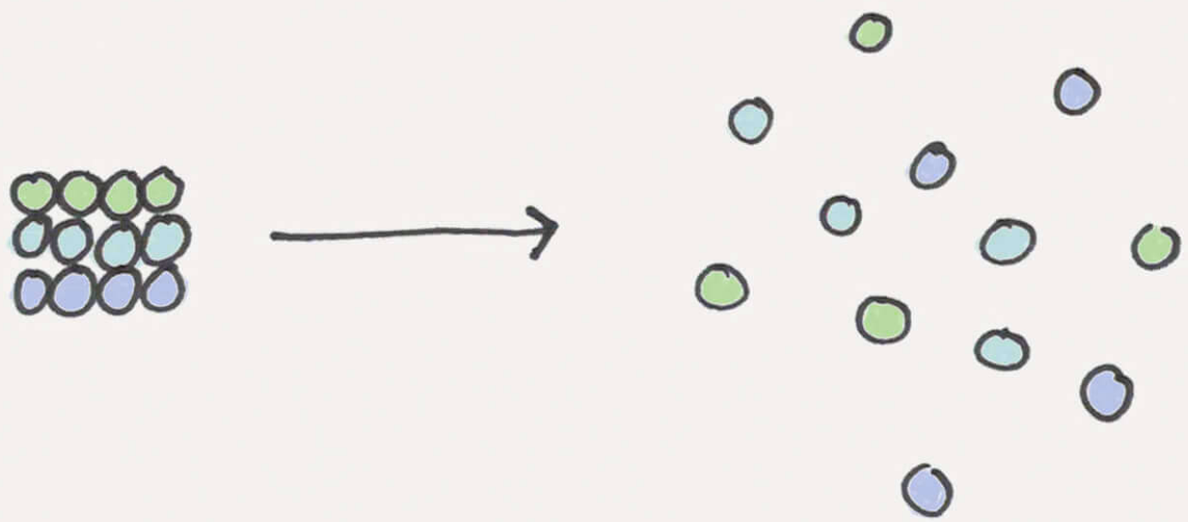

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PROJECT

ENTROPY OF NON-EQUILIBRIUM SYSTEMS

CHAIKIN LAB

DATE **DECEMBER 13TH**

CLIENT **ANKIT VYAS**

OUTLINE

- What're we doing for?
- How do we do it?
- What're the methods?
- What do we find?
- What can we do next?

