Spin-Glass Free Energy Landscape with Monte Carlo Simulations

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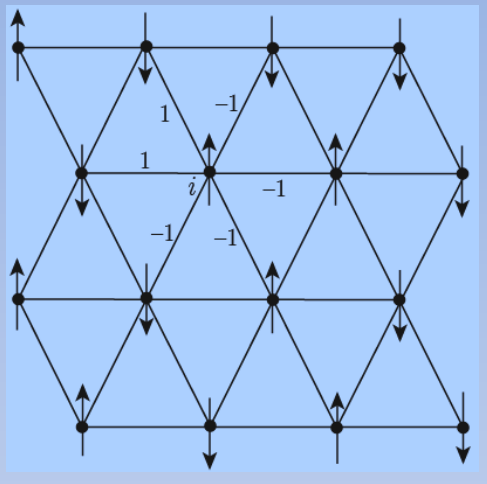


1. Triangular Ising Model

- Single-spin-flip dynamic;
- Internal energy calculated by the Hamiltonian;
- Minimal energy difference is 4.

2. Monte Carlo method

- Acceptance probability:

$$A(\mu \to \nu) = \begin{cases} e^{-\beta(E_\nu - E_\mu)} & \text{if } E_\nu - E_\mu > 0 \\ 1 & \text{otherwise.} \end{cases}$$

- Overlap Distribution:

$$overlap = \frac{\sum_{i=0}^{N} m_i^a m_i^b}{|M^a| \cdot |M^b|}$$

- Normalized internal energy difference:

$$|\Delta E| = \frac{E_\mu - E_\nu}{E_\mu + E_\nu}$$

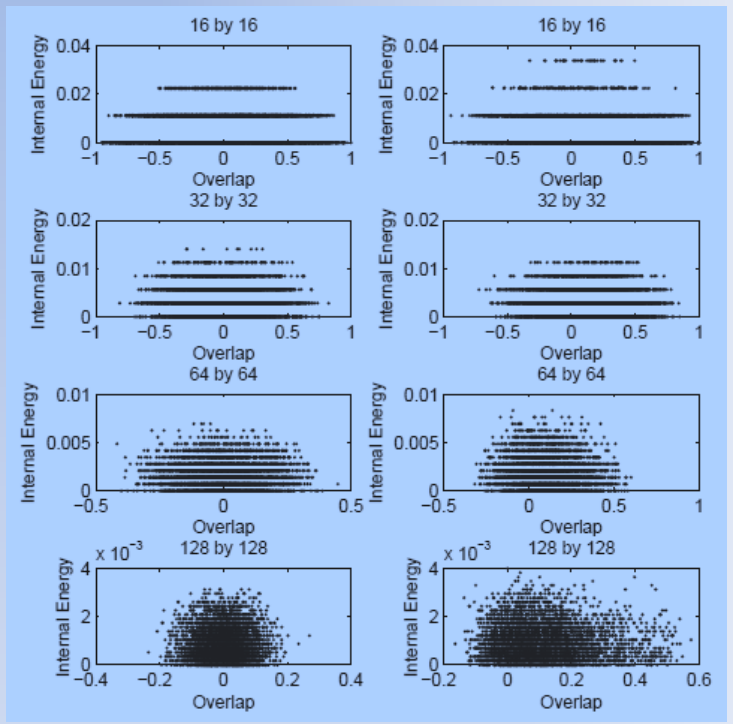
Abstract

Spin glass materials are disordered systems exhibiting high magnetic frustration. These properties cause the system to have a rough free energy landscape, which in turn results in their peculiar static and dynamical behavior. We have studied the geometrical description of the landscape. We apply Monte Carlo methods in order to obtain replicas of equilibrium energy states, and the overlap of these replicas. We found that although the magnetization of the ground states can be totally different at the same time, the internal energy of the ground states can be very close. We also noticed that spin glass systems retain memory from previous ground states when thermally cycled within the spin-glass phase.

where

1) E_μ is system internal energy at ground state μ,
2) m_i^a is the average magnetization at site i in the replica a,
3) $|M^a| = \sqrt{\sum_{i=0}^{N} m_i \cdot m_i}$.

Overlap vs Energy difference



Heat up to paramagnetic phase

Stay in Spin-glass Phase

3. Results

- No direct relationship between sameness of the replicas and internal energy of the replicas;
- Certain memory of the first ground state can be retained if system stays in spin-glass phase.