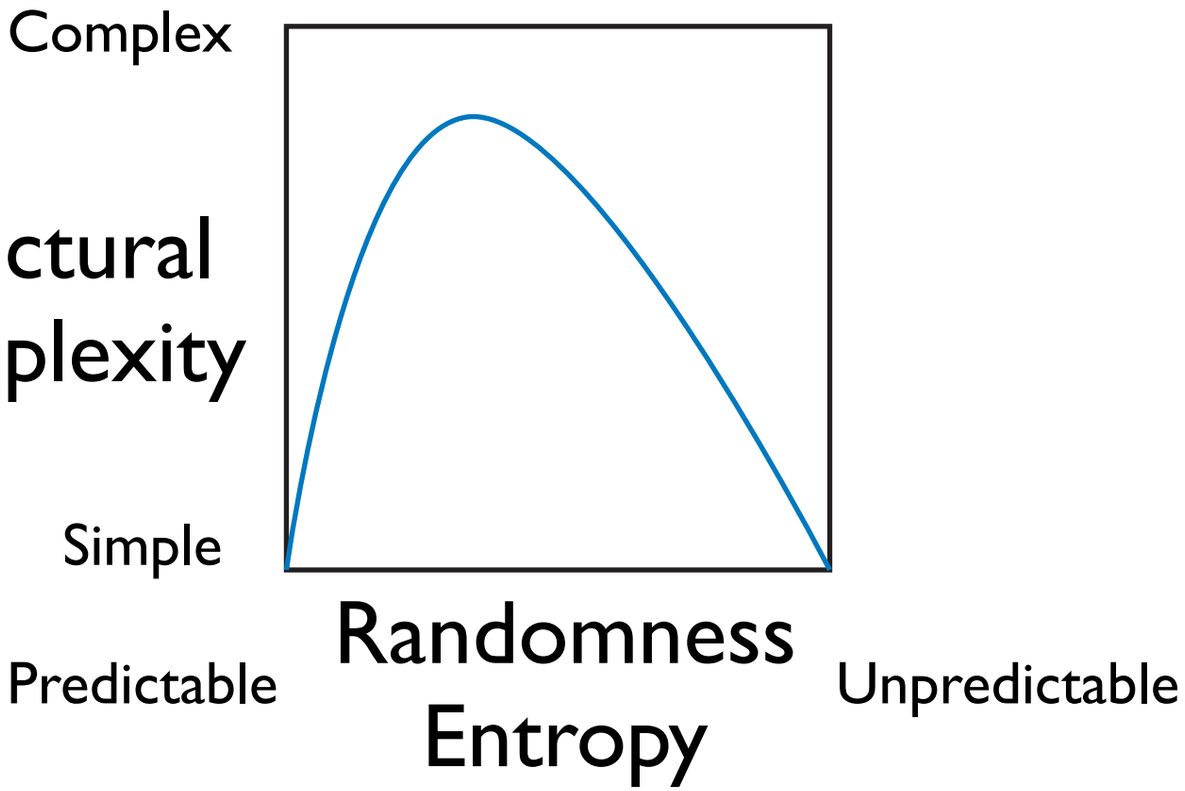
Applications

Measures of Complexity ...

Complexity-Entropy Diagram:
Analyze a class of processes



Analogous to Thermodynamic Phase Diagram (gas, liquid, solid).
But uses only intrinsic computation properties.

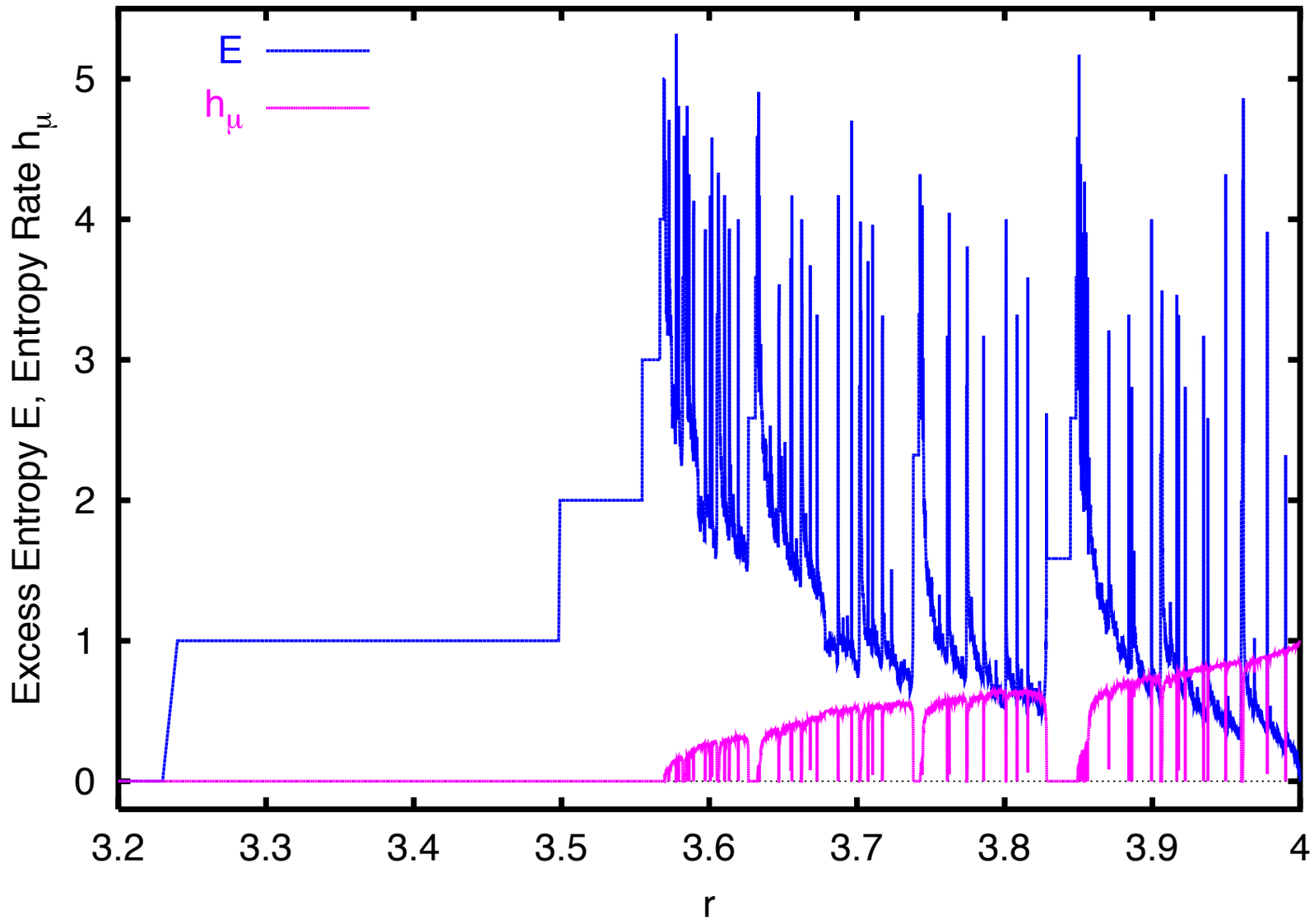
A wide diversity of Complexity-Entropy Diagrams.

