

2-D Ising Model with non-local links - a study of non-locality problem

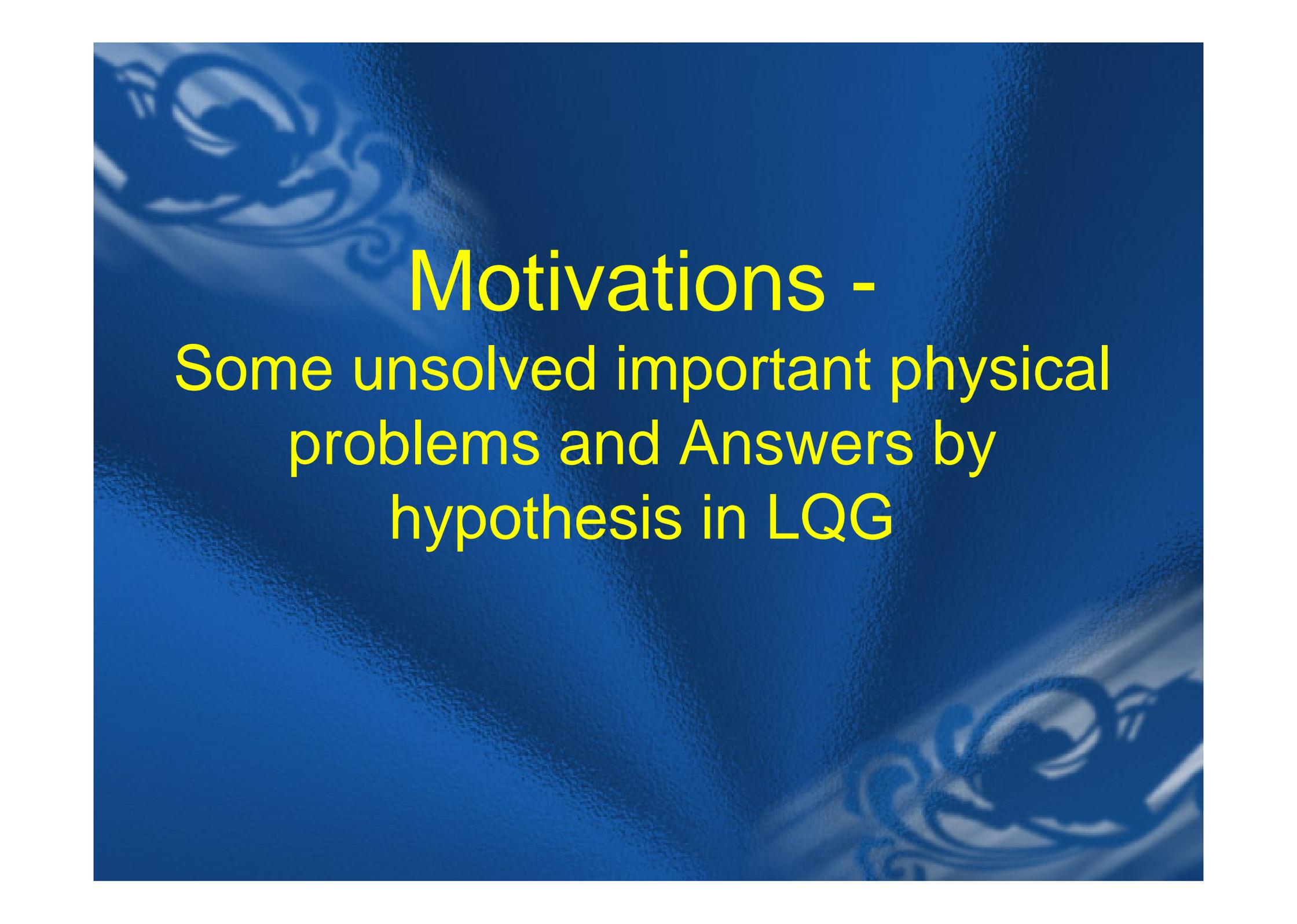
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Loops'05, AIE, Golm, Germany, 2005

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Outline

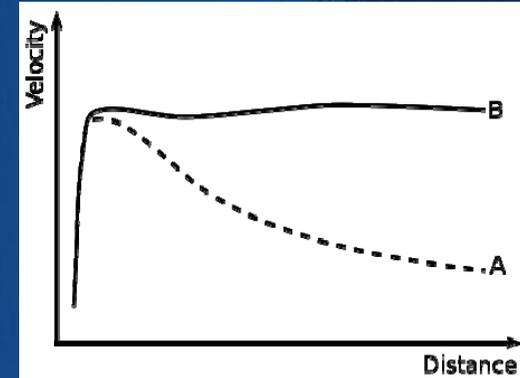
- ◆ Motivations
 - ◆ Some unsolved important physical problems and the hypothetical answers by LQG
- ◆ Simulation of a 2-D Ising spin system with non-local (NL) links
- ◆ Effects of NL links on statistical behaviors of 2-D Ising systems
 - ◆ Effects of the amount of NL links
 - ◆ On C_V curves and Critical temperatures (T_C)
 - ◆ On Correlation functions ($g(r)$)
 - ◆ Effects of the configurations of NL links on the lattice
 - ◆ On C_V curves and Critical temperatures (T_C)
 - ◆ On Correlation functions ($g(r)$)
 - ◆ An intuition from the effects on C_V and T_C
- ◆ Conclusions
- ◆ Future works