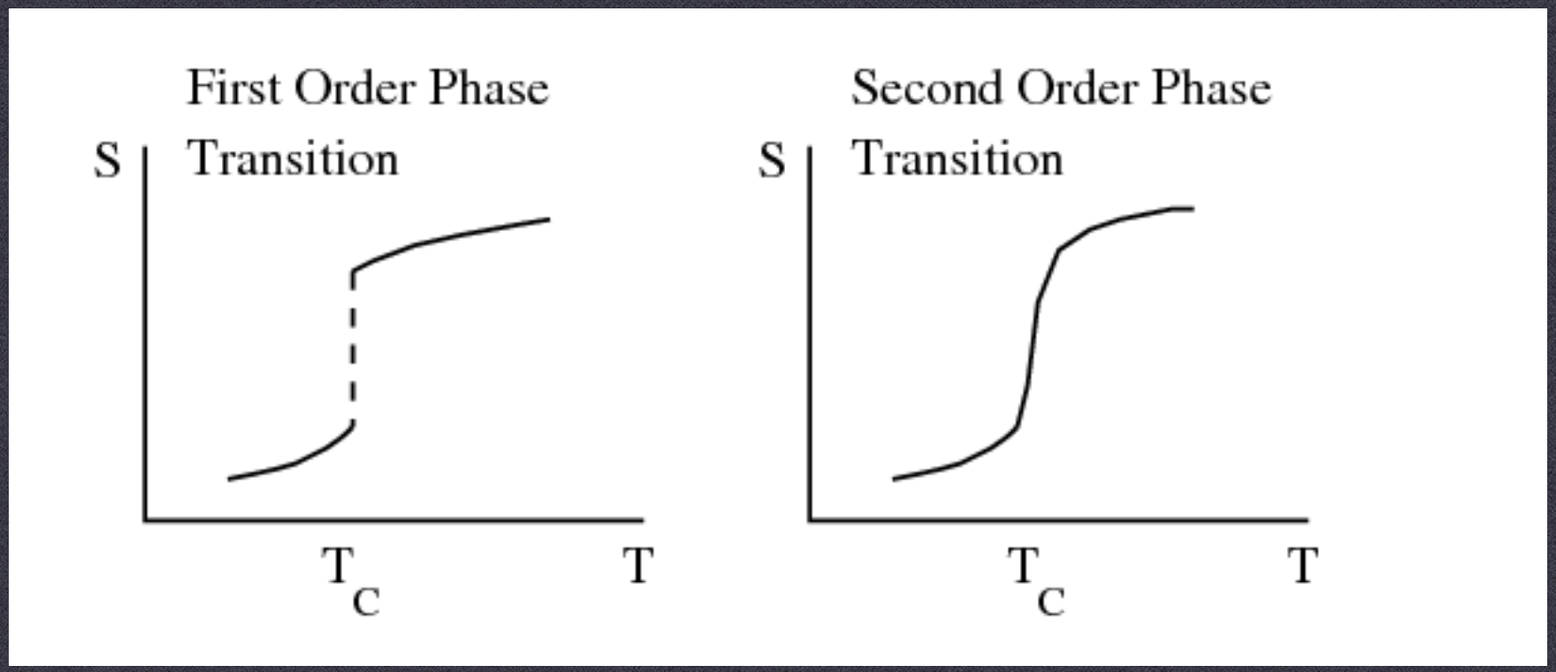
- Characterize Non-equilibrium systems
- Kolmogorov/CID
- LZ78 and Hilbert Curve
- You'll see in a bit!

SHANNON/INFORMATION ENTROPY

$$H_n(X) = -\sum_{x_1 \ldots x_n} p(x_1 \ldots x_n) \log p(x_1 \ldots x_n)$$

- Entropy “measures our ignorance, how likely our predictions are to be wrong”
- For equilibrium systems, statistical mechanics gives us the tools to determine various p’s and the entropy
- Not so easy for non-equilibrium system

