SWAP method for spin lattice models

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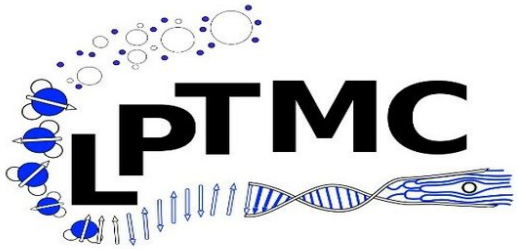


Problem: Slow relaxational dynamics

Edwards-Anderson model (2d)

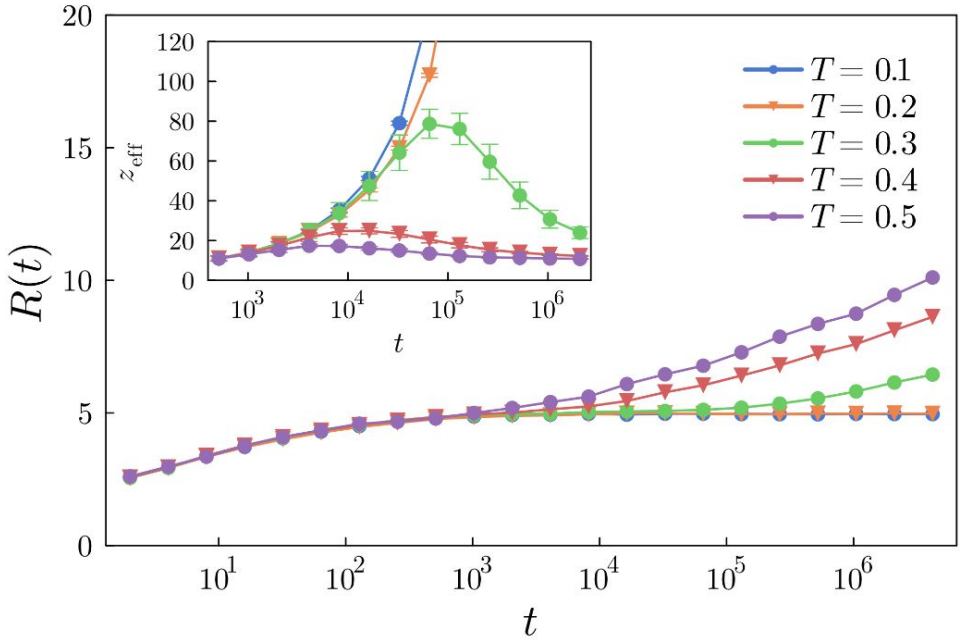
$$\mathcal{H} = -\sum_{\langle ij \rangle} J_{ij}\sigma_i\sigma_j, \quad \sigma_i = \pm 1, \quad i = 1, \ldots, N$$

4-Point Correlation Function

$$C_4(r,t) = \frac{1}{N}\sum_{i,j=1}^{N}\left[\langle \sigma_j^{(1)}(t)\sigma_i^{(1)}(t)\sigma_j^{(2)}(t)\sigma_i^{(2)}(t)\rangle\right]\Big|_{|\vec{r}_i-\vec{r}_j|=r}$$

Growing length

$$R(t) = 2\int_0^\infty dr\; C_4(r,t)$$



Solution for structural glasses

Efficient swap algorithms for molecular dynamics simulations of equilibrium supercooled liquids