Measures of Complexity ...

Complexity-Entropy Diagram:

Analyze a class of processes ...

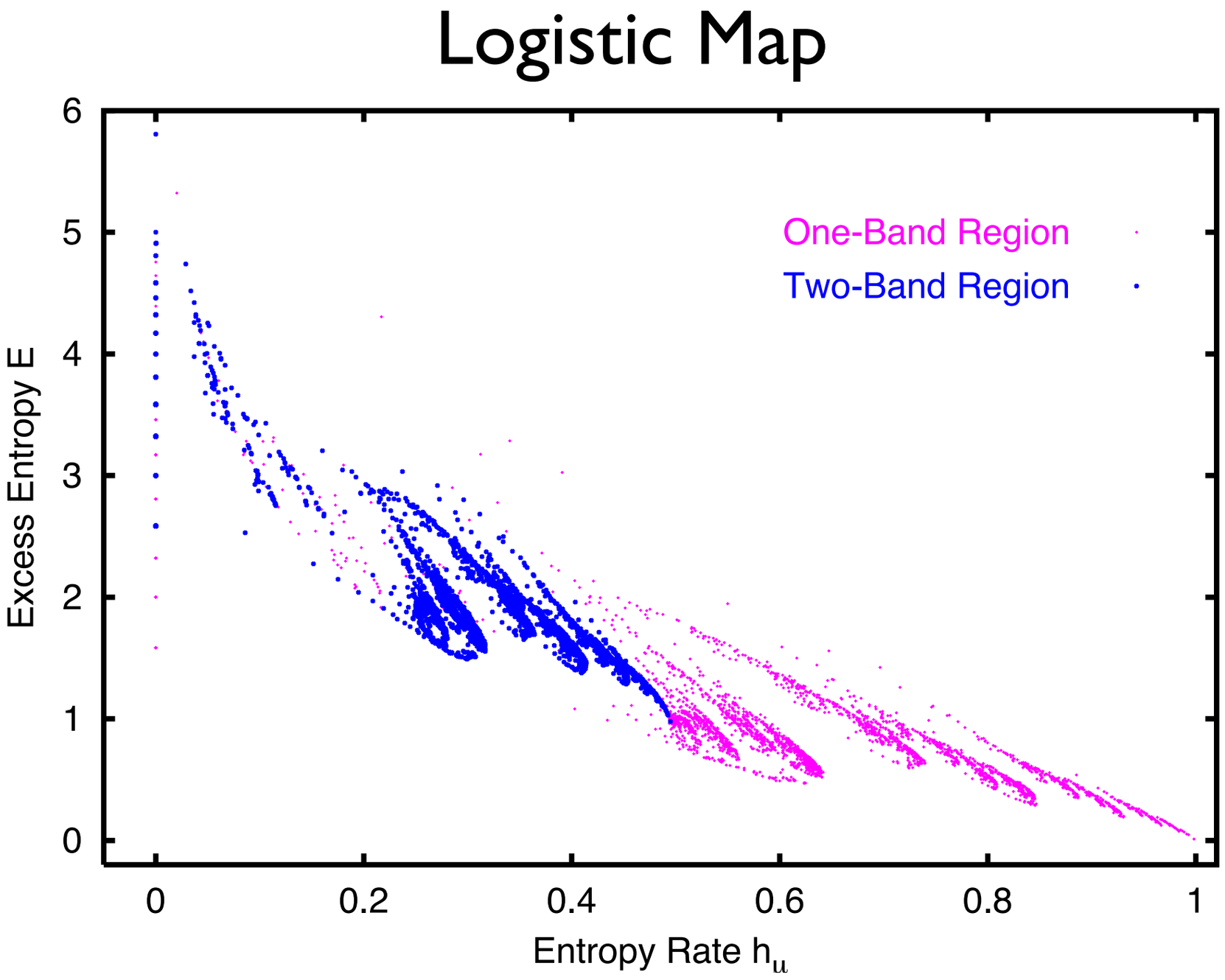
Logistic Map



Measures of Complexity ...