PHASE TRANSITIONS

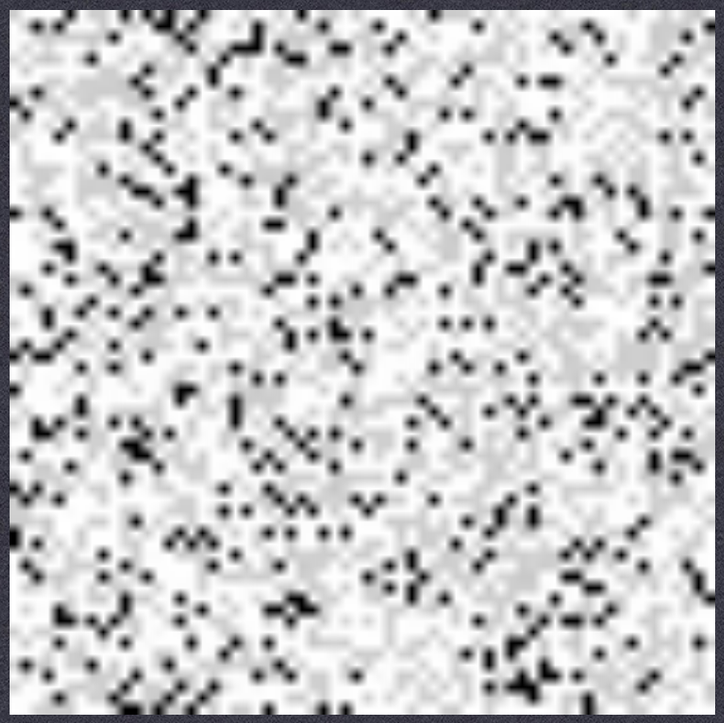


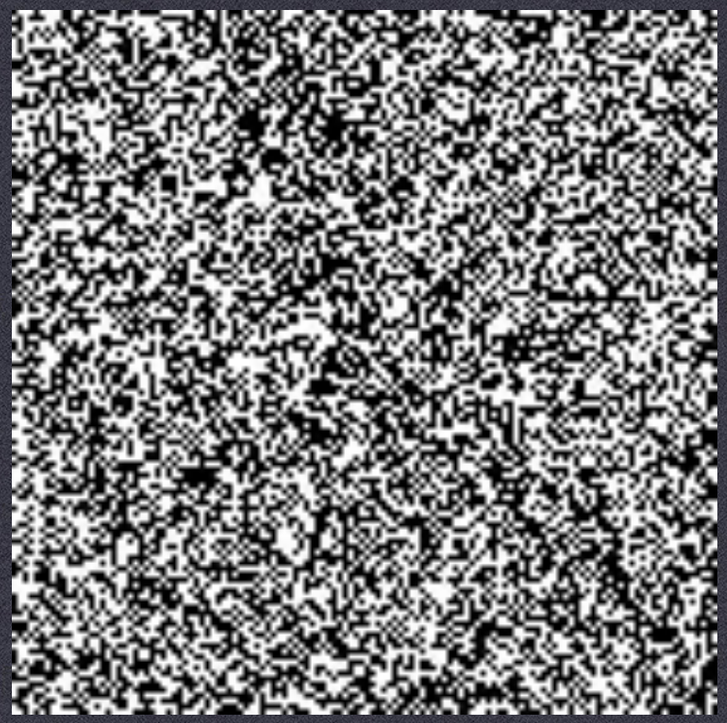
- First Order Phase Transitions see a discontinuity in the Entropy
- Second Order Phase Transitions see a discontinuity in the derivative of the Entropy

KOLMOGOROV COMPLEXITY AND COMPRESSION

- Kolmogorov Complexity: shortest program code to produce an object
- In Information Theory, (you can check the reference) the Kolmogorov Complexity for low complexity objects reaches Shannon Entropy
- Not possible to determine Kolmogorov Complexity, but we instead use other lossless compression techniques to provide an upper bound for Entropy
- CID = L(x)/L

