LONG RANGE SPIN GLASS FROM SHORT RANGE ANTIFERROMAGNETS

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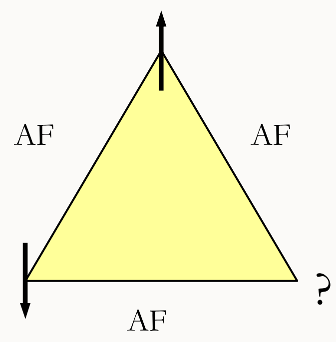
OVERVIEW

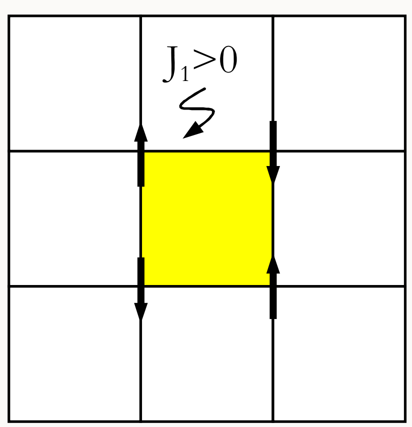
- Frustrated magnets at low temperatures
- Doping and orphan spins
- A two-dimensional, long range spin glass

FRUSTRATED MAGNETS

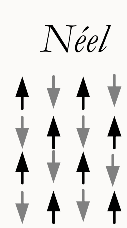
Classical Spins



Antiferromagnetic interactions can create frustration



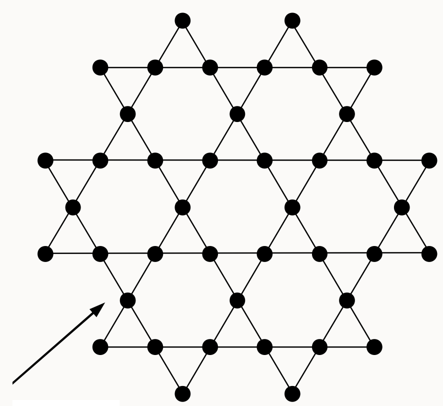
(a)



Some AF order to Neel states at T=0 K

FRUSTRATED MAGNETS

Some AF models *do not* order even at T=0 *K*



Kagome lattice

Is a *spin liquid,* where the ground state is macroscopically degenerate but no order exists

Ising $\langle S_i S_j \rangle \sim e^{-r_{ij}/\xi}$

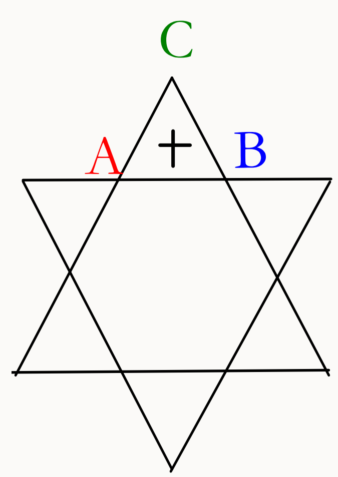
It all depends on the lattice!

FRUSTRATED MAGNETS

Heisenberg on Kagome

$$H = J \sum_{<i,j>} \mathbf{S}_i \cdot \mathbf{S}_j$$

$$H = J \sum_{triangles} (\mathbf{S}_A + \mathbf{S}_B + \mathbf{S}_C)^2 - \frac{J}{2} \sum_i \mathbf{S}_i^2$$



So at T=0

$$\mathbf{S}_A + \mathbf{S}_B + \mathbf{S}_C = 0$$

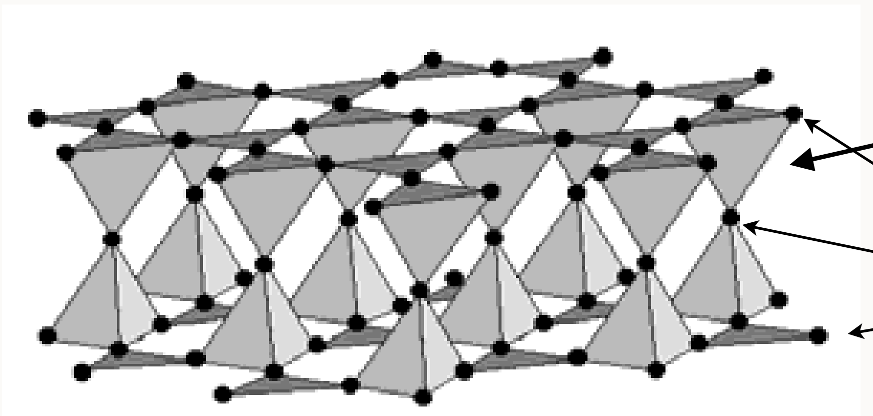
local conditions

Finite entropy!