Motivations -

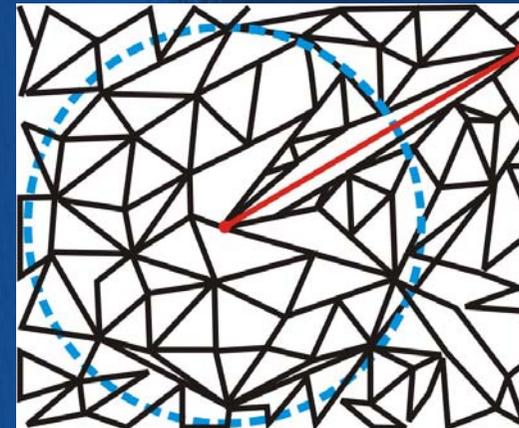
Some unsolved important physical problems and Answers by hypothesis in LQG

- ◆ Interpret matter particles in background independent quantum gravity, e.g. LQG?
- ◆ Origin of quantum physics?
- ◆ Explain rotation curve of spiral galaxies?
 - ✦ Dark matter
 - ✦ MOND



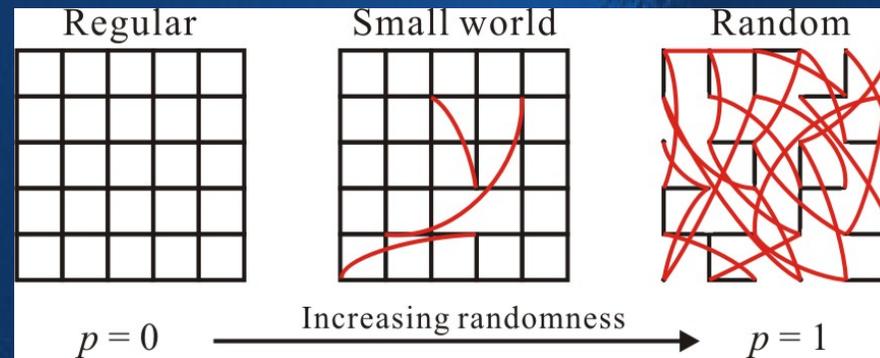
◆ LQG states are described by graphs. Then,

- ✦ Mismatch of **micro** and **macro locality** leads to NL links
- ✦ Ends of NL links carrying gauge field representations lead to charged matter;
- ✦ Ends of NL links carrying no gauge fields give a natural source of dark matter;
- ✦ MOND can be obtained on a regular lattice non-locally decorated according to some distribution function $P(r)$;
- ✦ NL links serve as the origin of quantum physics by disordering local degrees of freedom without violating local observables in the averaged energy conservation

