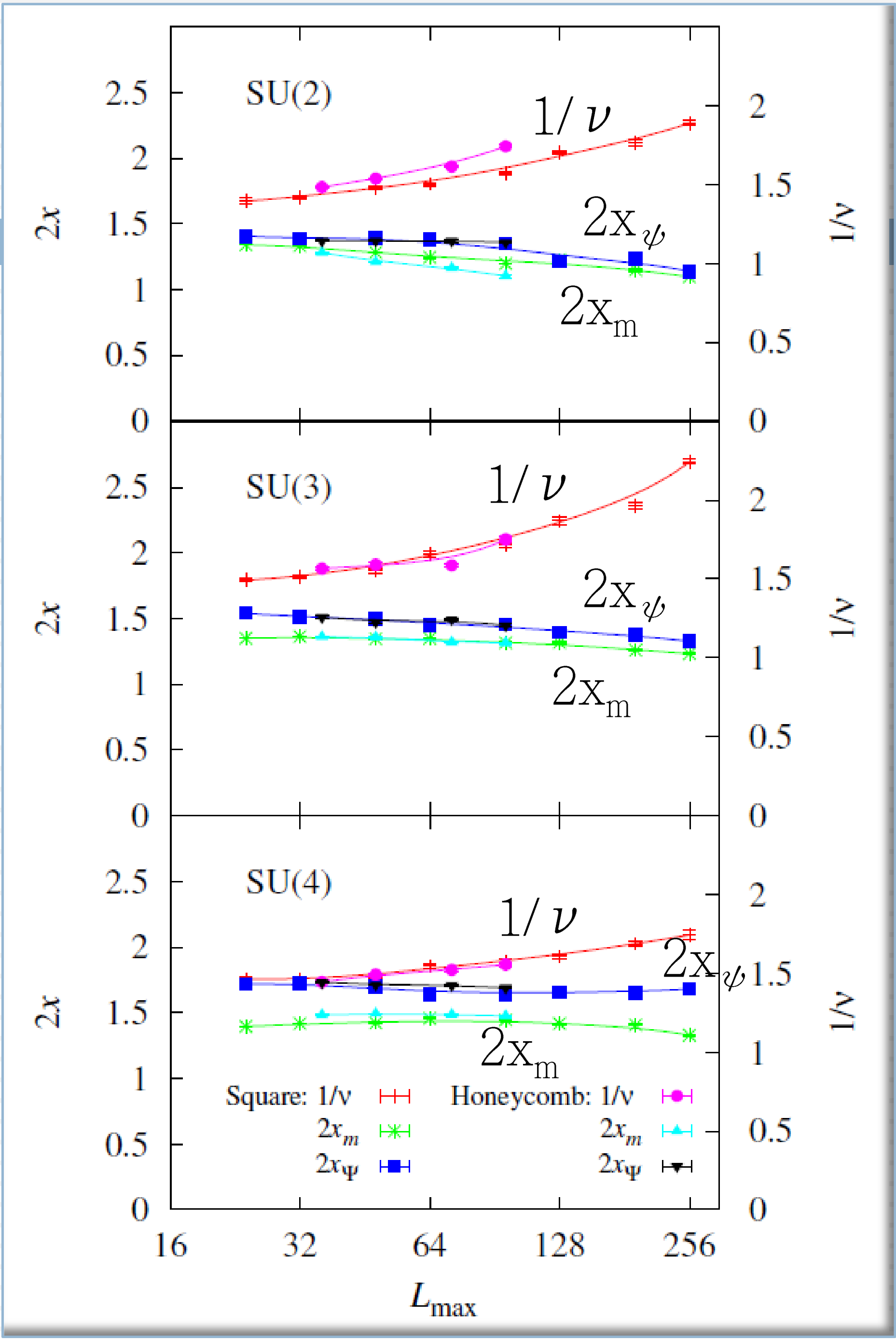
Harada et al PRB 88 220408 (2013)