even after fixing SO(3)

FRUSTRATED MAGNETS

This is a *spin liquid* to remarkably low *T*



$$p = 1$$

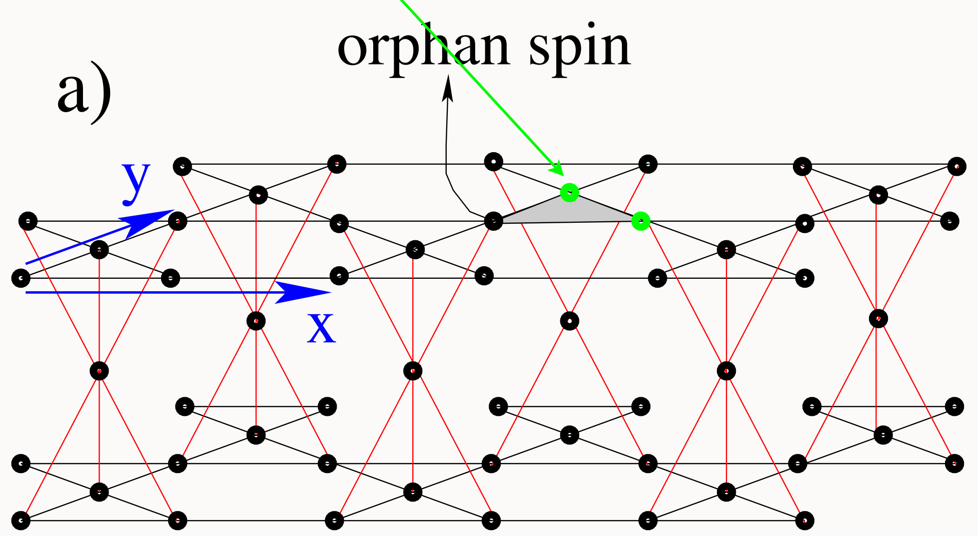
$$SrCr_{9p}Ga_{12-9p}O_{19}$$

Magnetic

Non magnetic

DOPING

Doping with *Ga* which is non-magnetic



The important situation is when two *Ga* fall in the same simplex

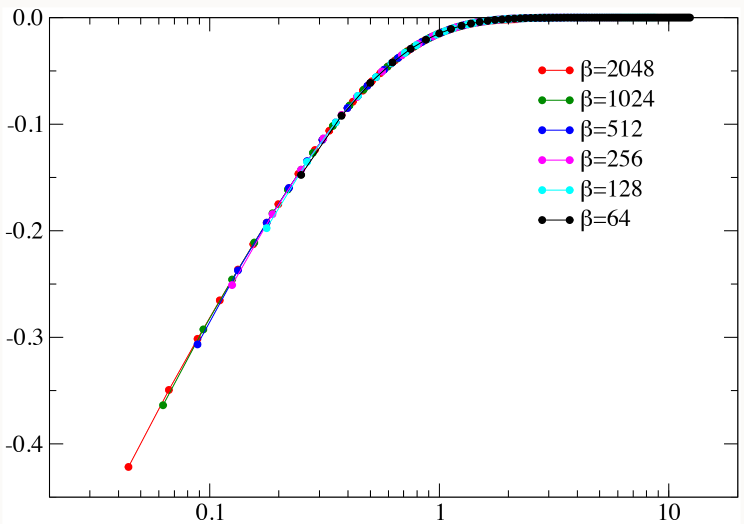
This leaves behind *orphan spin Cr*

DOPING