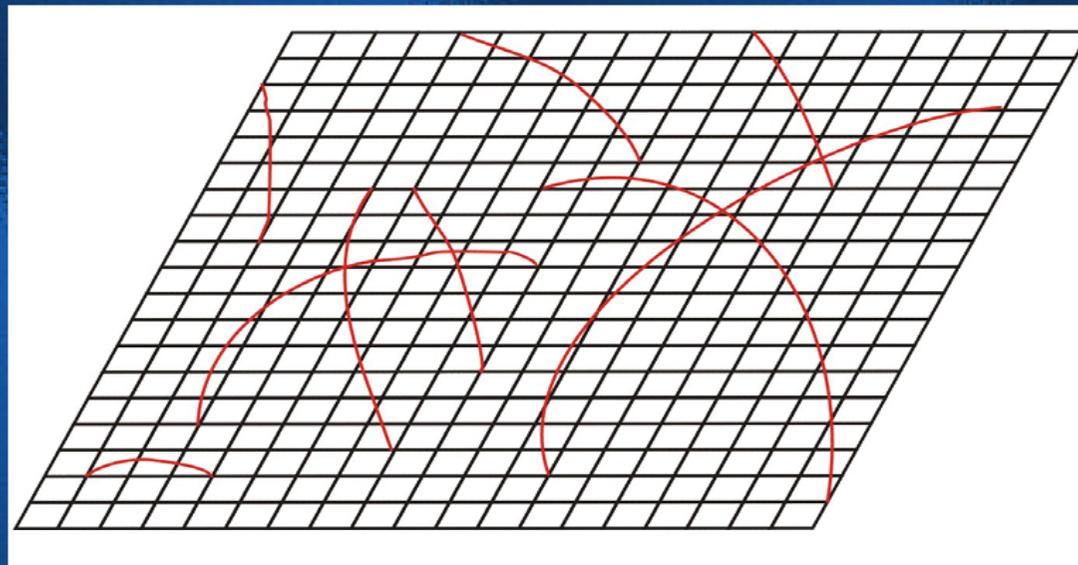


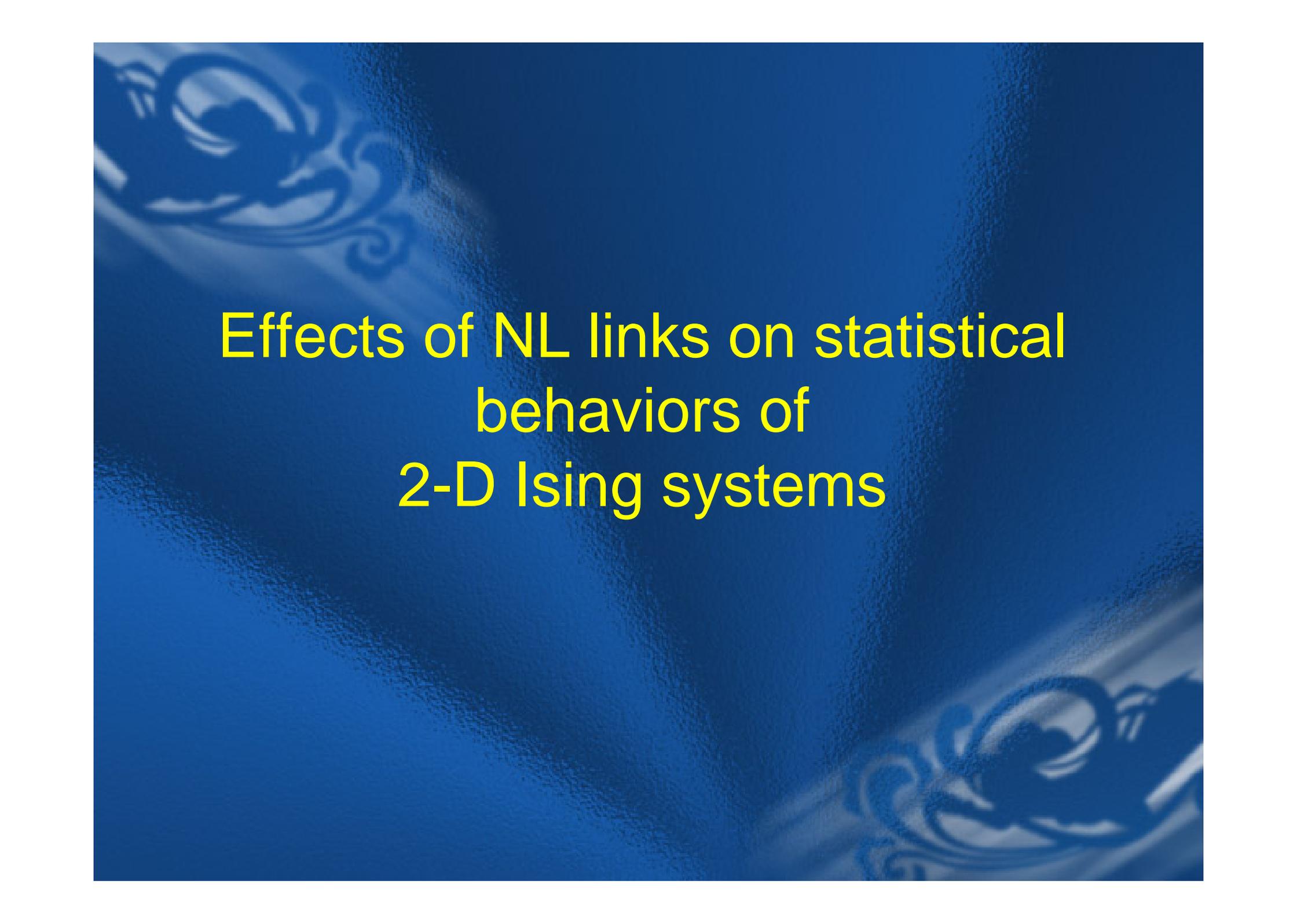
Simulation of a 2-D Ising spin system with NL links

- ◆ To address these questions, we can study, as a reference, the statistical behaviors of some well-know lattice systems decorated randomly with some NL links.
- ◆ This turns out to be related to a class of recently studied systems called small world networks.



- ◆ We studied 2-D Ising systems with some randomly distributed NL links.

