

A Multicanonical Monte Carlo Study of the 3D $\pm J$ Spin Glass

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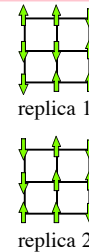
The $\pm J$ Model

$$H = - \sum_{\alpha=1,2} \sum_{\langle i,j \rangle} J_{ij} \sigma_i^{(\alpha)} \sigma_j^{(\alpha)}$$

$J_{ij} = \pm 1$ (quenched)

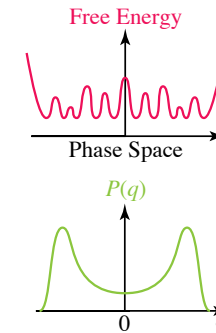
Overlap Order Parameter

$$q = \frac{1}{N} \sum_{i=1}^N \sigma_i^{(1)} \sigma_i^{(2)}$$

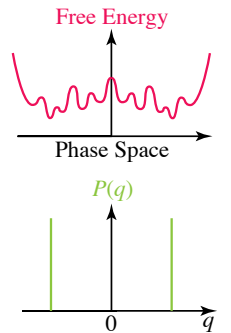


Low-Temperature Phase

Mean-field picture
(Parisi *et al.*)

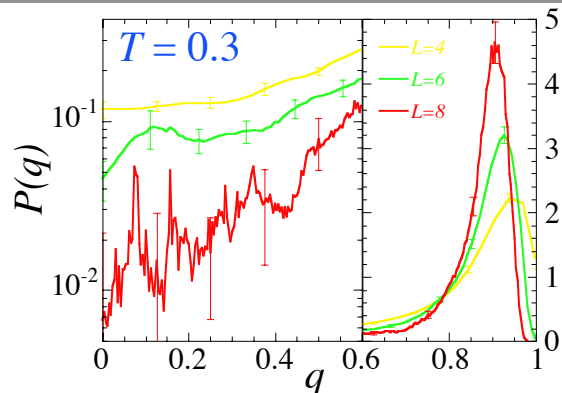


Droplet picture
(Fisher & Huse)

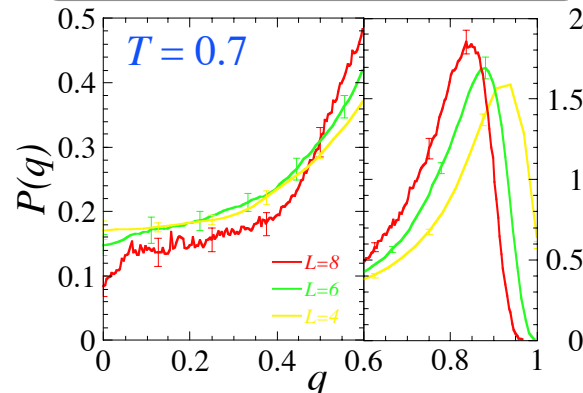


$L \rightarrow \infty$
 $T \approx 0$

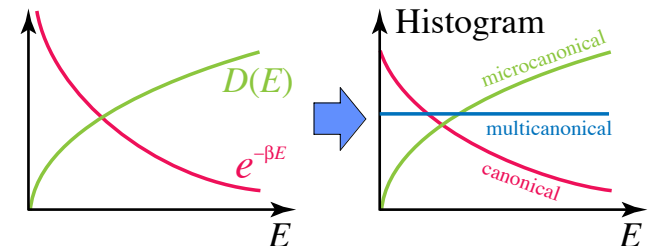
Order-Parameter Distribution



At higher temperatures



Flattening the histogram



Microcanonical: Few low-energy states

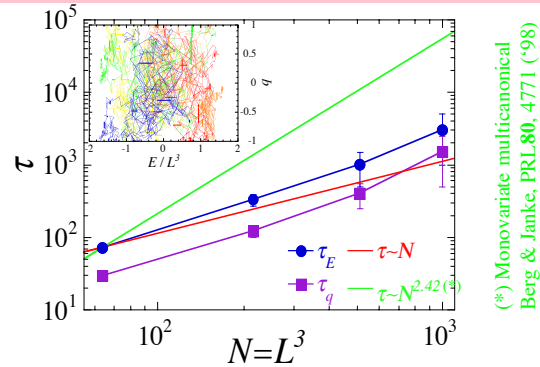
Canonical: Few high-energy states

Trapped by local minima

Multicanonical: Samples uniformly

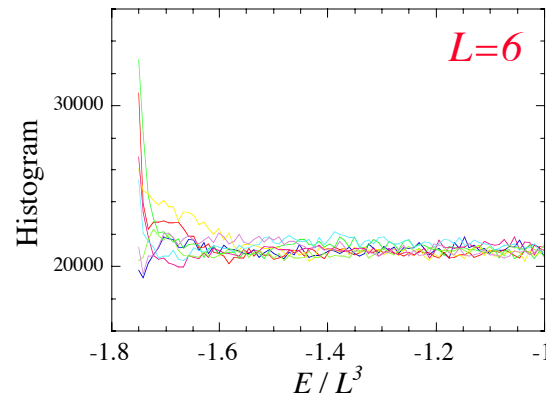
Auto-Correlation Time

Making the bivariate histogram $h(E,q)$ flat

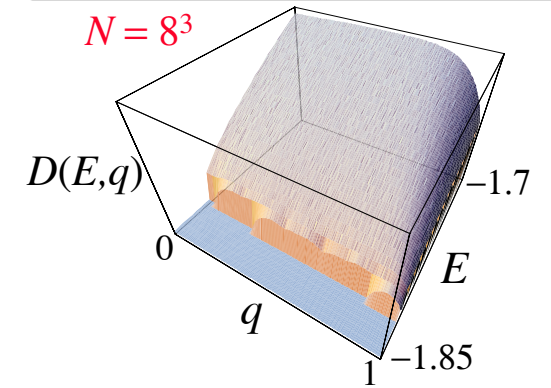


(*) Monovariate multicanonical
Berg & Janke, PRL 80, 4771 ('98)

Monovariate Multicanonical



Density of States $D(E,q)$



Summary

- **Bivariate Multicanonical Monte Carlo Method**
→ Correlation Time: $\tau \sim N$
- **Low-Temperature Phase**
→ The result of $P(q; T=0.3)$ suggests the droplet picture

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