Montecarlo simulations show that effectively

$$H = \sum_{ij} J_{eff}(r_{ij}) \mathbf{S}_i \cdot \mathbf{S}_j$$

$$J_{eff}(r_{ij}) = -T \mathcal{J}(\sqrt{T} r_{ij})$$



$$\mathcal{J}(y) \simeq \log(1/y) \quad y \ll 1$$

$$\mathcal{J}(y) \simeq e^{-y} \quad y \gg 1$$

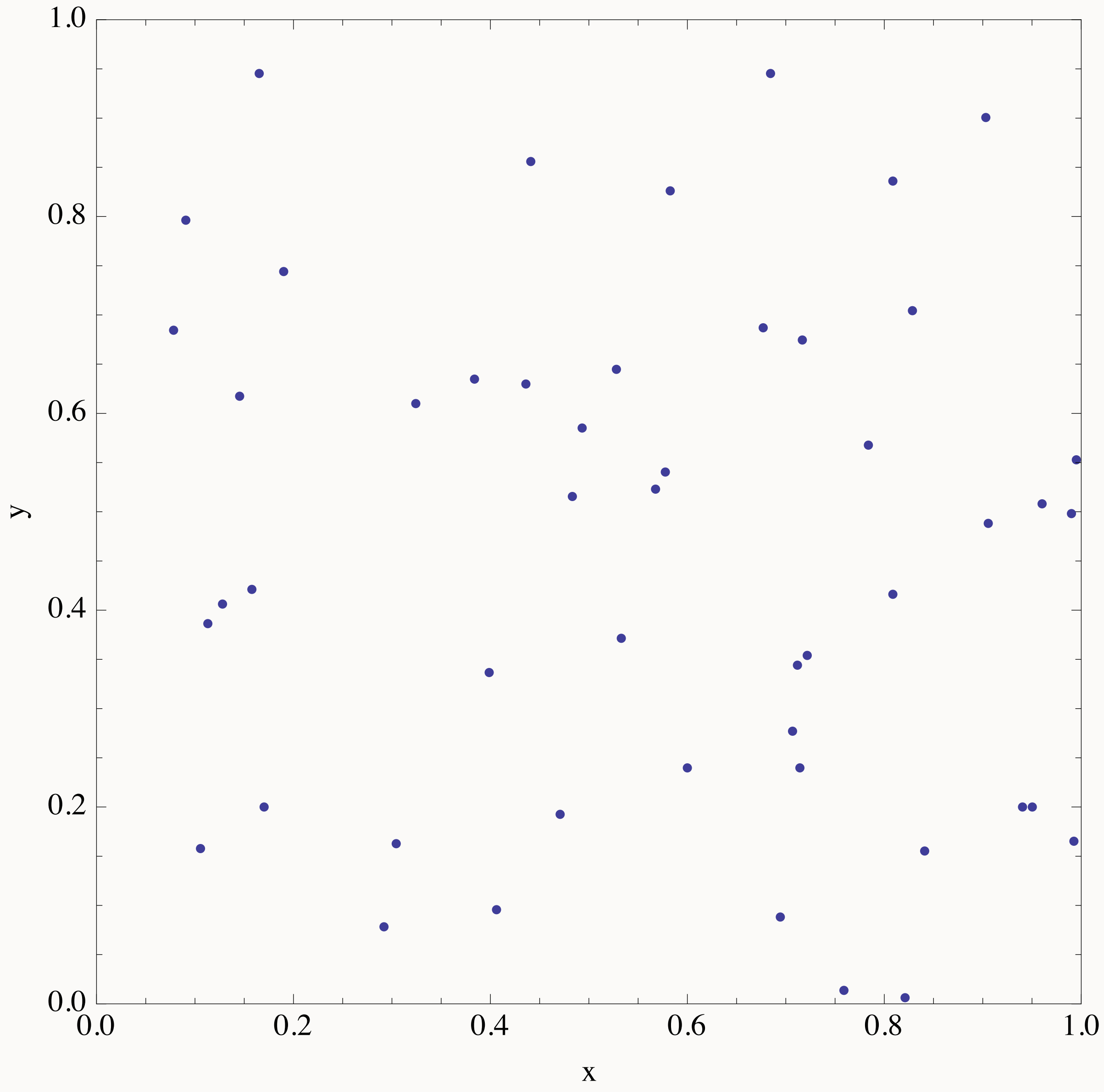
DOPING

The long-range correlations of the spin liquid implies long-range interactions of the *orphan spins*