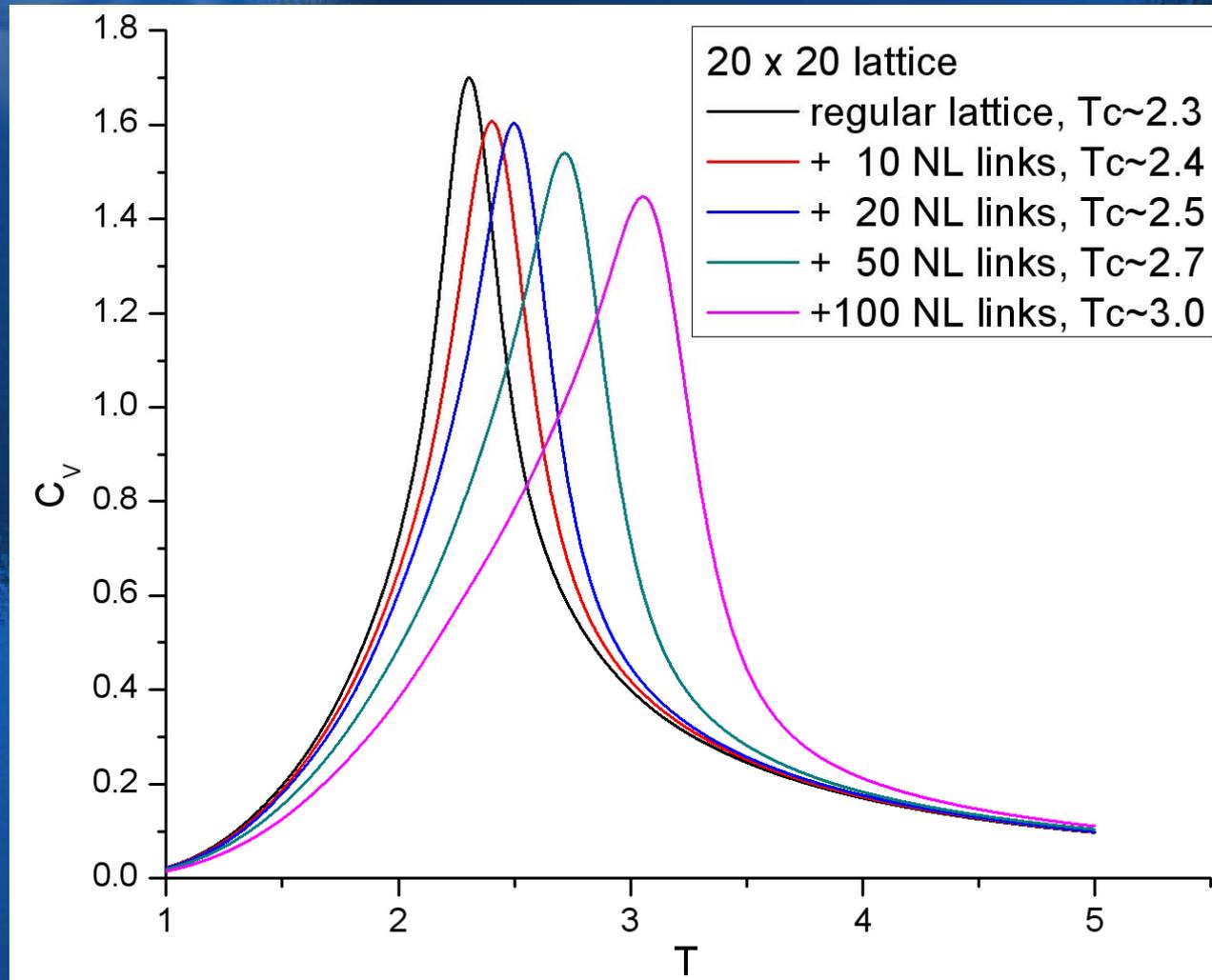




Effects of NL links on statistical
behaviors of
2-D Ising systems

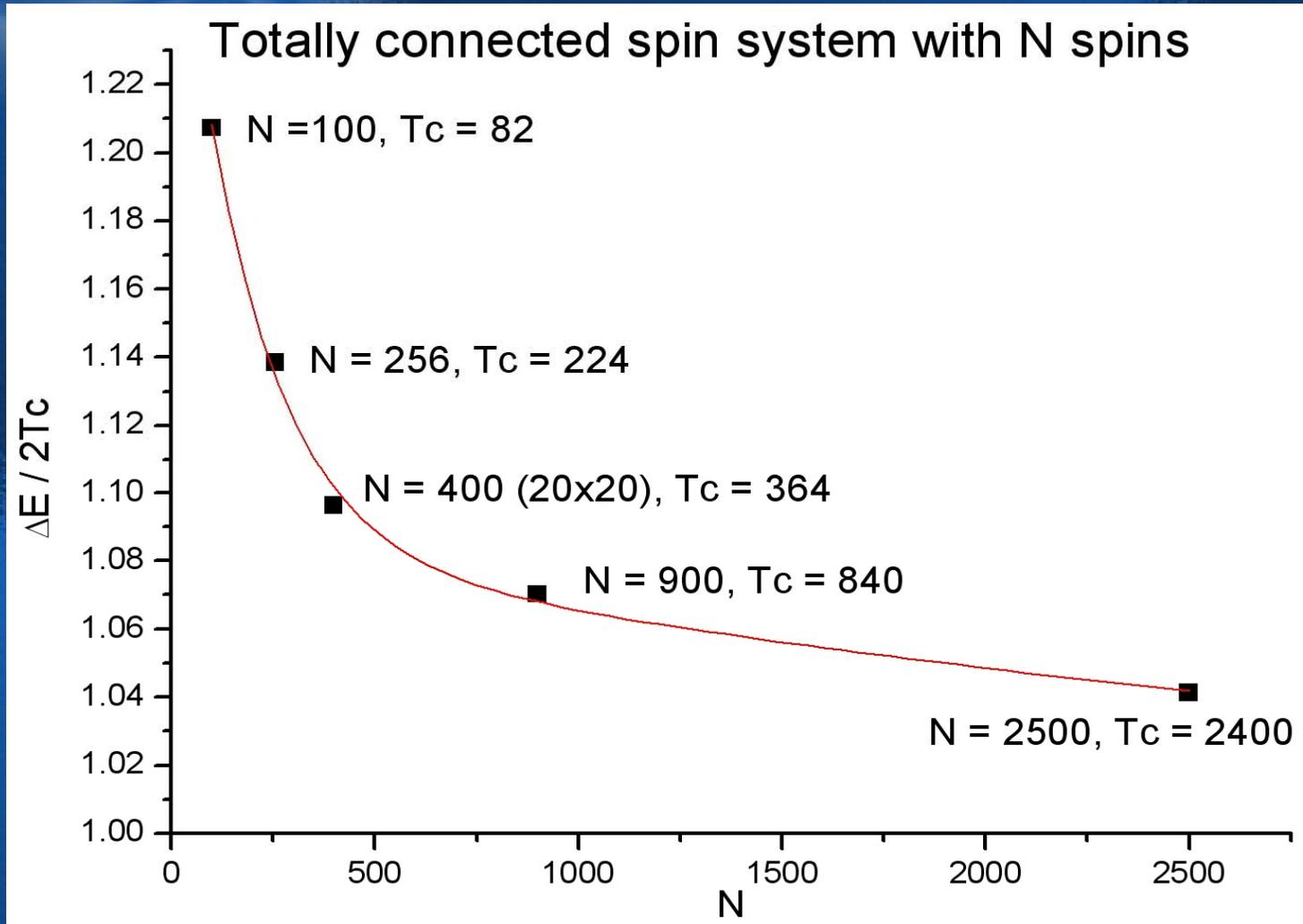
Effects of the amount of NL links

- ◆ On C_V curves and Critical temperatures (T_C)



