Major concepts in Leonard Susskind’s Statistical Mechanics

Lecture 1

- Basic Probability
- Entropy (**S**) & Information
- “-1st Law”: Conservation of Information (Liouville’s Thm.)
- Phase space

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- Boltzmann Constant
- Temperature **T**

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- 0th Law: Thermal equilibrium “transitive”
- 1st law: Energy is conserv
- 2nd Law: Entropy increases
- Temperature, Equilibrium
- Stirling’s Approximation Of Factorial
- Lagrange Multipliers

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- Boltzmann-Gibbs Distribution (distribution of energy levels)
- Derivation of Boltzmann dist From total probability and energy.
- Partition Function **z** (sum of counts at all energy levels)
- Energy as derivative of partition function
- Entropy in terms of average energy and partition function
- Ideal Gas Partition Function

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- Pressure of Ideal Gas
- Helmholz Free Energy
- Adiabatic: “slowly”, No heat added, Reversible, Stable energy levels
- Theorem relating Change in energy, entropy, volume
- Fluctuations (Variance)

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- Exact/ Inexact, curl
- Inexact:Total heat to change state is path dependent

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- Hamiltonian: System energy description e.g. kinetic + potential
- Boltzmann Distribution Of Harmonic Oscillator
- Quantum Mechanical Harmonic Oscillator
- Entropy:
  - property of system
  - what you know about system
- Chaotic system can fill phase space = maximum entropy

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- Poincare recurrence & Reversibility
- Symmetry
- Boltzmann Brain
- Simple Magnet Model (no interactions)

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- 1-D and many-D Ising Model
- Phase Transition
- Correlation Function
- Duality - system equivalence
- Mean Field Approximation

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- Liquid-Gas Transition In Ising Model

How to find partition function (z) and Boltzmann Distribution:

- find **Hamiltonian** (energy equation) of each particle i
  - (e.g. position, momentum)
- plug in to
  $$z = \int e^{-\beta E_i}$$
- gives **Boltzmann distribution** of energy:
  $$p_i = \frac{1}{z} e^{-\beta E_i}$$

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