Complexity-Entropy Diagram:

Analyze a class of processes ...

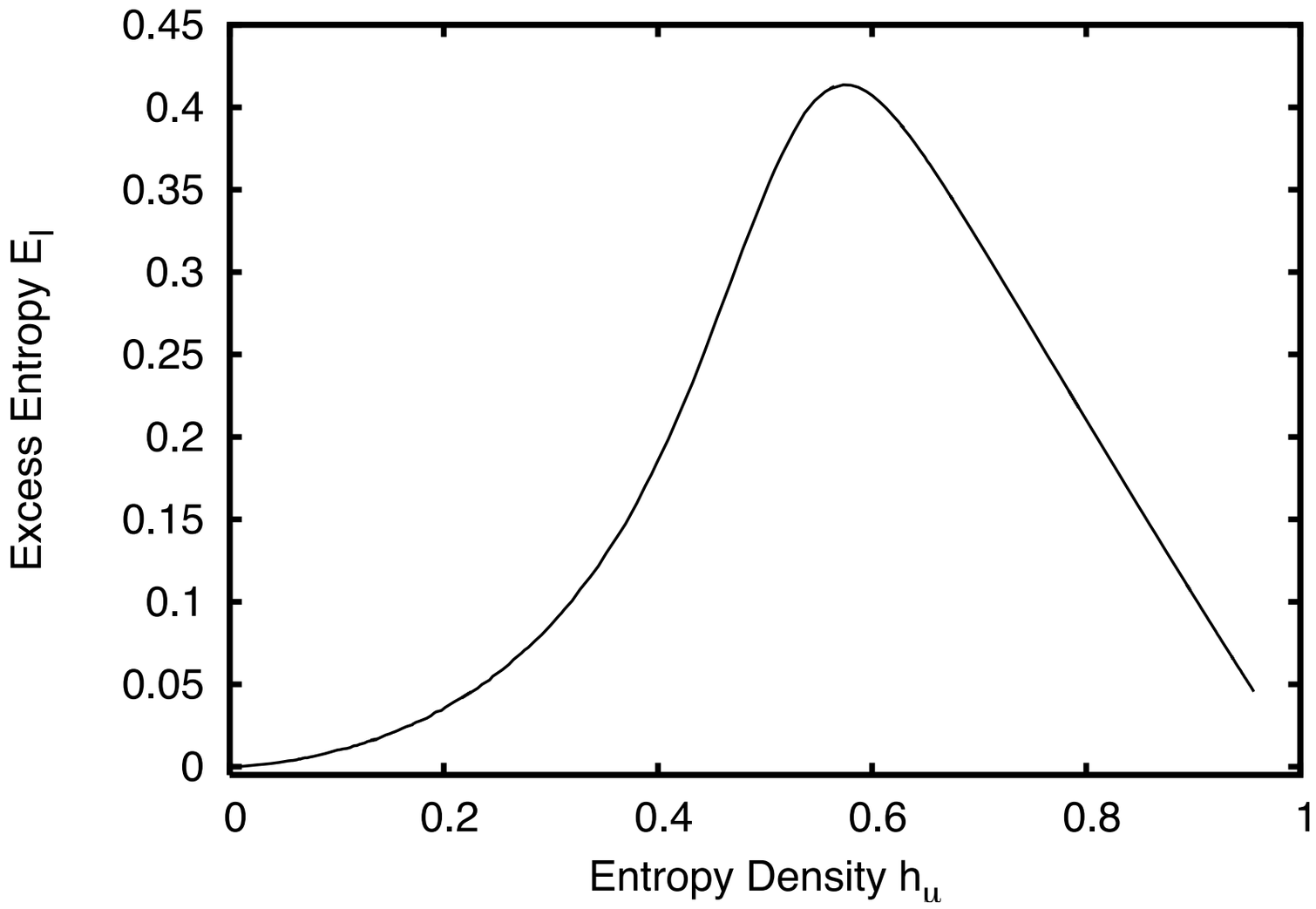


Measures of Complexity ...

Complexity-Entropy Diagram:

Analyze a class of processes ...