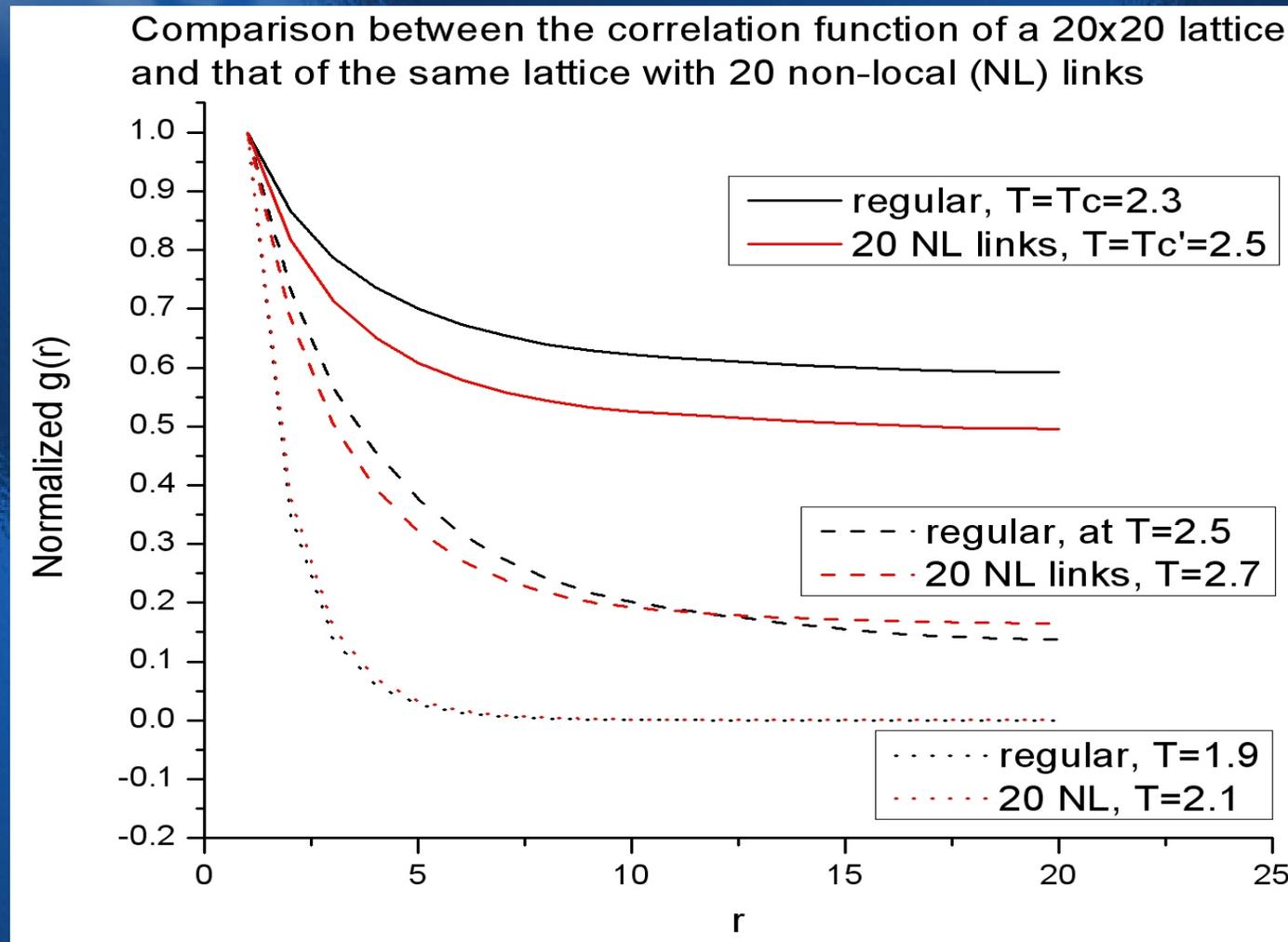
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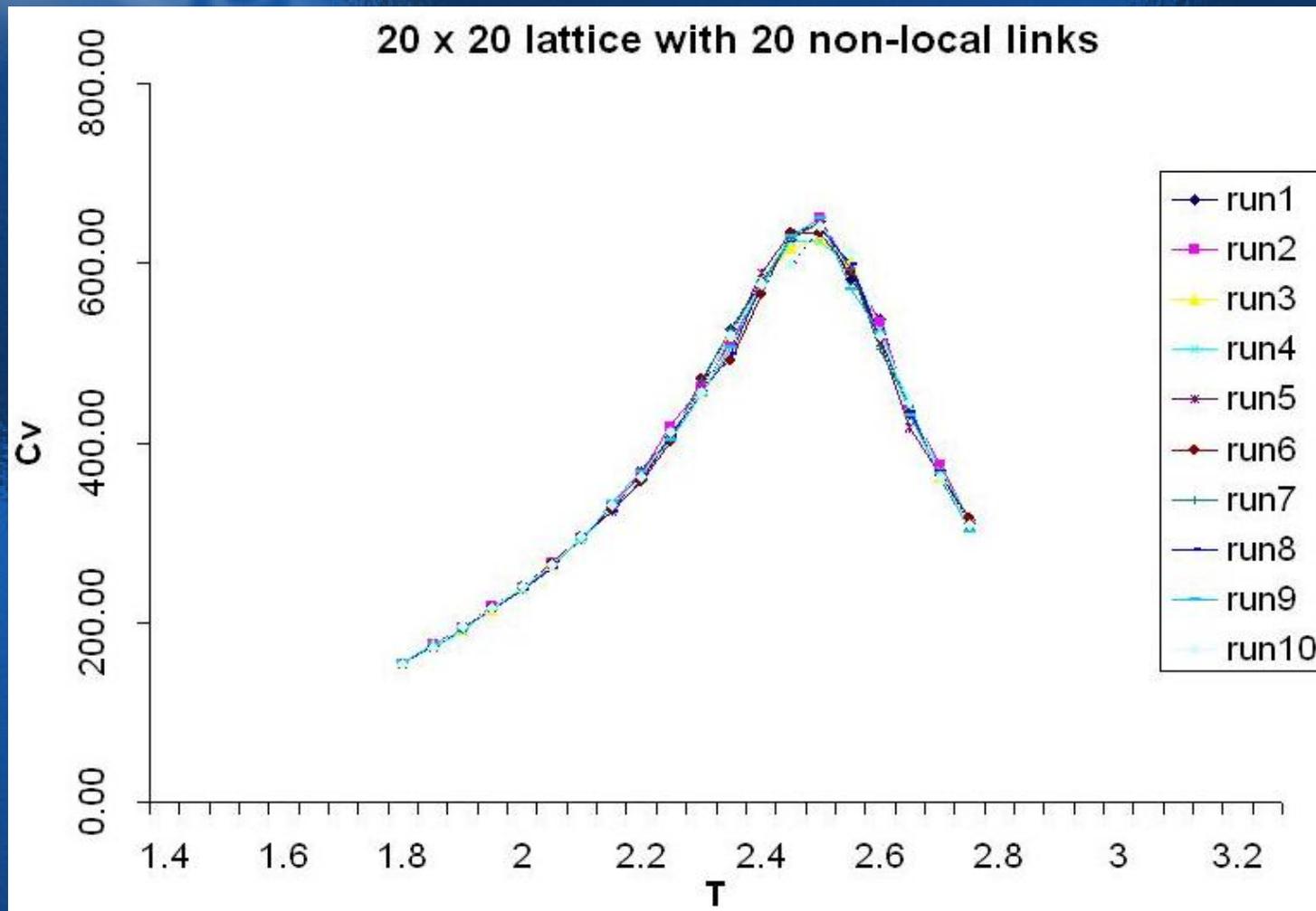
Effects of the amount of NL links