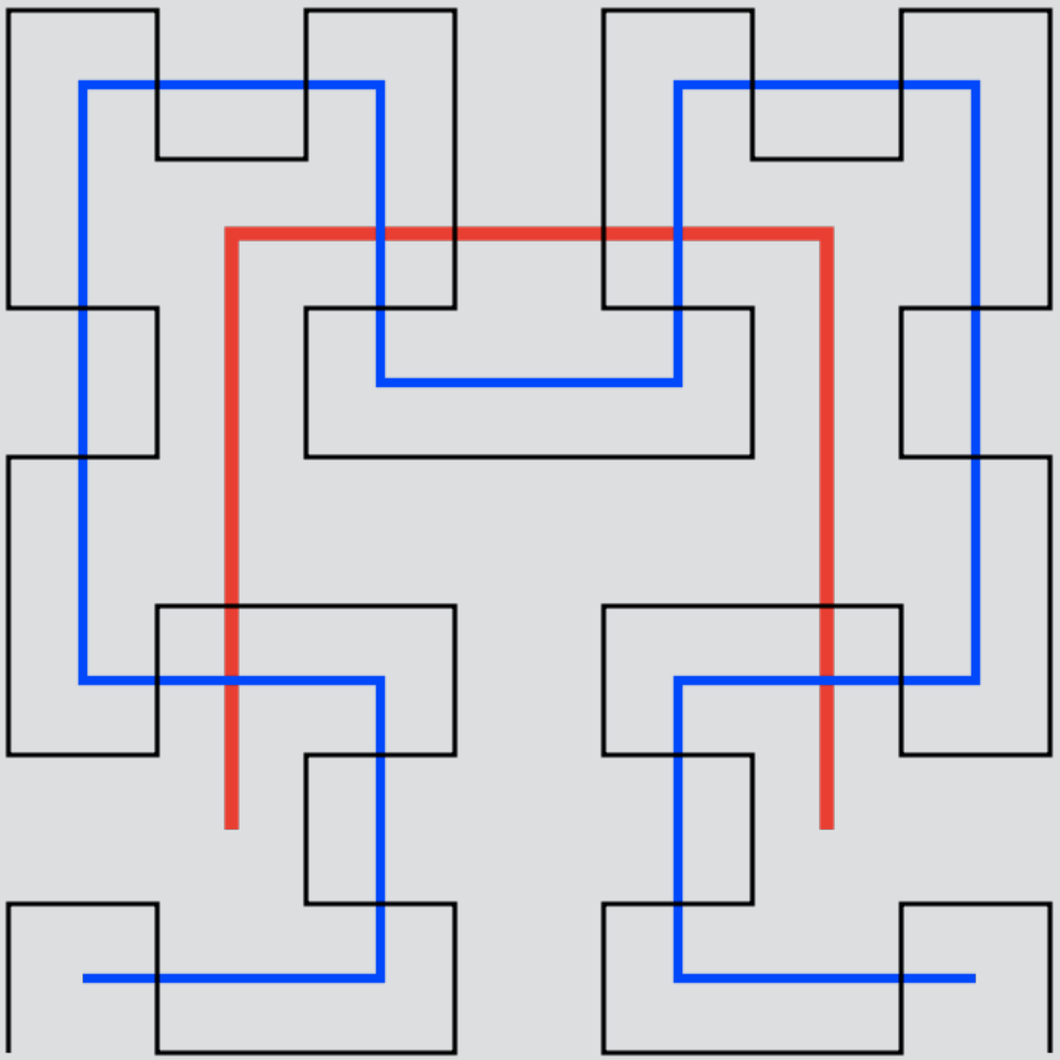
MANNA MODEL

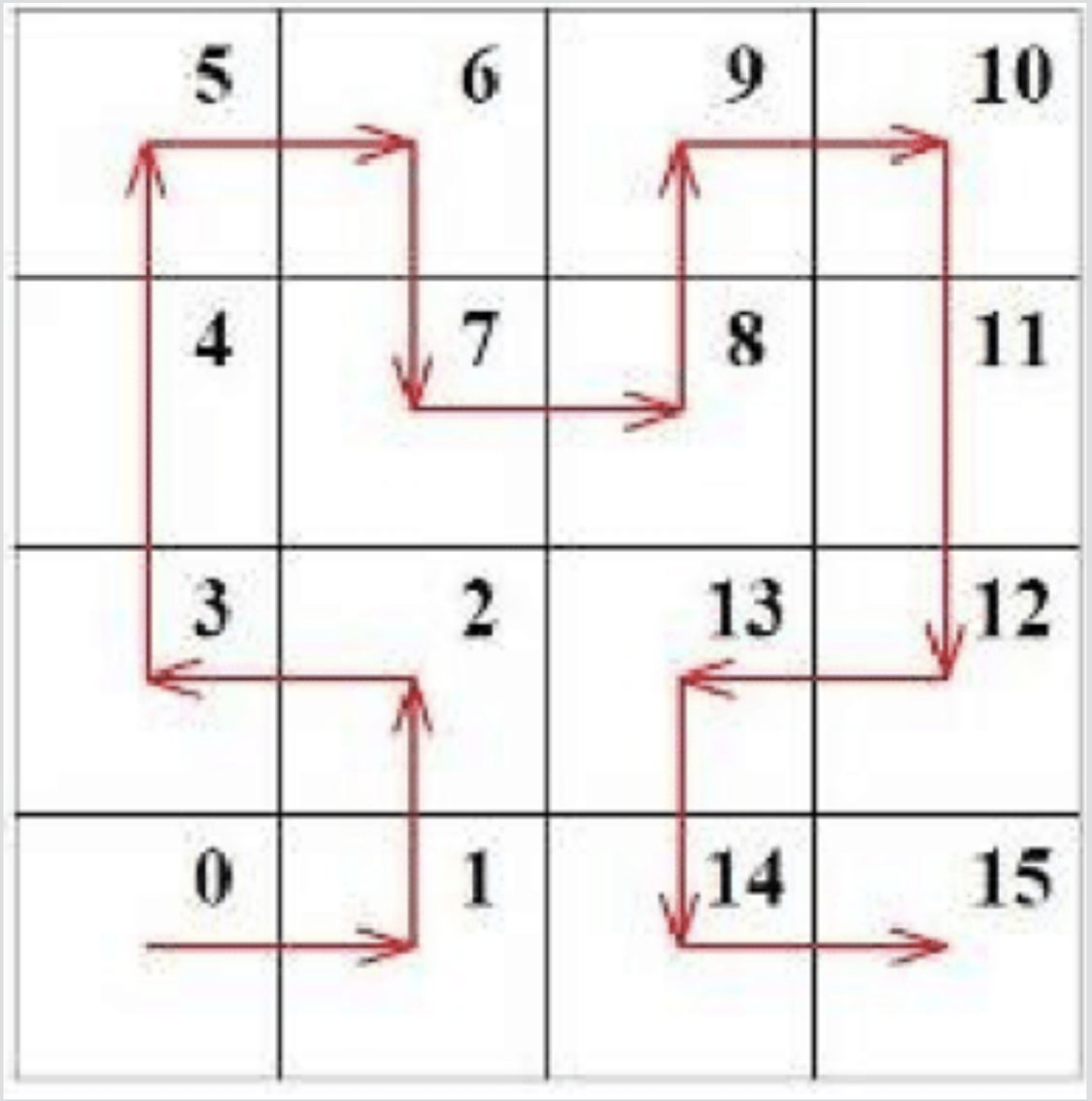




1. If 2 or more particles inhabit a site, it's considered active
2. Active sites are updated parallel
3. All particles in an active site are then moved randomly to a neighboring site (up, down, left, or right)

HILBERT CURVE





LZ78 COMPRESSION

ABACABAAABACABA

(0,A) (0,B) (1,C) (1,B) (1,A) (4,A) (0,C) (6,)

[A, B, AC, AB, AA, ABA, C]