2D Ising Spin System

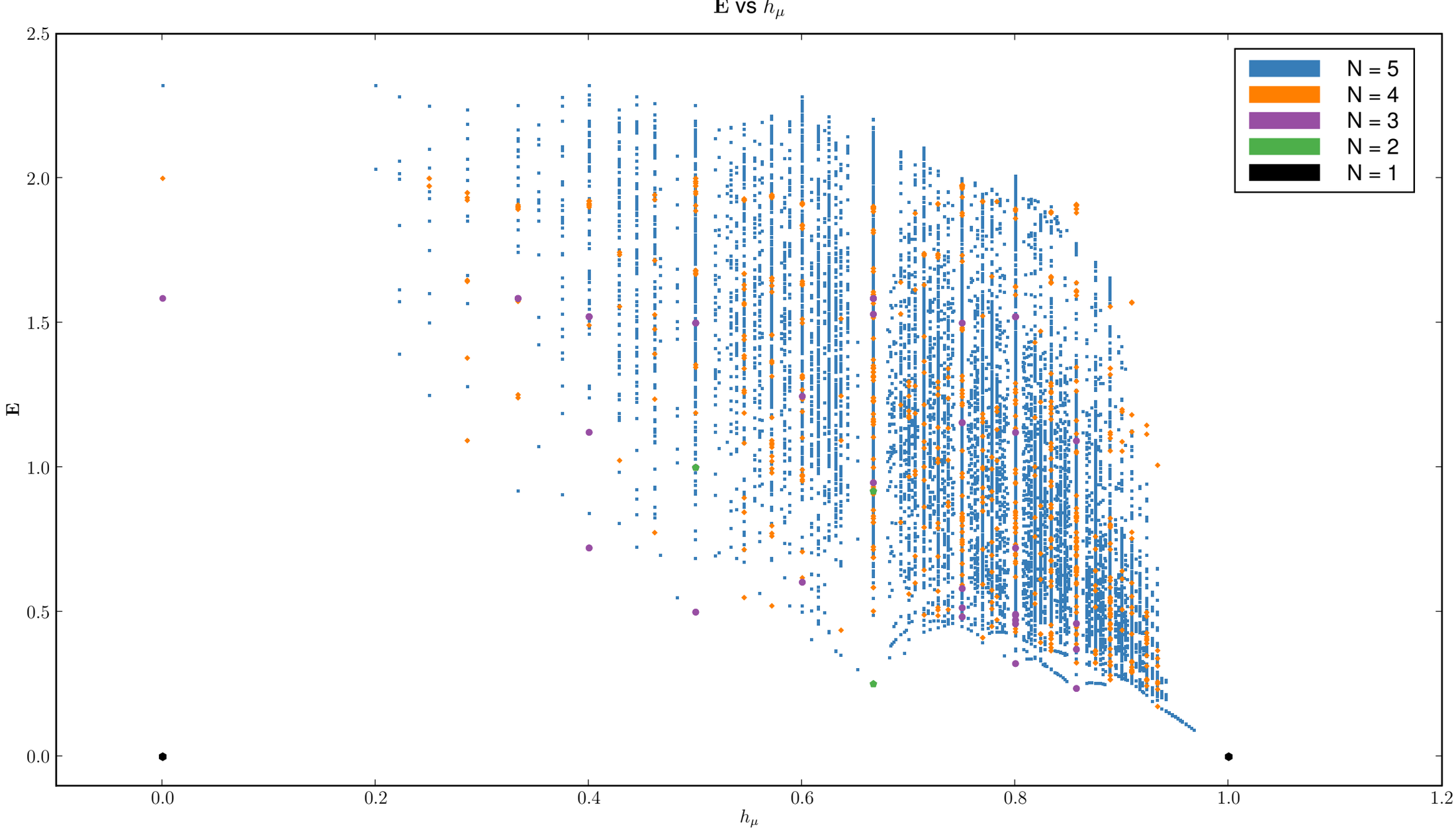


Measures of Complexity ...

Complexity-Entropy Diagram:

Analyze a class of processes ...