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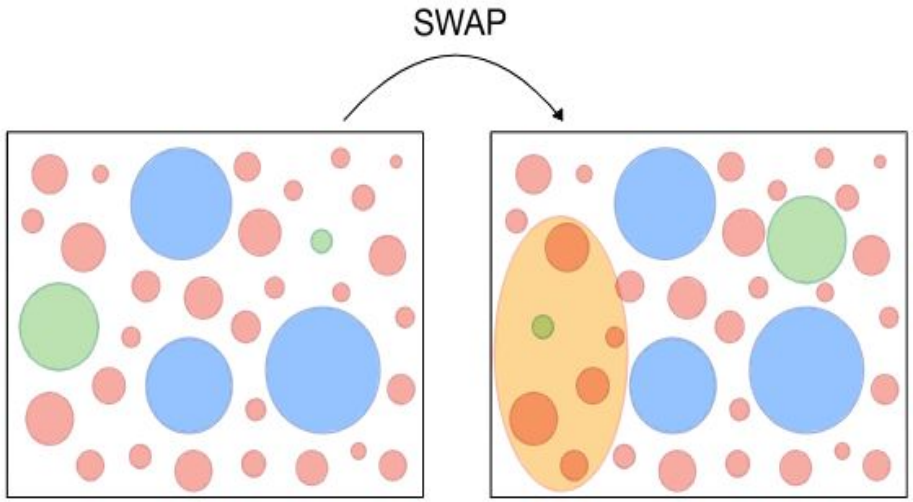
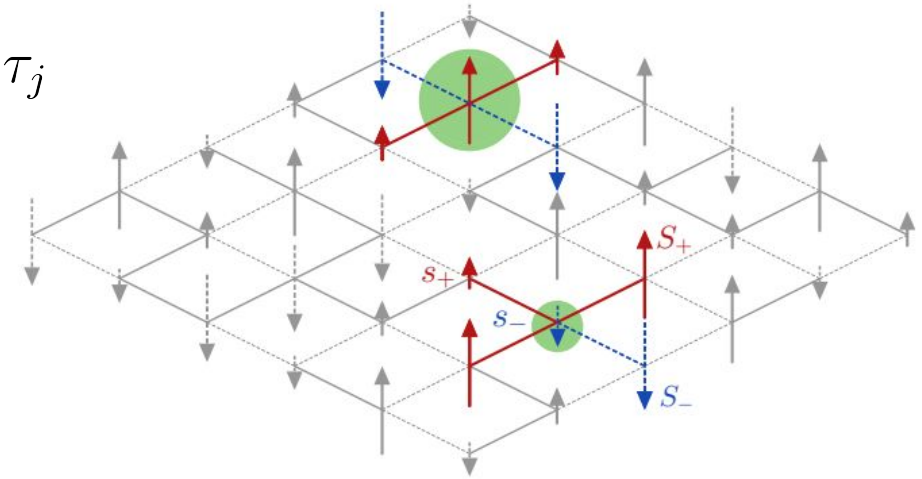


Mapping to spin lattices

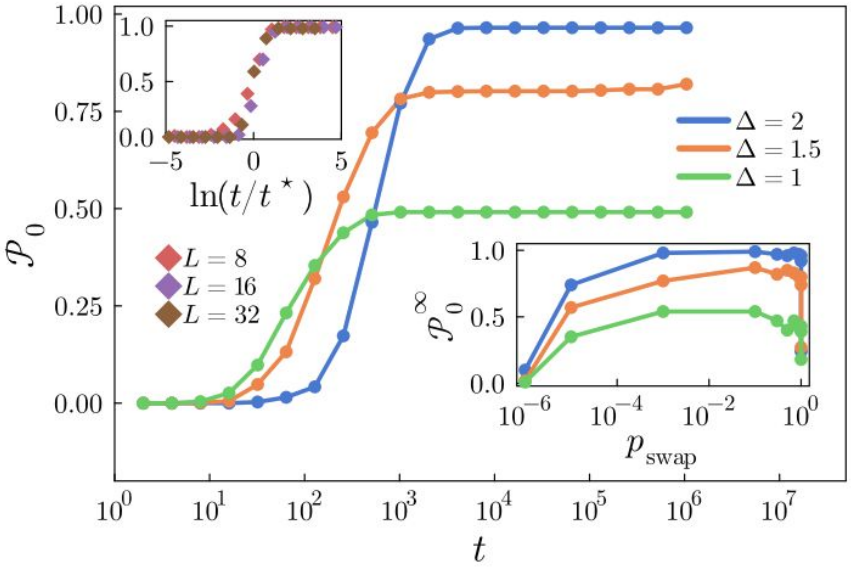
$$\mathcal{H} = -\sum_{\langle ij \rangle} J_{ij} s_i s_j, \quad s_i = \sigma_i \tau_i \quad \text{with} \quad \tau_i \in [1 - \Delta/2, 1 + \Delta/2]$$