$$H = \sum_{ij} J_{eff}(r_{ij})\mathbf{S}_i \cdot \mathbf{S}_j$$

the locations of the spins are random

LONG RANGE SPIN GLASS



$$H = \sum_{ij} J_{eff}(r_{ij}) \mathbf{S}_i \cdot \mathbf{S}_j$$

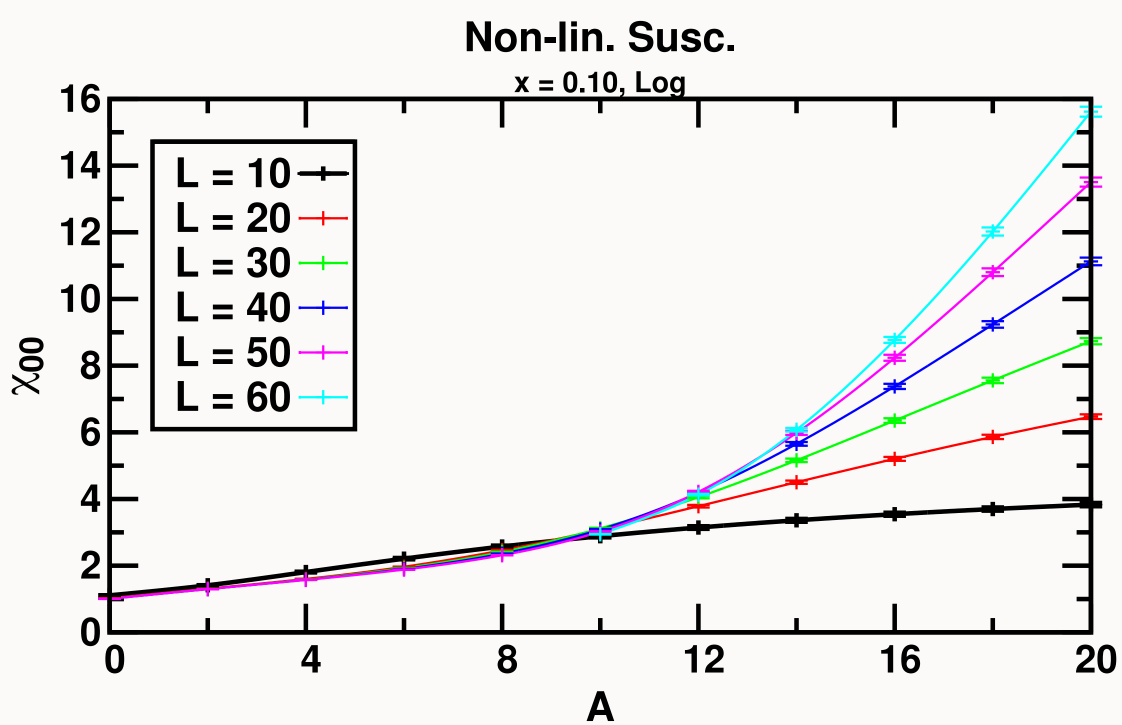
Frustration+disorder

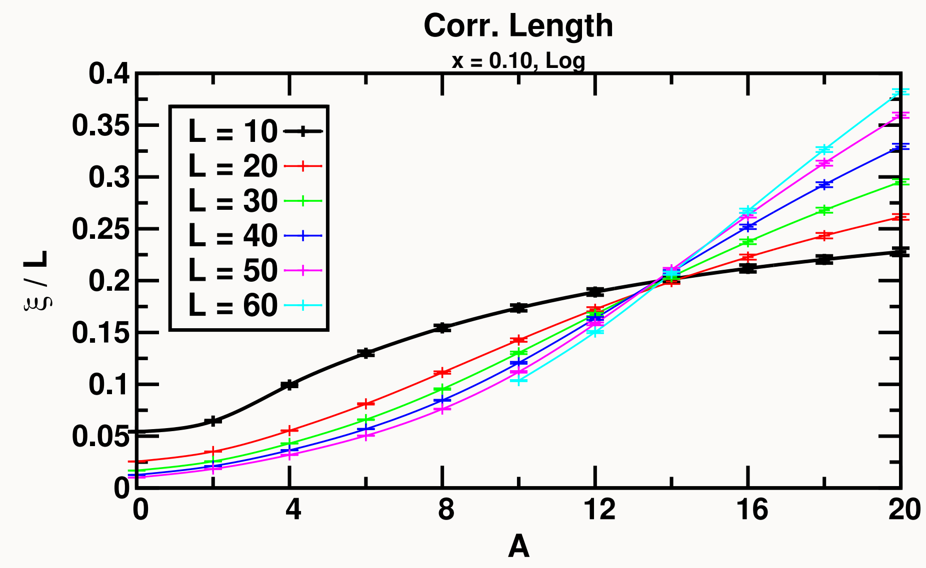
Does it have a spin glass phase?

