Probing the existence of a finite-temperature glass transition in short-range Potts glasses

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Motivation: The equations describing the dynamics of the Potts glass with $p > 4$ in mean field are almost identical to the mode coupling equations describing the glass transition in structural glasses. In principle, we can therefore gain insights about the structural glass transition by investigating spin systems.

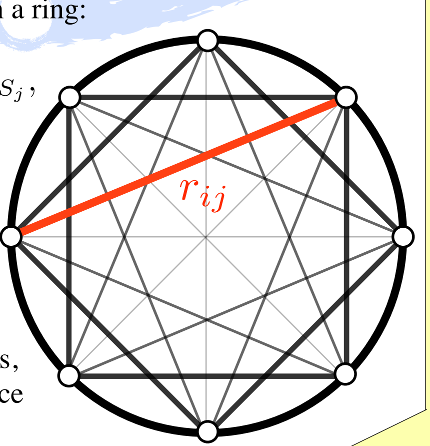
Problem: We want to know if there is a phase transition outside the mean field regime (i.e. for any $d < d_{\mathrm{ucd}}$). However, the required numerical effort renders the simulation of systems at large space dimensions unfeasible.

Solution: Study a one dimensional Potts glass with random power law interactions on a ring:

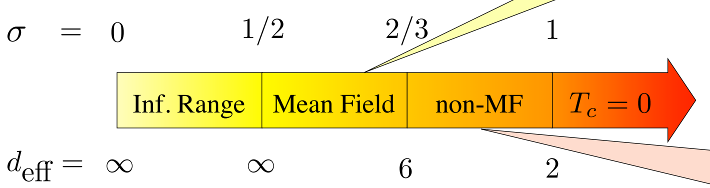
$$\mathcal{H} = -\sum_{ij} \frac{J_{ij}}{r_{ij}^{\sigma}}\, \delta_{S_i,S_j},$$

$$S_i \in \{1,\dots,10\}$$

$\mathcal{P}(J_{ij})$ Gaussian



The tuning parameter σ changes the relative weights of the interactions, and thus the effective space dimension:



Method: Use parallel tempering Monte Carlo simulations and detect the transition using the two-point correlation function ξ_N, which scales as:

$$\xi_N / N^{\nu/3} = \mathcal{X}[L^{1/3}(T - T_c)], \quad (1/2 < \sigma \le 2/3,\ \mathrm{MF})$$

$$\xi_N / N = \mathcal{X}[L^{1/\nu}(T - T_c)], \quad (2/3 < \sigma,\ \mathrm{non\text{-}MF})$$

We expect one of these scenarios for the correlation length: