Order by disorder:

(1) A search for a model with a finite temperature transition.
(2) Dynamics across the phase transition.

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Order by disorder (ObD) is the mechanism whereby a system with a non-trivially degenerate ground states develops long-range order by the effect of classical or quantum fluctuations [1]. From a theoretical point of view, the ObD mechanism is a relatively common occurrence in geometrically frustrated spin models [2], such as the fully frustrated domino model where it was discussed for the first time [1]. Nevertheless, conclusive evidence for thermal ObD remains unseen in the laboratory so far. The difficulty lies in establishing whether order is selected through the ObD mechanism (a huge disproportion in the density of low-energy excitations associated with particular ground states) or is due to energetic contributions not taken into account that lift the ground-state degeneracy.

Using a mean-field cluster variational method, a low-temperature expansion, and Monte Carlo simulations, we demonstrated thermal ObD in Ising pyrochlores with staggered antiferromagnetic order frustrated by a magnetic field [3]. Our analysis elucidates the mechanism whereby a symmetry-broken state is selected by infinitesimal thermal excitations, and establishes a route to the much-sought-after experimental realization of classical ObD, both in two-dimensional artificial systems, or in antiferromagnetic all-in-all-out pyrochlores. This analysis can be pursued in many directions and we propose to follow two of them here.

(1) A search for a model with a finite temperature transition.

All theoretical realizations of ObD are such that the transition occurs at zero temperature. This is not practical to be observed experimentally. It would be very interesting to have a model system with an ObD transition at finite temperature. We believe that such a mechanism is possible in models with quenched randomness, a natural extension to mimic real samples that are usually affected by the presence of impurities, defects, and imperfections. More specifically, we will focus on the 2d fully frustrated domino model [1] and we will try to tailor disorder to tune the ObD critical temperature to be finite.

(2) Dynamics across the phase transition

As far as we know, there is no analysis of the dynamics of ObD. This constitutes the subject of a second research project. The idea is to prepare the frustrated domino model [1] in three kinds of equilibrium initial conditions: the paramagnetic disordered phase at high temperature, the ordered phase at finite low temperature, and the disordered state at zero temperature, and evolve them out of equilibrium under different parameters (using Monte Carlo simulations). One should then observe coarsening phenomena in the ordered phase, or disordering processes at zero temperature. How these occur is an interesting question that has not been answered. We think that understanding the stochastic dynamics of this model may be of help in finding experimental evidence for the ObD phenomenon.

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