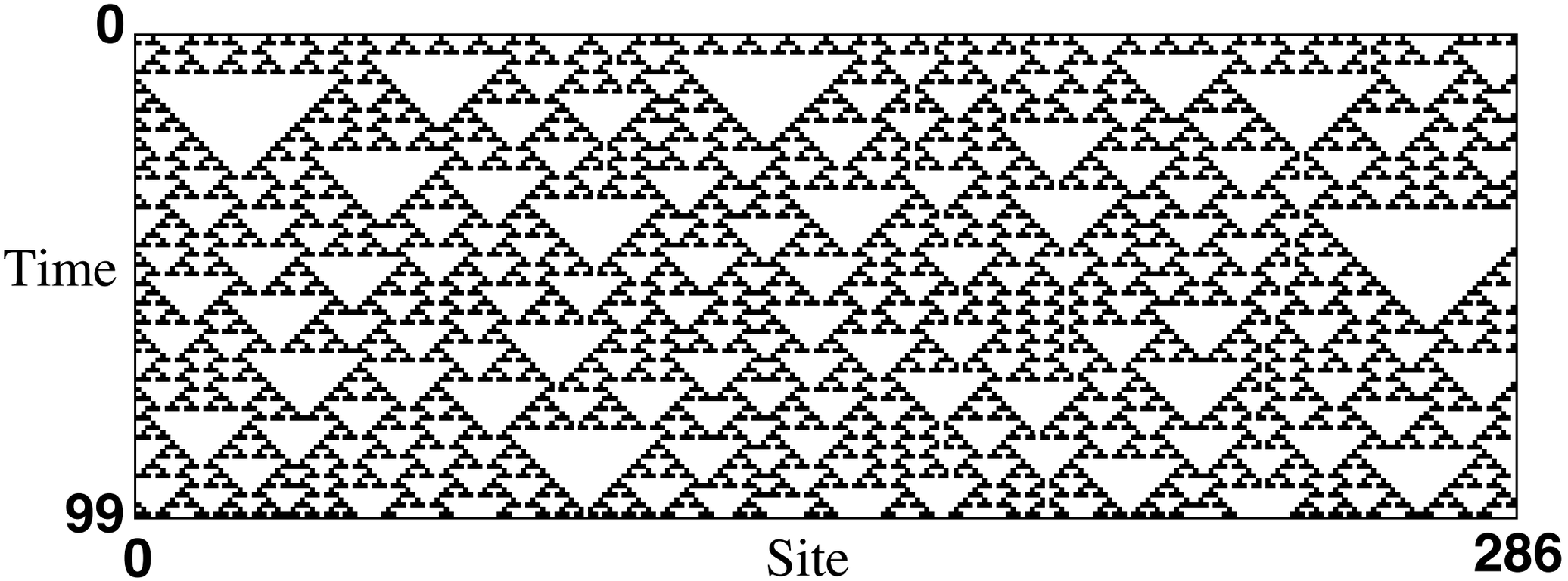
Topological ε-Machines



Complexity Lecture 2: Computational Mechanics (CSSS 2011); Jim Crutchfield

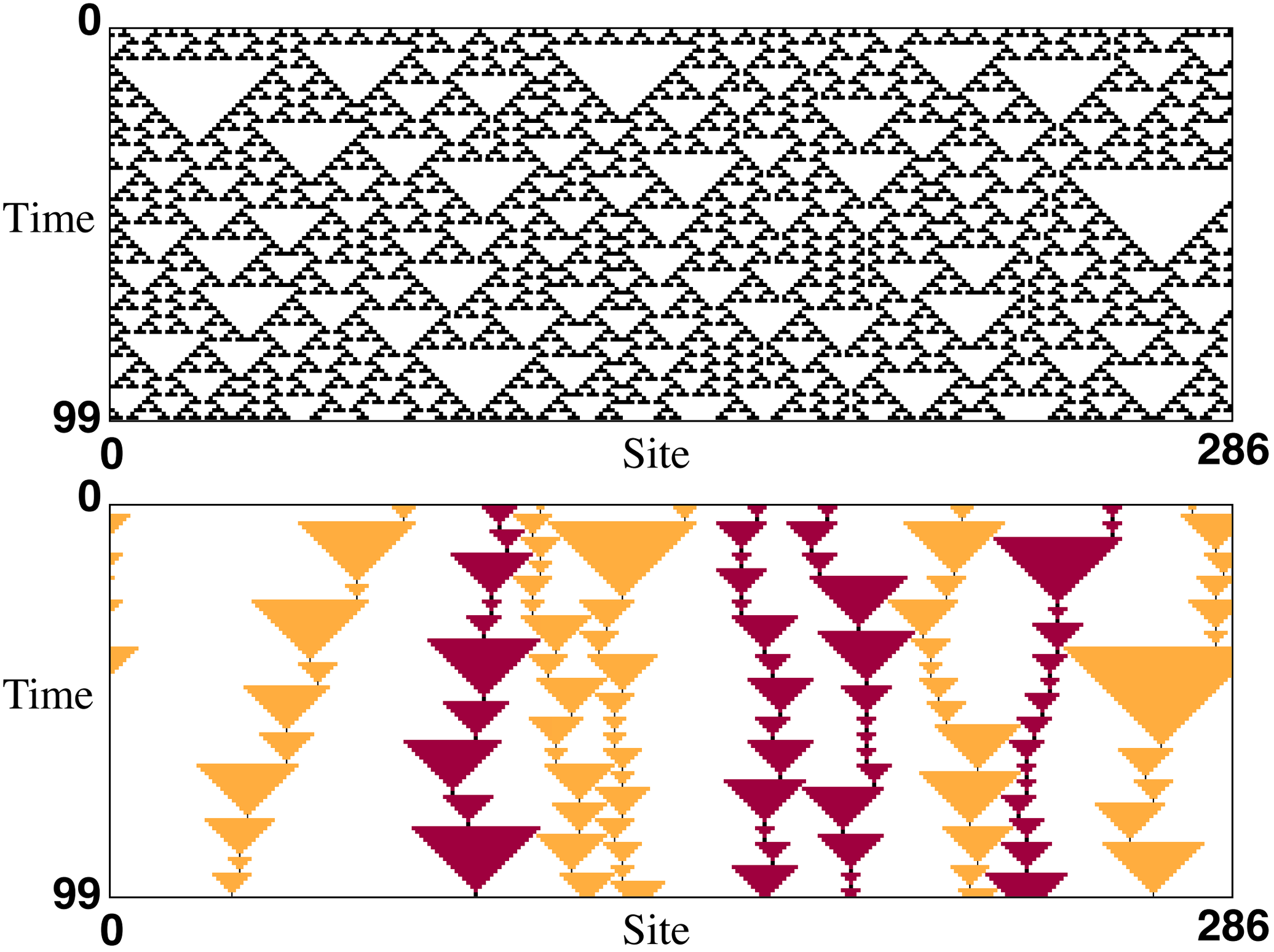
Measures of Complexity ...