$$H \leq \frac{C(log_2 C + log_2 \alpha)}{L}$$

RESULTS

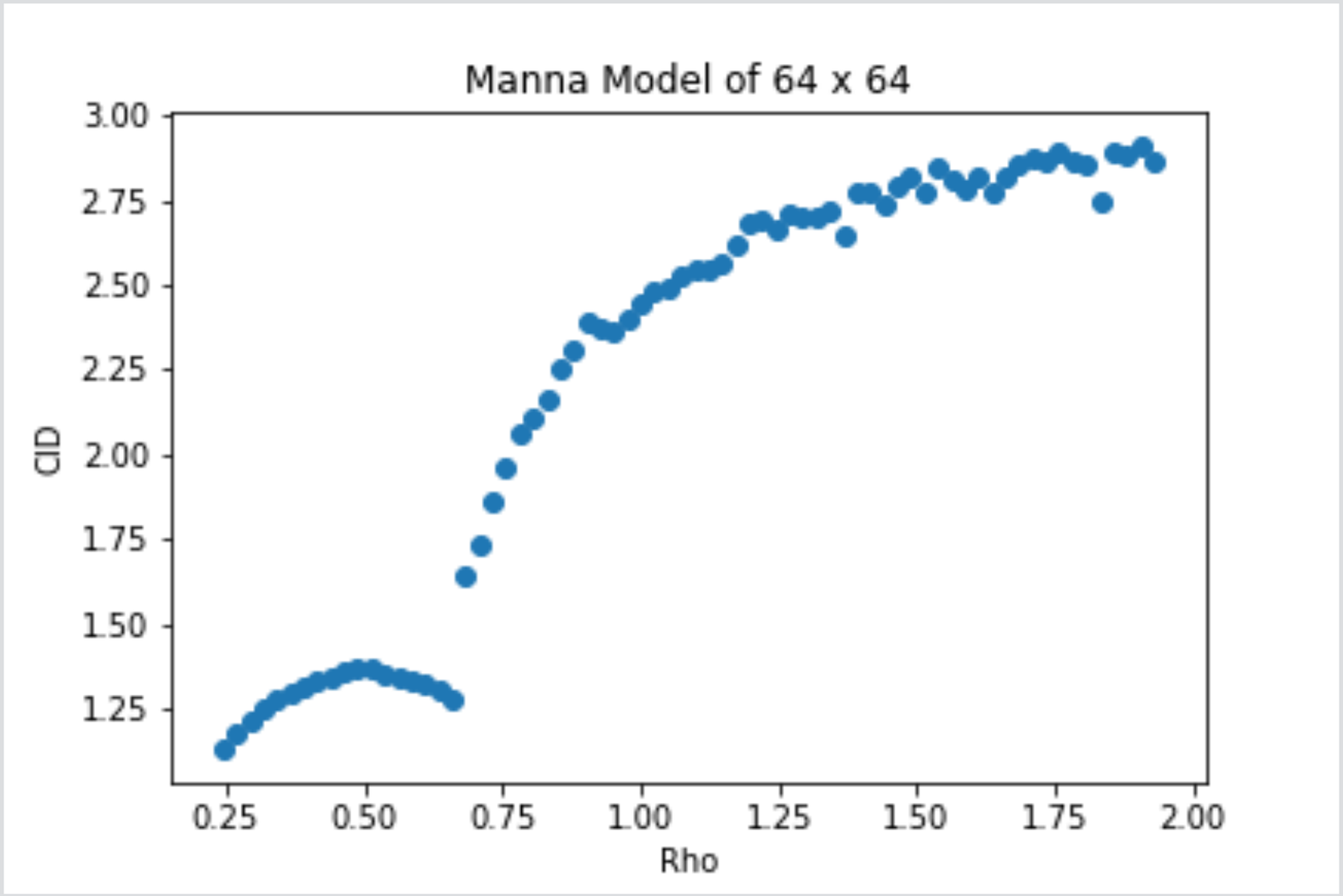


Figure 1. CID computed for a Manna Model of 64 x 64

RESULTS

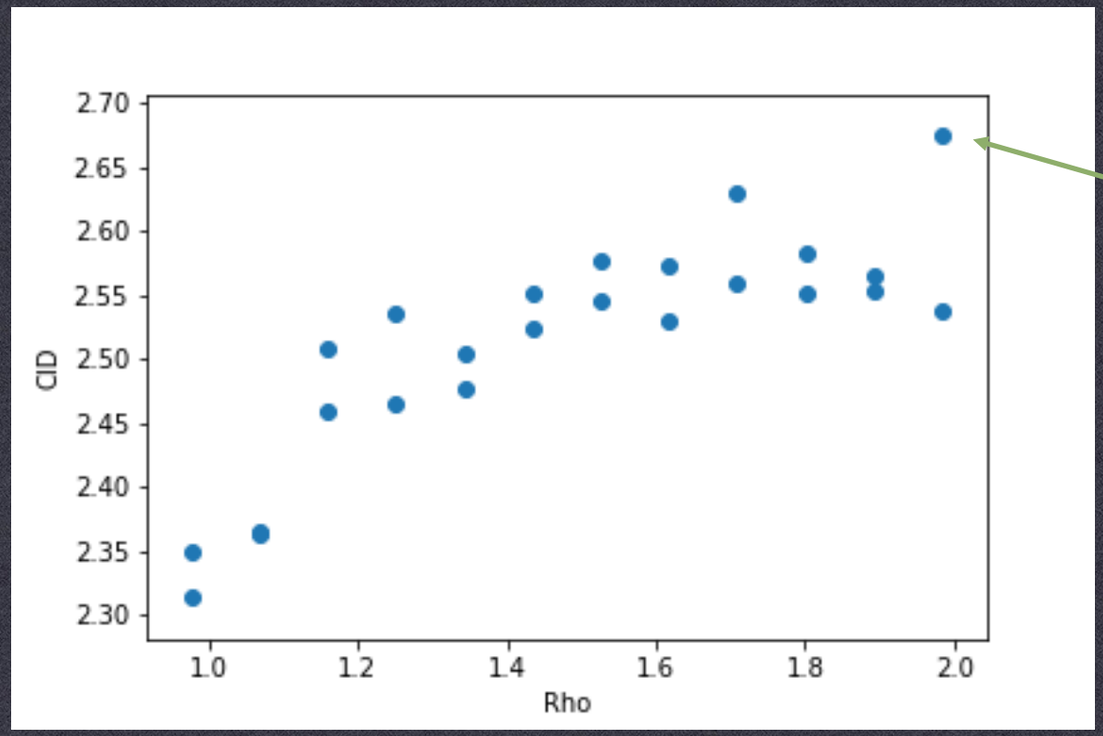


Figure 2. CID computed for a Manna Model of 128 x 128

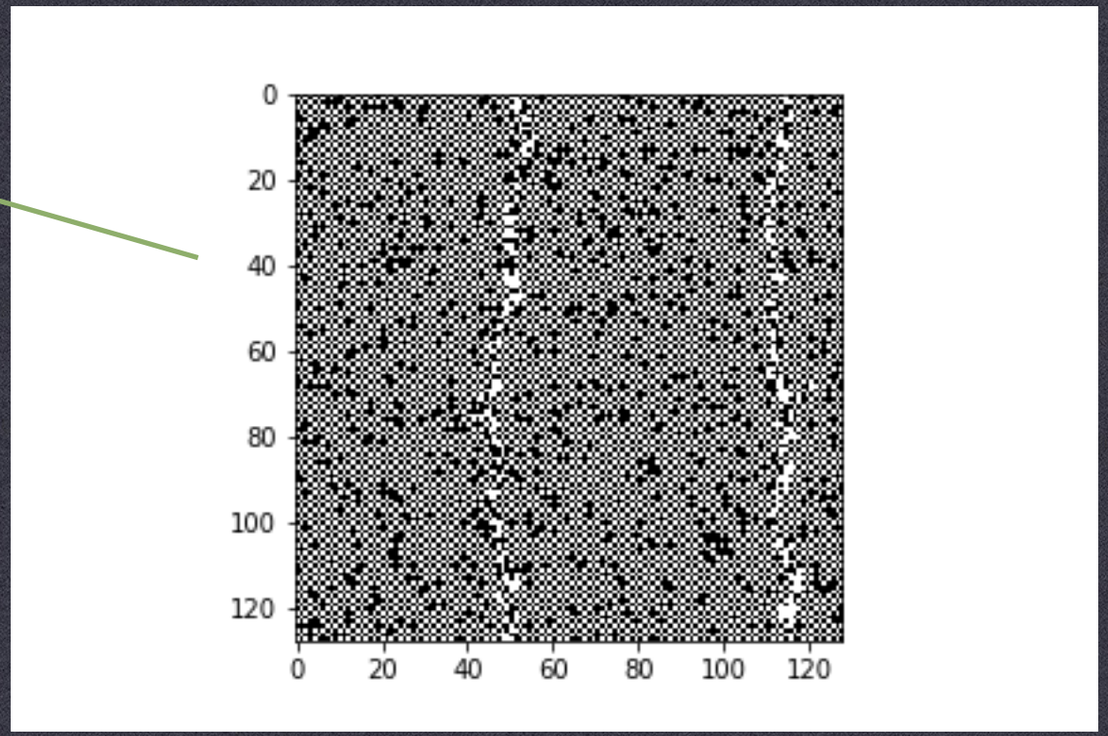


Figure 3. Outlier due to boundaries forming across periodic boundary conditions

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3. https://ps.uci.edu/~cyu/p115A/LectureNotes/Lecture19/html_version/lecture19.html

THANKS! ANY QUESTIONS?

Thank you Stefano Martiniani, Professor Chaikin, and Professor Macfayden!