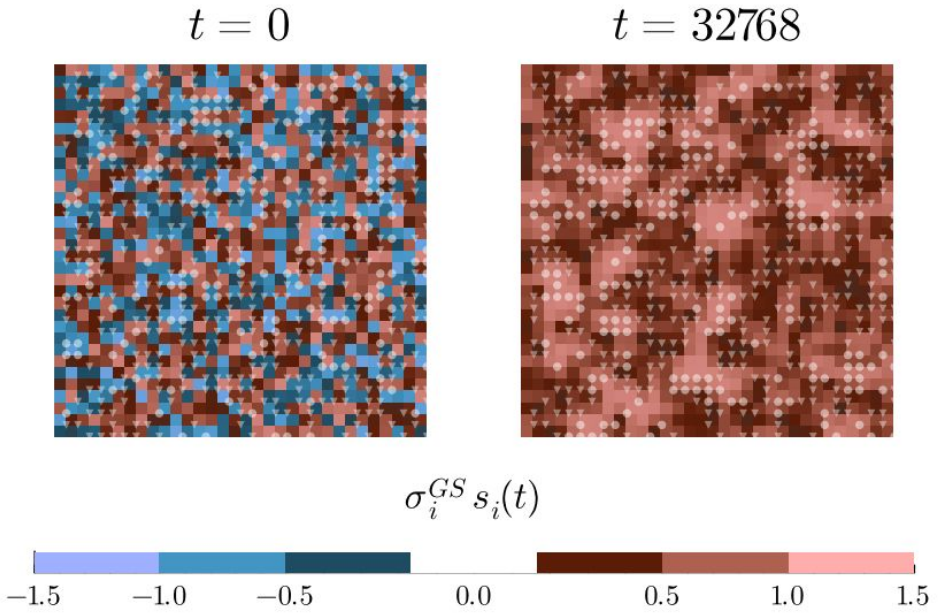
$$\text{and} \quad 0 \leq \Delta \leq 2$$

$$\mathcal{H} = -\sum_{\langle ij \rangle} \mathcal{J}_{ij} \sigma_i \sigma_j, \quad \mathcal{J}_{ij} = J_{ij} \tau_i \tau_j$$



We are able to find the ground states!





hskTan!

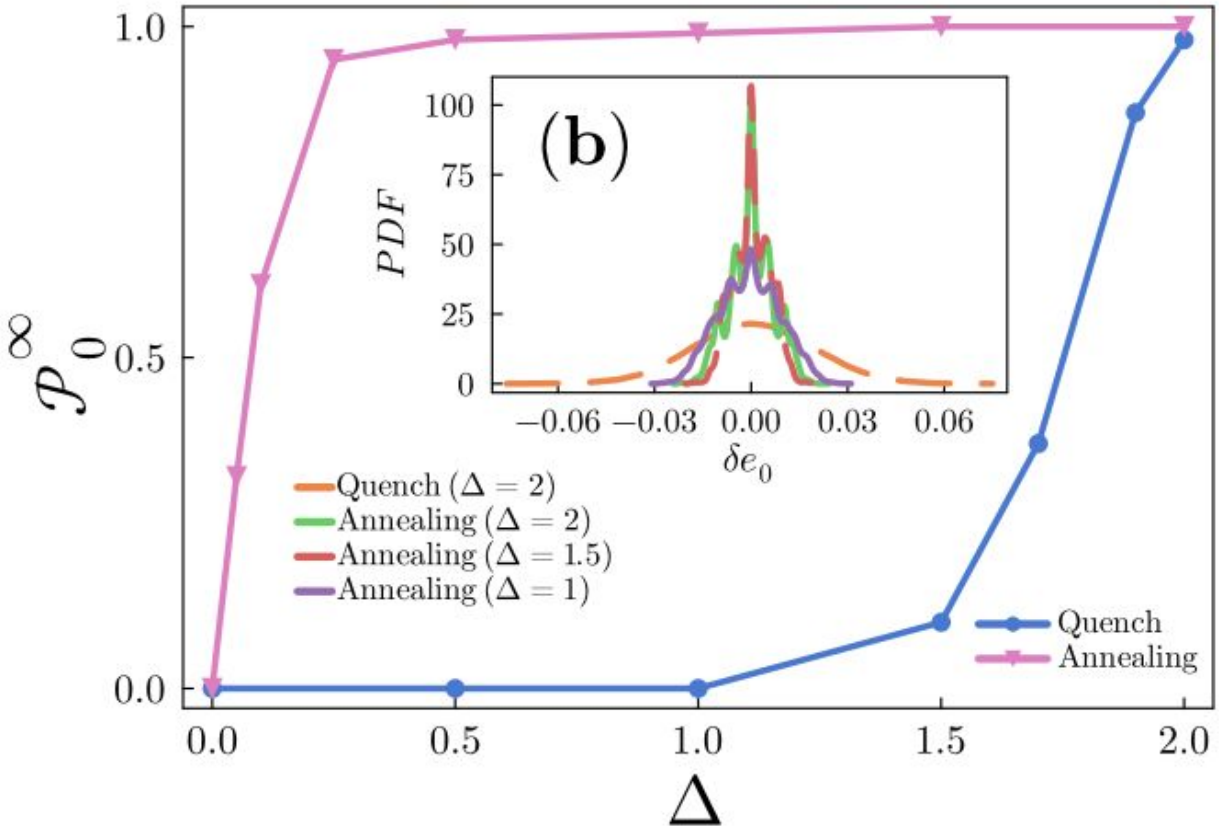
hskTan!

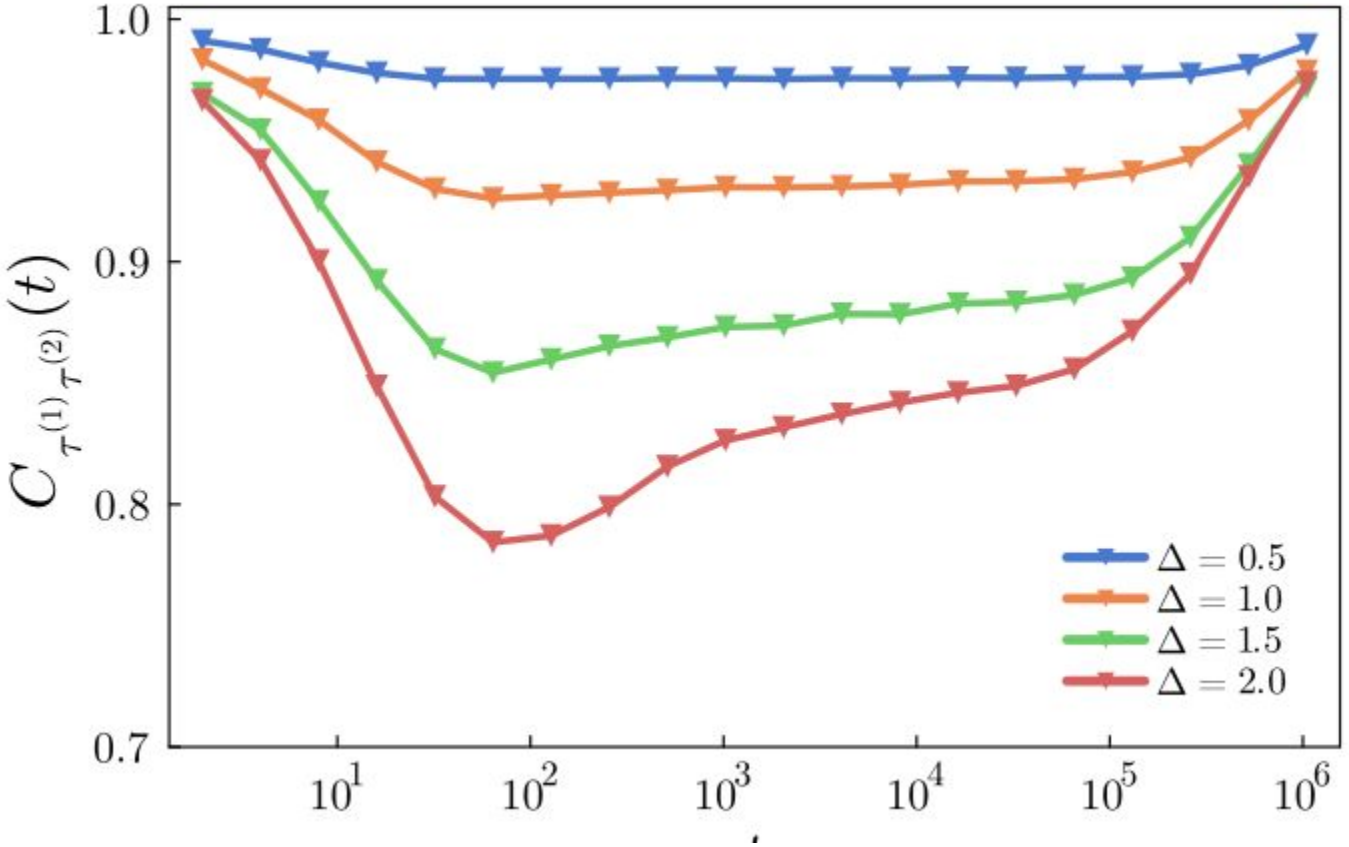
Tskhan!

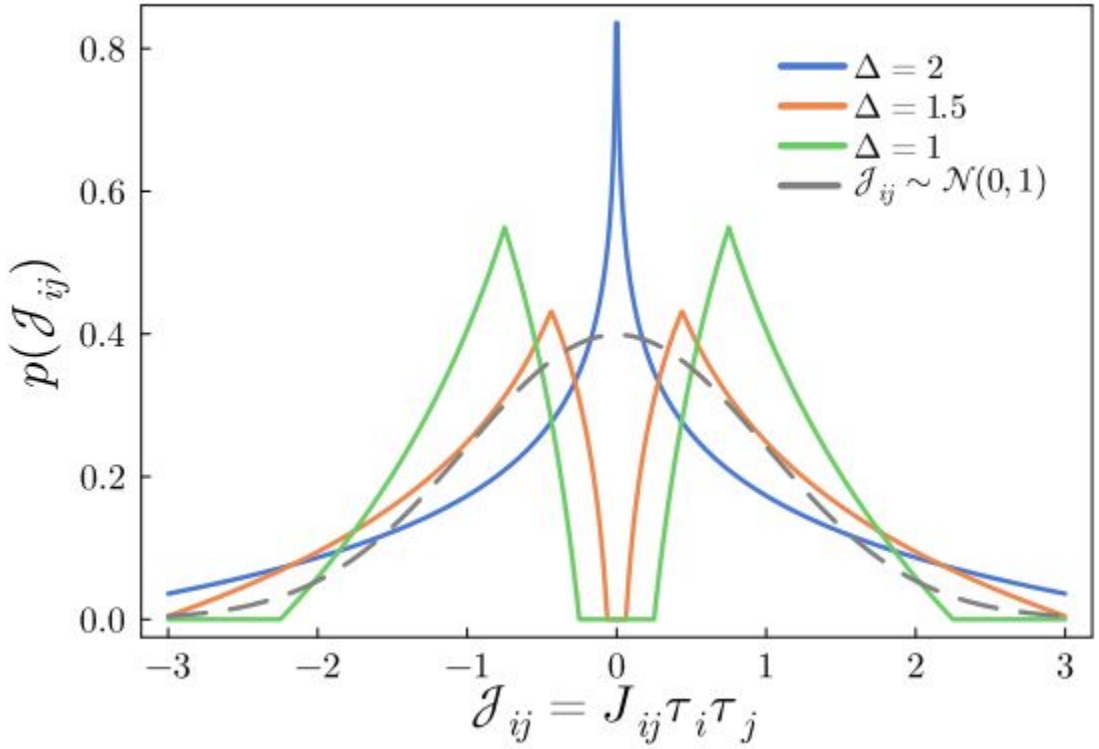
Thksan!

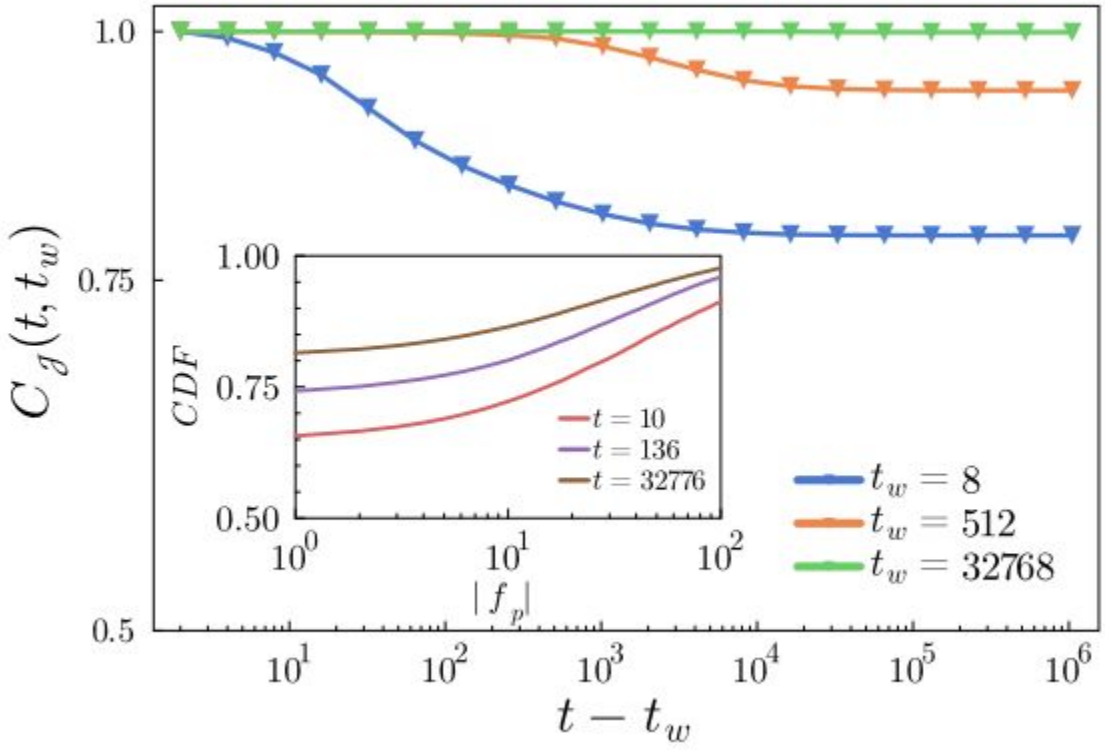
Thaskn!

Thanks!


1.0
0.5
0.0
$\mathcal{P}_0^\infty$
0.0
0.5
1.0
1.5
2.0
Δ
Quench
Annealing
(b)
100
75
50
25
0
PDF
−0.06
−0.03
0.00
0.03
0.06
δe_0
Quench ($\Delta = 2$)
Annealing ($\Delta = 2$)
Annealing ($\Delta = 1.5$)
Annealing ($\Delta = 1$)


1.0
0.9
0.8
0.7
$C_{\tau^{(1)}\tau^{(2)}}(t)$
10^1
10^2
10^3
10^4
10^5
10^6
$\Delta = 0.5$
$\Delta = 1.0$
$\Delta = 1.5$
$\Delta = 2.0$


0.8
0.6
0.4
0.2
0.0
$p(\mathcal{J}_{ij})$
−3
−2
−1
0
1
2
3
$\mathcal{J}_{ij} = J_{ij}\tau_i\tau_j$
$\Delta = 2$
$\Delta = 1.5$
$\Delta = 1$
$\mathcal{J}_{ij} \sim \mathcal{N}(0,1)$


1.0
0.75
0.5
$C_g(t, t_w)$
10^1
10^2
10^3
10^4
10^5
10^6
$t - t_w$
$t_w = 8$
$t_w = 512$
$t_w = 32768$
1.00
0.75
0.50
CDF
10^0
10^1
10^2
$|f_p|$
$t = 10$
$t = 136$
$t = 32776$