Cellular Automata Computational Mechanics

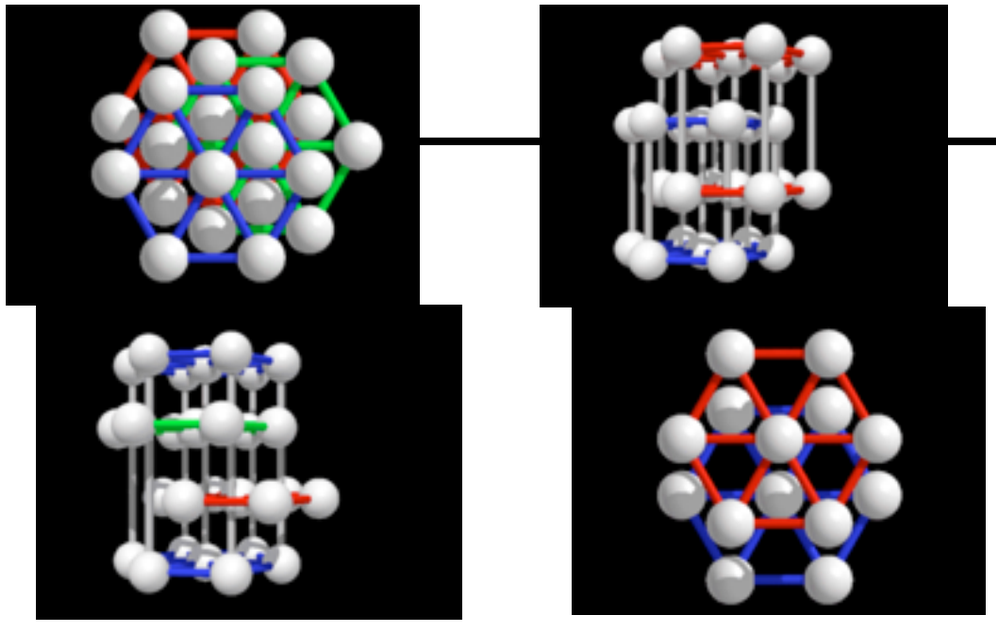


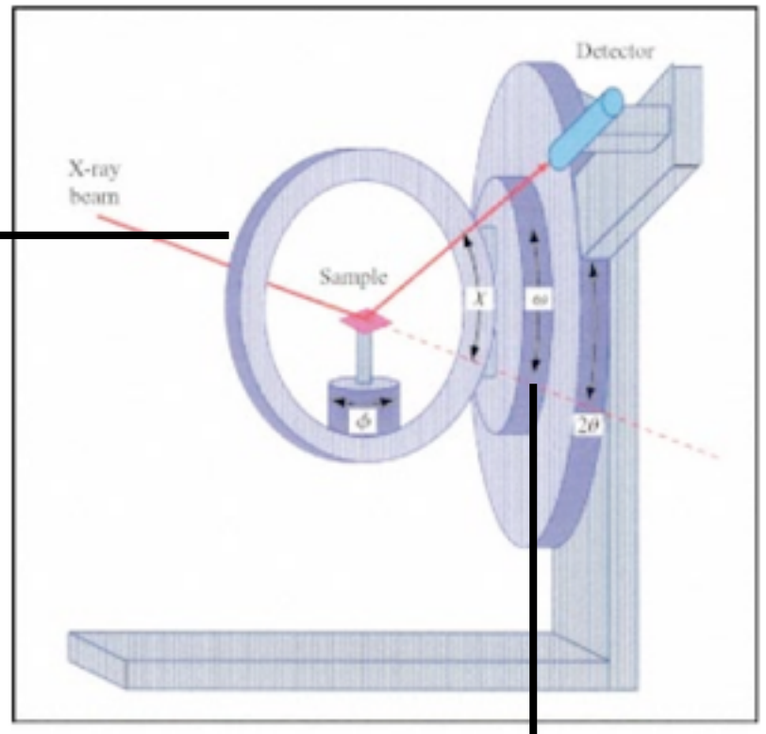
Measures of Complexity ...

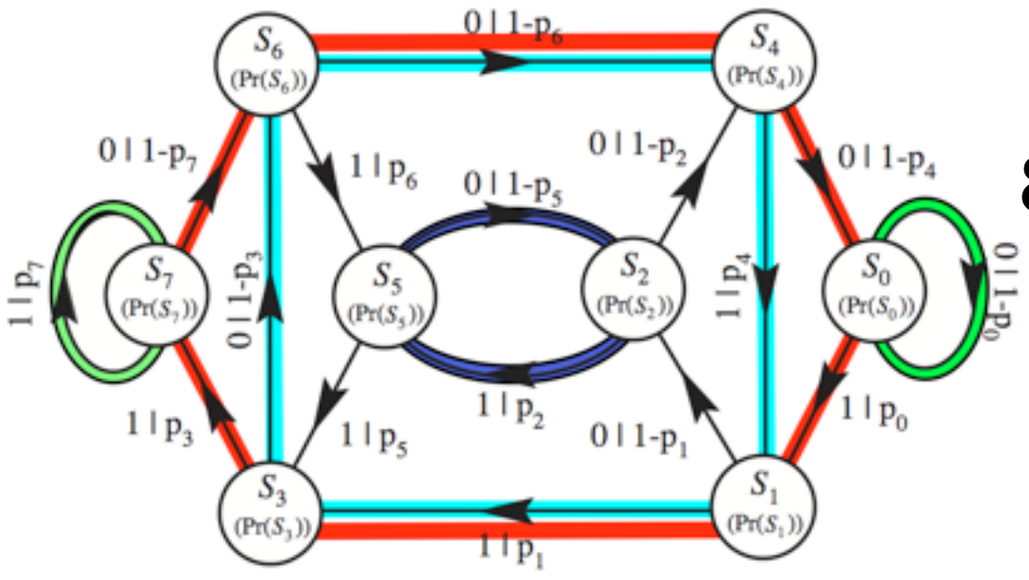
Cellular Automata Computational Mechanics



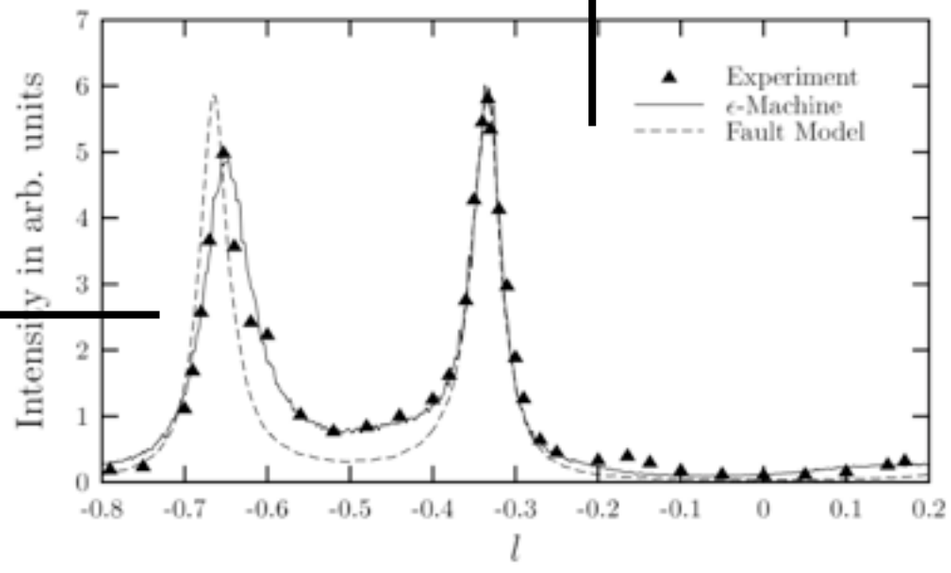
Computational Mechanics: Application to Experimental X-Ray Diffraction







ε-MSR



D. P. Varn, G. S. Canright, J. P. Crutchfield, "Discovering Planar Disorder in Close-Packed Structures from X-Ray Diffraction: Beyond the Fault Model", Phys. Rev. B 66: 17 (2002) 174110-2.

Computational Mechanics: Application to Experimental Molecular Dynamics Spectroscopy

Multiscale complex network of protein conformational fluctuations in single-molecule time series

Chun-Biu Li*†‡, Haw Yang§¶, and Tamiki Komatsuzaki*†‖

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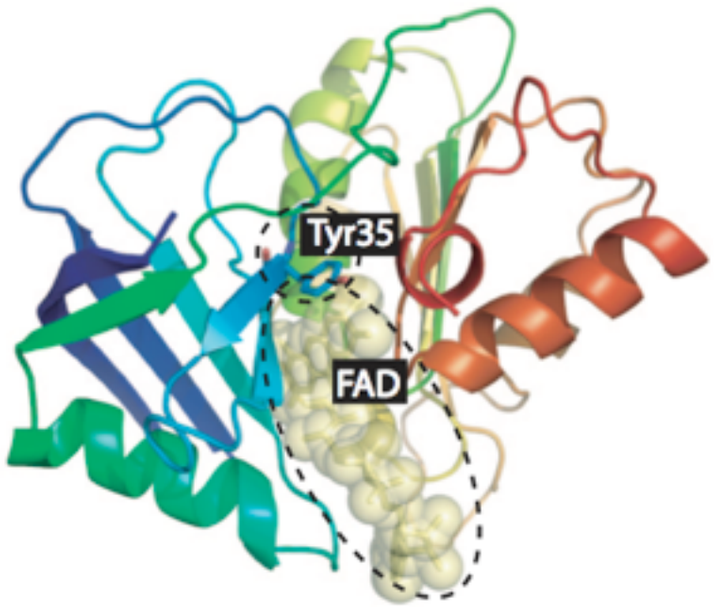
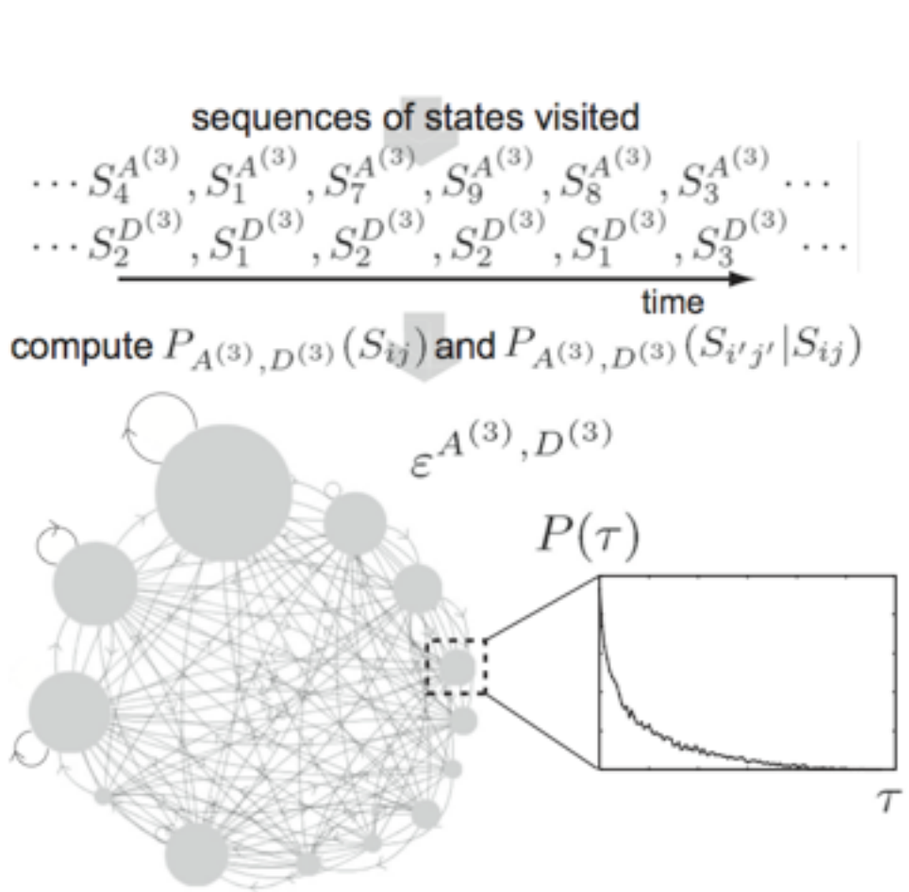




C.-B. Li, H. Yang, & T. Komatsuzaki, PNAS 105:2 (2008) 536–541.

Measures of Complexity ...

Computational Mechanics Applications:

Chaotic Dynamical Systems
Symbolic Dynamics
Statistical Mechanical Models: Spin systems (Ising, glasses, ...)
Single-Molecule Dynamics
Cellular Automata
Hidden Markov Models
Crystallography
Hydrodynamics: dripping faucet, turbulence
Quantum Systems (in progress)

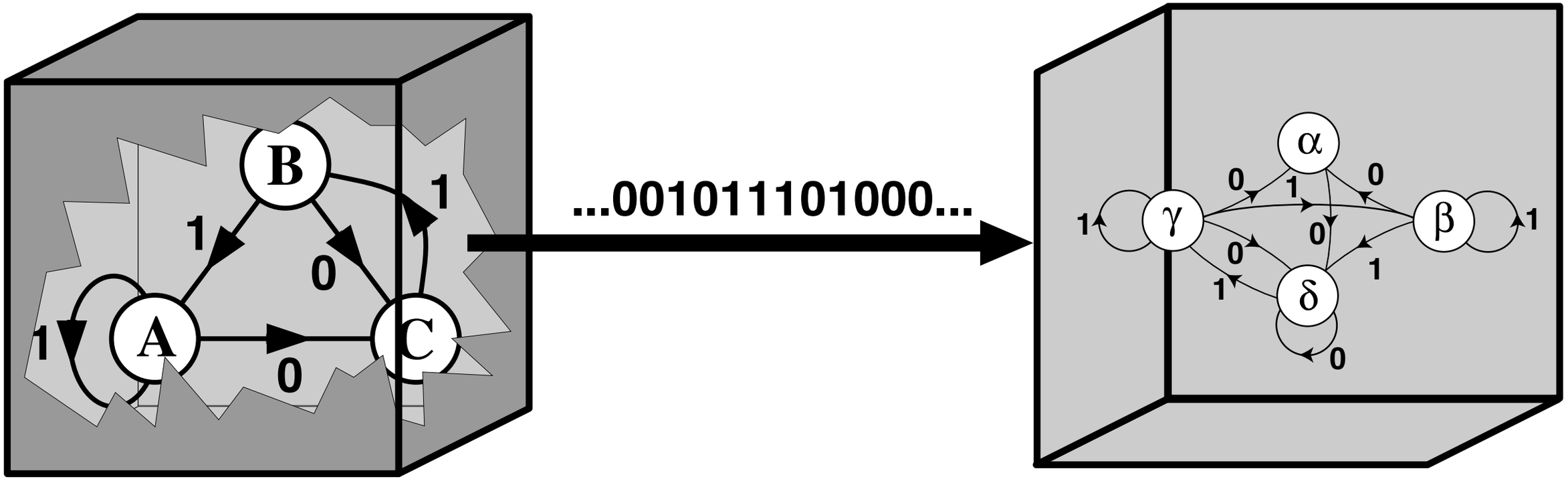
Measures of Complexity ...

Computational Mechanics Research:

- Intrinsic computation
- Statistical inference
- Quantum chaotic dynamics & measurement effects
- Continuous processes
- Spatiotemporal processes
- Network dynamics
- Neurobiological processes
- Multiagent systems
- Distributed robotics
- Evolutionary dynamics
- ...

Measures of Complexity ...

Lecture narrative:



System **Instrument** **Process** **Modeller**

Forms of Chaos:
- Deterministic sources of novelty
- Mechanisms that produce unpredictability
- Sensitive dependence on initial condition
- Sensitive dependence on parameter

Measurement Theory:
- Partitions
- Optimal Instrument:

$$\max_{\{\mathcal{P}\}} h_\mu$$
$$\min_{\{\mathcal{P}\}} C_\mu$$

How random?

$$\lambda, H(L), h_\mu$$

How structured?

$$C_\mu, \mathbf{E}, \mathbf{T}, \mathbf{G}, \mathcal{R}$$

Universal model:

$$\epsilon - \text{Machine}$$

- Pattern defined
- Causal Architecture
- Intrinsic Computation

Measures of Complexity ...

Further reading:

Computational Mechanics Archive:
csc.ucdavis.edu/~cmg/