- ◆ On Correlation functions ($g(r)$)



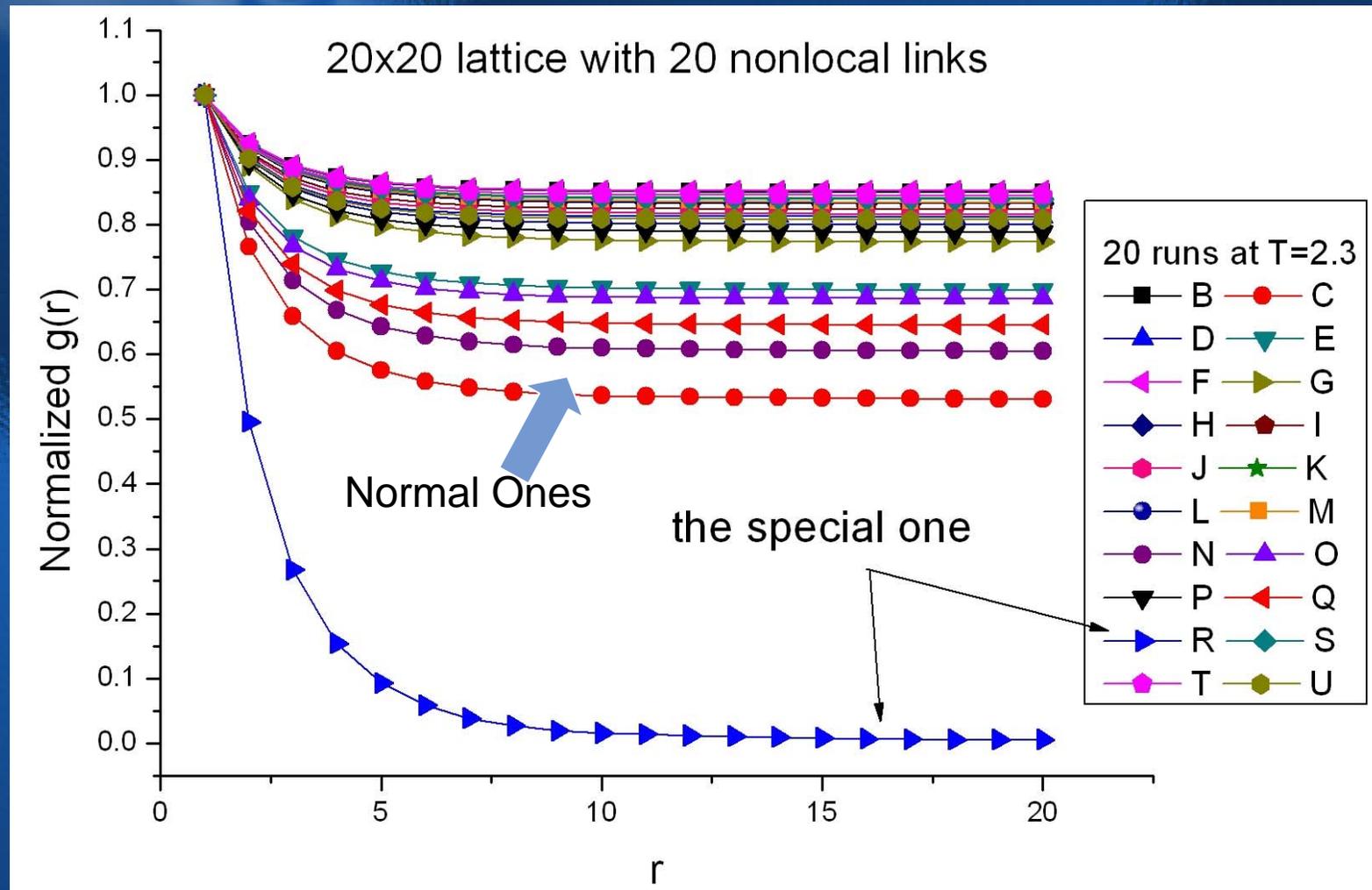
Effects of the configurations of NL links on the lattice

