Tmux

Terminal **mu**ltiple**x**or

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Systecon

Hello World in tmux

- Random and self avoiding walks
- Spin lattices
- Dual transformations
- Geometric properties
- Ising, XY

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Ways of defining fractal dimension

Scaling Mass

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Scaling Mass

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$$L \to \frac{1}{2}L$$

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Scaling Mass

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$$L \to \frac{1}{2}L$$

$$\left(\frac{1}{2}\right)^d M = \frac{1}{4}M$$

$$d = 2$$

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$$L \to \frac{1}{2}L$$

$$\left(\frac{1}{2}\right)^d M = \frac{1}{3}M$$

$$\begin{aligned} d &= \log_2(3) \\ &\approx 1.585 \end{aligned}$$

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Box Counting Method

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$$N \sim \frac{1}{\epsilon^d}$$

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Box Counting Method

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$$N \sim \frac{1}{\epsilon^d}$$

$$d = \lim_{\epsilon \to 0^+} \frac{\ln N(\epsilon)}{\ln 1/\epsilon}$$

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Hausdorff Dimension

$$\mathcal{H}_d(A) = \lim_{\delta \to 0} \inf \left\{ \sum_{B \in \mathcal{B}} (\mathrm{diam}(B))^d \right\}$$

$$\dim_H(A) = \inf\{d > 0 : \mathcal{H}_d(A) = 0\}$$

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Algorithms for Working with Graph Patterns

Worm Algorithm

- Graph configurations
- Metropolis steps

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Labeling and Dividing the Graph

- Hoshen-Kopelman Algorithm
- Graph Dividing

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Ising Model

Ising Loop Expansion

$$Z \propto \sum_{\{S\}} \left(1 + \tanh(K) \sum_{l=1} S_i S_j + \tanh^2(K) \sum_{l=2} (S_i S_j)(S_{i'} S_{j'}) + \ldots \right)$$

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Ising Loop Expansion

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Scaling Dimension Ising Cluster

Here was a figure [1] B. Duplantier, Conformally Invariant Fractals and Potential Theory, Physical Review Letters 84, 1363 (2000).

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Box Dimension Ising Cluster

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Comparison of Dimensions $2D$ Ising

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Largest Ising Loop on a 128^2 Lattice

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$2D$ Ising Animation

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XY Model

XY Loop Expansion - Hamiltonian & Partition Function

$$H = -J \sum_{\langle ij \rangle} \cos(\theta_i - \theta_j)$$

$$Z = \prod_i \int \frac{\mathrm{d}\theta_i}{2\pi} \prod_{\langle ij \rangle} e^{K \cos(\theta_i - \theta_j)}$$

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XY Loop Expansion

$$Z \sim \int \frac{\mathrm{d}\theta_i}{2\pi} e^{i\sum_{\langle ij\rangle} j_{\langle ij\rangle}(\theta_i - \theta_j)}$$

$$\sim \delta_{0,\sum_{\langle ij\rangle} j_{\langle ij\rangle}}$$

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$3D$ **XY Animation** - 4^3 **system**

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Villain Model

$$E = \frac{1}{2}\sum_i j_i^2$$

$$\lim_{\beta\to\infty}\beta_d = 0 \qquad \lim_{\beta\to 0}\beta_d = \infty$$

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Winding Number

$$\rho_s = L^{2-d} T \langle W_\mu^2 \rangle$$

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Winding Number

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$3D$ XY Model Hausdorff Dimension

- Hove, Mo and Sudbo (2000): $D_H = 2.287 \pm 4 \cdot 10^{-3}$[1]
- Prokof'ev and Svistunov Comment (2006): $D_H = 1.765 \pm 2 \cdot 10^{-3}$[2]

[1] J. Hove, S. Mo and A. Sudb, Hausdorff Dimension of Critical Fluctuations in Abelian Gauge Theories, Physical Review Letters 85, 2368 (2000).

[2] N. Prokofev and B. Svistunov, Comment on Hausdorff Dimension of Critical Fluctuations in Abelian Gauge Theories, Physical Review Letters 96 (2006).

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Box Counting Method $3D$ XY

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Comparison of Dimensions $3D$ XY

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$3D$ **XY Animation - Largest cluster**

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Summary

	D_H
Box	1.35193(5)
Scaling	1.386(2)
D_H^G	1.375 [1]
SAW	1.33

Table 1: $2D$ Ising

	D_H
Box	1.77468(4)
Prokof'ev	1.765(2) [2]
Sudbo	2.287(2) [3]

Table 2: $3D$ XY

[1] B. Duplantier, Conformally Invariant Fractals and Potential Theory, Physical Review Letters 84, 1363 (2000).

[2] N. Prokofev and B. Svistunov, Comment on Hausdorff Dimension of Critical Fluctuations in Abelian Gauge Theories, Physical Review Letters 96 (2006).

[3] J. Hove, S. Mo and A. Sudb, Hausdorff Dimension of Critical Fluctuations in Abelian Gauge Theories, Physical Review Letters 85, 2368 (2000).

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Extra slides: Box Dimension 64^2 Ising

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Extra slides: Susceptibility $2D$ Ising

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Extra slides: Largest Ising cluster

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Extra slides: Self avoiding walk

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Extra slides: Graph Dividing Algorithm

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