

Notes for today

- Homework 2: I will post this afternoon.
- Lecture recordings etc.: Reminder again that you should let me know if you have a Covid quarantine (or other University excuse). I can share lecture recording or a zoom link to view the lecture in real time.
- **Enable the microphone**

spin-1/2 non-interacting paramagnet (microcanonical ensemble solution):

$$U = \pm\mu B \text{ per atom} \rightarrow U = \mu B(N^- - N^+) = \mu B(2N^- - N)$$



- Equivalent to text example of 2-level system.
- Magnetic spin systems sometimes rapidly exchange energy, can be considered isolated 2-level system but still in internal equilibrium. Other examples laser systems (example, dilute set of atoms with 2 discrete energy levels in a transparent crystal, coupled by EM radiation field).
- Also 2-level systems are prototype for many other physical systems.

Plan:

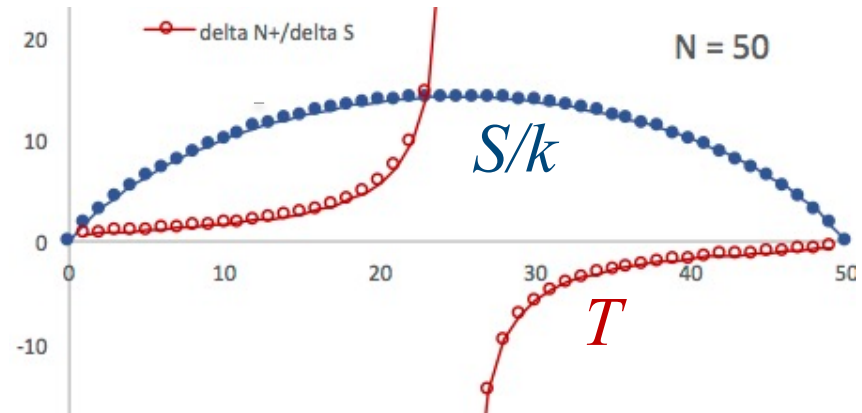
- Determine entropy.
- Then from $S(U, N)$ can determine T and other physical properties.

spin-1/2 non-interacting paramagnet (microcanonical ensemble solution):

$$U = \pm \mu B \text{ per atom} \rightarrow U = \mu B(N^- - N^+) = \mu B(2N^- - N)$$

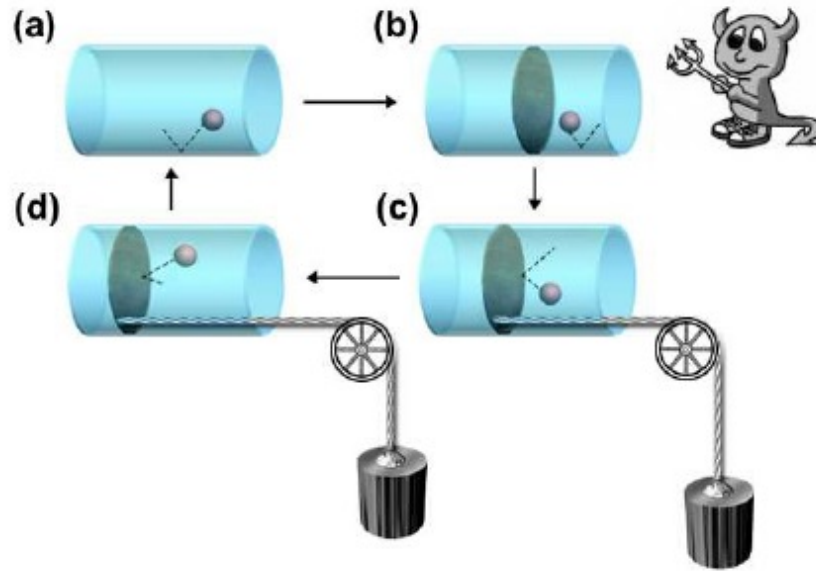


$$S = k_B \ln \left(\frac{(N)!}{(N^+)! (N^-)!} \right)$$



Log of this function same general shape as N increases even though Ω has increasingly sharper peak (*homework*). Unlike simple mixing example seen earlier, here each N^+ corresponds to a specific equilibrium case, in a closed system. Temperature can be obtained directly from S . (& note, temperature concept is defined only for large N in isolated systems.)

Szilard engine:

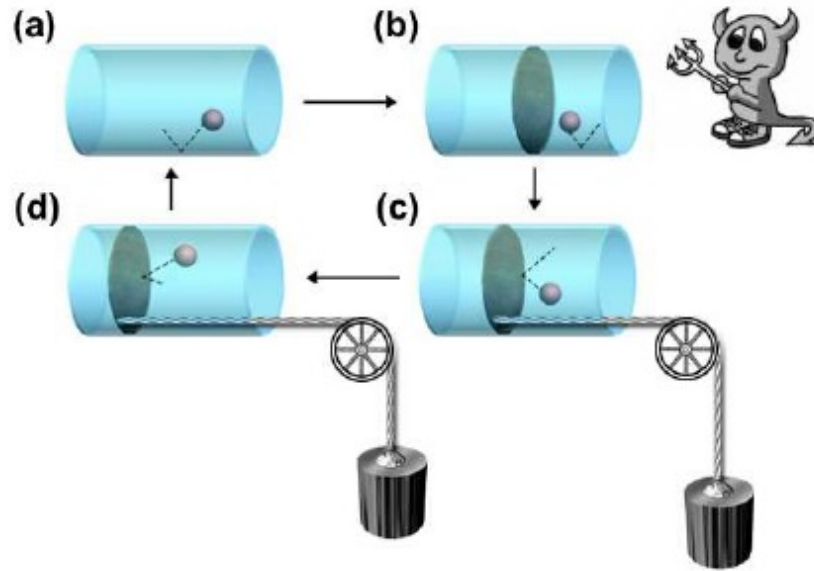


Maruyama, Nori, Vedral;
Rev. Mod. Phys. 2007, “The
physics of Maxwell’s demon
and information”

$$W = k_B T \ln 2$$

“for free”

Szilard engine:



Maruyama, Nori, Vedral;
Rev. Mod. Phys. 2007, “The
physics of Maxwell’s demon
and information”

$$W = k_B T \ln 2$$

“for free”

- Szilard: perhaps cognition process always expels $k \ln 2$ entropy (Maxwell Demon decision process presumably requires at least $k_B T \ln 2$ from heat source to do this, & probably much more).