- ◆ On C_V curves and Critical temperatures (T_C)



Effects of the configurations of NL links on the lattice

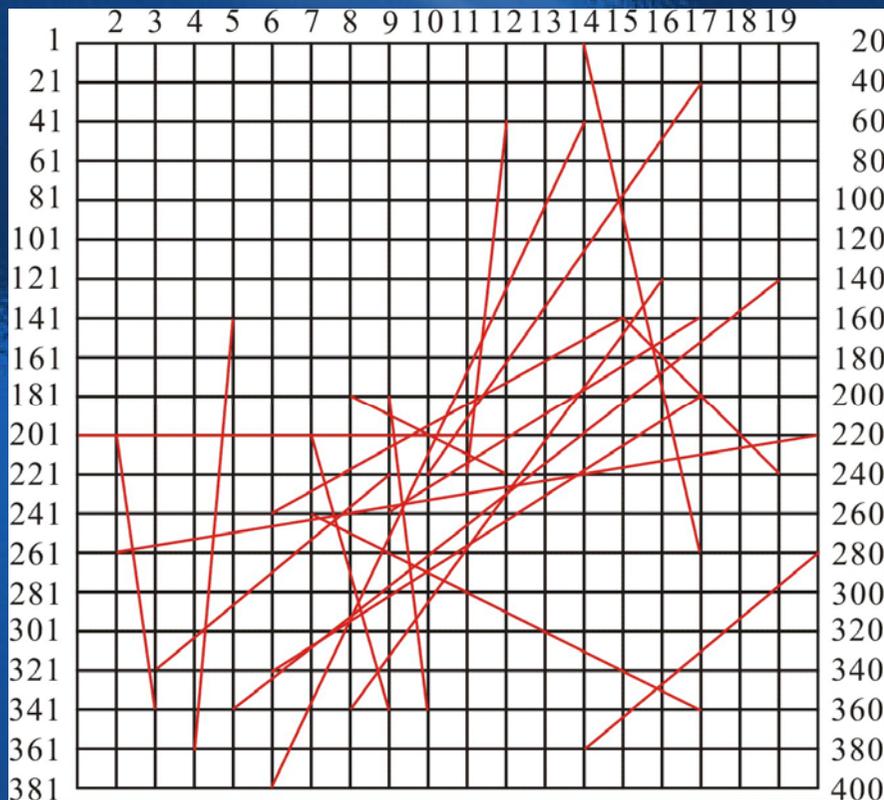
◆ On Correlation functions ($g(r)$)



Effects of the configurations of NL links on the lattice

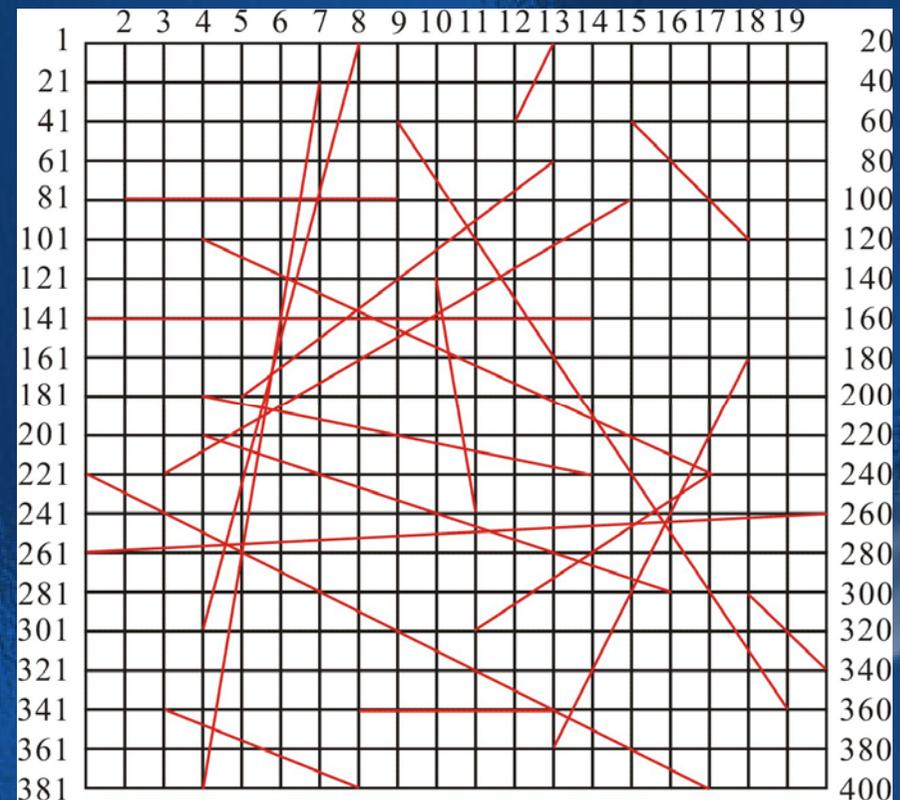
- ◆ Configurations of 20 NL links on a 20 x 20 lattice

For the special one



In general, $\min L(\text{NL link}) \geq 5$
 $\text{avg } L(\text{NL link}) \geq 10$

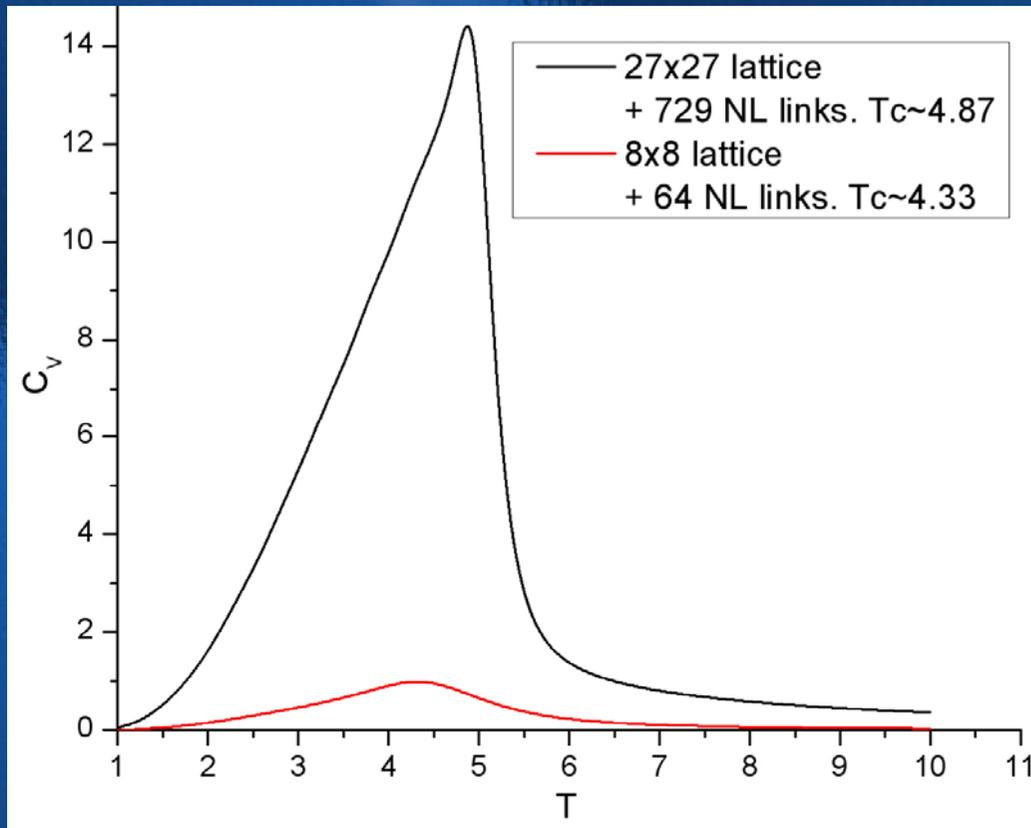
A typical normal one



In general, $2 \leq \min L(\text{NL link}) \leq 4$
 $\text{avg } L(\text{NL link}) \leq 10$

A hint from the effects on C_V and T_C

- ◆ A 4x4x4 3D lattice has same number of nodes as and 64 links more than a 8x8 2D lattice. A 9x9x9 3D lattice has same number of nodes as and 729 more links than a 27x27 2D lattice, then?



- ◆ This may suggest that
 - ◆ physics in the real 3D world is an emergent from some fundamental physical theory in lower dimension space with NL links or in the space where dimensionality can not be well defined.
 - ◆ The dimension of our space is not presumably fixed but is indeed something subject to some fundamental physical law.

Conclusions

- ◆ For a 2-D Ising system with NL links
 - ✦ T_C increases as # of NL links till the system is totally connected.
 - ✦ When totally connected, T_C increases with the system size
 - ✦ Half width of the C_V -curve increases with # of NL links
 - ✦ When totally connected, the half width increases with the system size
 - ✦ T_C and C_V -curve are insensitive to configurations of given # of NL links
 - ✦ $g(r)$ behaves similarly to those of regular lattices, but with different falling off speed.
 - ✦ $g(r)$ is sensitive to configurations of given # of NL links. This suggests that some observed phenomena, e.g. galactic rotation curve, might be determined by a specific type of configurations of NL links.

Future works

- ◆ First, adopt better Monte Carlo algorithms with almost no critical slowing down, e.g. multi-canonical + Swendsen-Wang.
- ◆ Then, study in more detail the impact of configurations of NL links on systems' behaviors.
- ◆ So that we can study the effects of different distribution function $P(r)$ of NL links on the system.
- ◆ Apply similar studies on large lattice systems
- ◆ Ultimate goal:
 - ◆ do similar study on spin networks!
 - ◆ together with theoretical calculation, validate all the hypothesis.