Key points of 03/21 lecture

- grand canonical ensemble, quantum:

$$\mathcal{Q}(z,V,T) = Tr\left(e^{-\beta(\hat{\mathcal{H}}-\mu\hat{N})}\right) = \sum_N Tr\left(e^{-\beta(\hat{\mathcal{H}}-\mu N)}\right) = \sum_N z^N \underbrace{Tr\left(e^{-\beta\hat{\mathcal{H}}}\right)}_{Q}$$

$\hat{N}$ = number operator

N = # of particles

Sum over all states

$$\hat{\rho}_G = \frac{e^{-\beta(\hat{\mathcal{H}}-\mu\hat{N})}}{\mathcal{Q}(z,V,T)}$$

- micro canonical ensemble, quantum:

$\Gamma(E) \triangleq$ number of states in energy interval $[E, E+\Delta E]$.

$$\hat{\rho}_{MC} = \sum_n \left(\frac{1}{\Gamma(E)}\right) |\psi_n\rangle\langle\psi_n|$$

Sum goes over all eigenstates whose energy lies in $[E, E+\Delta E]$

all states contribute equally

- Quantum many-body system:
  - bosons (integer spin): wave fct symmetric under exchange of any pair of particles
  - fermions (half-integer spin): wave fct anti-symmetric under exchange of any pair of particles

Boltzmann particles (theory construction): no exchange symmetry