LONG RANGE SPIN GLASS

Apparently yes

Divergences in the large coupling limit





LONG RANGE SPIN GLASS

Details:

$$\chi(\vec{k}) = N \sum_{\alpha,\beta} \langle |Q_{\vec{k}}^{\alpha,\beta}|^2 \rangle,$$

$$Q_{\vec{k}}^{\alpha,\beta}(t) = \frac{1}{N} \sum_i S_{i,1}^{\alpha}(t) S_{i,2}^{\beta}(t) e^{i\vec{k}\cdot\vec{r}_i}.$$

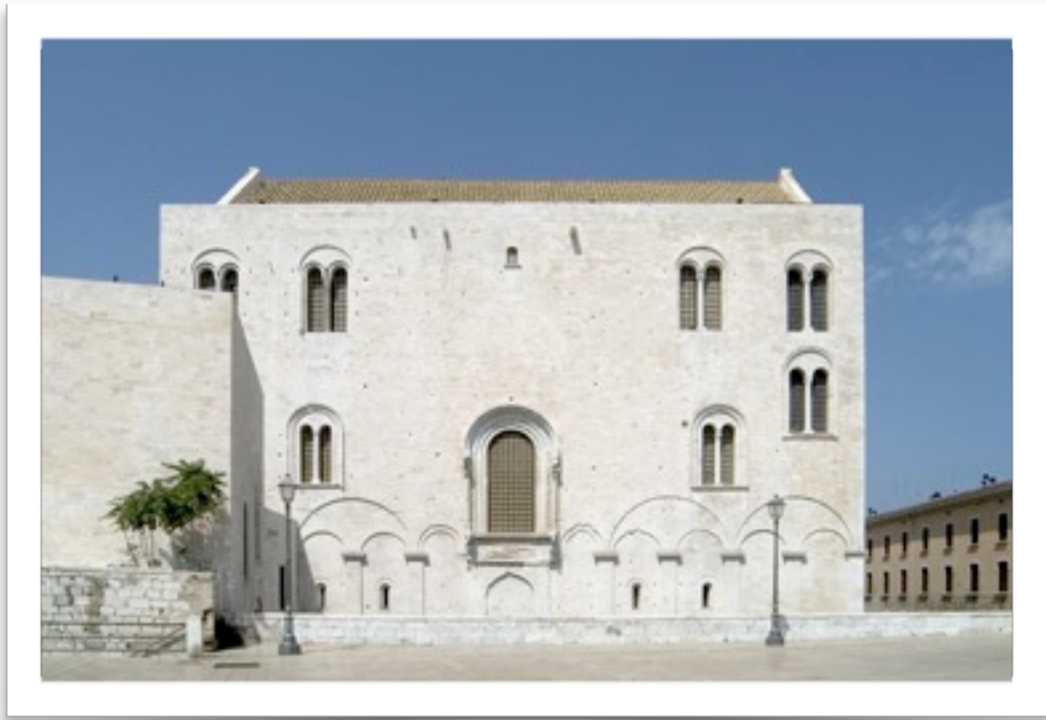
$$\xi_L = \frac{1}{2\sin(k_{min}/2)} \left(\frac{\chi_{SG}(0)}{\chi_{SG}(\vec{k}_{min})} - 1 \right)^{1/2}$$

LONG RANGE SPIN GLASS

Still in the working:

a) Is it really a glassy phase?
b) Does it look like a long-range (SK-like) or short range ($d=2$) SG?
c) What is the critical phase?
d) What about many local minima in the SG phase?

CONCLUSIONS



Thank you and Merry Christmas in the city of Santa Claus