Strong Finite-Size Corrections

FSS analysis using only triplets of systems (L/2, 2L/3, L)

Estimates still drifting at L=256.

y=1/ν may reach y=d,
x is still a long way to x=0



Harada et al PRB 88 220408 (2013)

Scaling Dimension of ψ^2

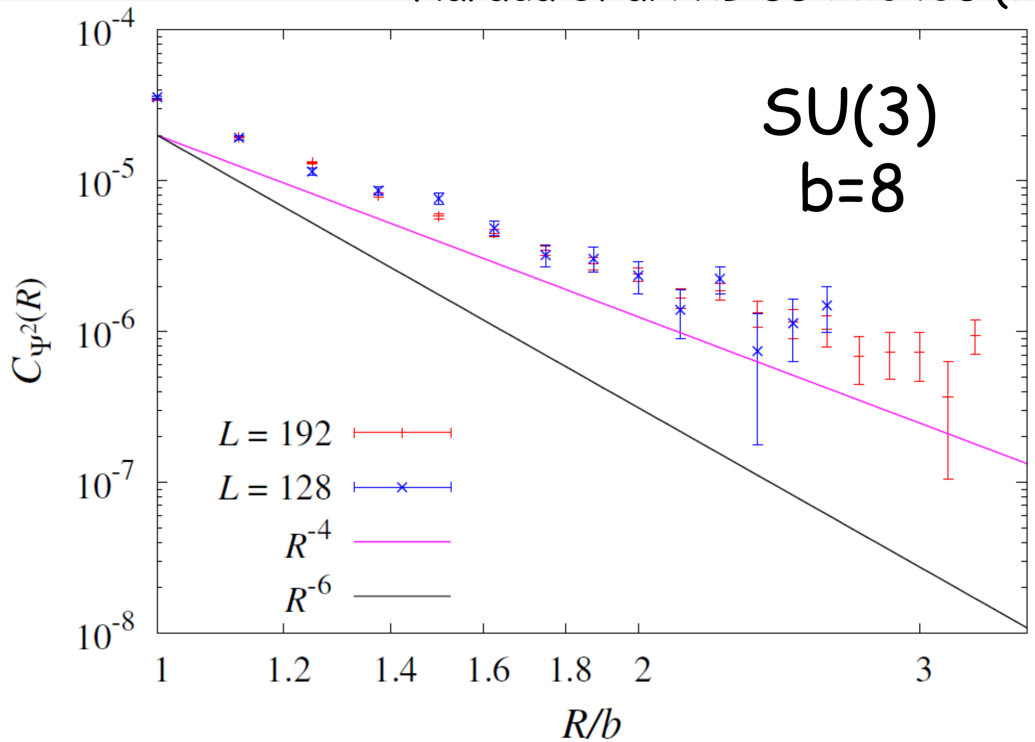
Harada et al PRB 88 220408 (2013)

$$2x \approx 4$$

$$\Rightarrow y \approx 1 > 0$$

ψ^2 is relevant at SU(3) DCP (even if it exists)

2D system with strong spatial anisotropy does NOT have DCP



$$C_{\Psi^2}\left(R_{ij}\right) \equiv \left\langle \left(\overline{\Psi}_j^*\right)^2 \left(\overline{\Psi}_i\right)^2 \right\rangle$$

$$\overline{\Psi}_i \equiv \frac{1}{b^2} \sum_{j \in b \times b} \Psi_j \ = \left(\text{block average around } i\right)$$

Conclusion

◆The transition is well described as a critical phenomena
(at least within a limited size-range)
- reasonable scaling plots
- universality (Q2 and Q3, square and honeycomb)
- areement with 1/N expansion

◆Strong corrections to scaling
- $y = 1/\nu$ is still increasing (may eventually reach the 1st order transition value $y=d$)
- $x = (1+\eta)/2$ is weakly decreasing (still a long way to $x=0$)

--- We still don't know whether it is 1st order or 2nd order.

END