Key points of 02/09 lecture

- $A = U - TS$ (A establishes connection betw. canonical ensemble and SM)

  internal energy
  $U = \langle \mathcal{H} \rangle$

- Energy fluctuations: $\dfrac{\sqrt{\langle \mathcal{H}^2 \rangle - \langle \mathcal{H} \rangle^2}}{\langle \mathcal{H} \rangle} = \dfrac{\sqrt{k T^2 C_v}}{\langle \mathcal{H} \rangle}$

  $\xrightarrow{\text{"typically"}} 0$ as $N \to \infty$

- For two-level system with N particles:

  $\underbrace{\langle \mathcal{H} \rangle = U}_{\text{canonical ensemble}} = E(T, N)$ energy (macro variable in microcanonical ensemble)

  we showed this

- Isolated system: $\Delta S(E, V, N) \geq 0$. The entropy of an isolated system can never <u>decrease</u>.

- System in contact with heat reservoir: $\Delta A(T, V, N) \leq 0$. The Helmholtz free energy of a system in contact with a heat reservoir can never <u>increase</u>.