Statistical Physics II

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Contents

1 Quantum statistical Physics

1.1 Ensembles

- As discussed in Stat-phys I, there are three types of ensembles we are concerned with.

1.1.1 Microcanonical

- This is for completely isolated systems. Here we have that S, V, N_i are conserved. The main thermodynamic function is $E = E(S, V, N)$.

1.1.2 Canonical

- Now the system is in a heat bath and is allowed to exchange energy with the surroundings. Here we have that T, V, N_i are conserved. The main thermodynamic function is $F = F(T, V, N)$.

1.1.3 Grand-Canonical

- Now the system is in a heat and particle bath and is allowed to exchange energy and particles with the surroundings. Here we have that T, μ_i are conserved. The main thermodynamic function is $\mathcal{J} = \mathcal{J}(T, V, \mu_i)$.
- In the thermodynamic limit, the physics at equilibrium can be effectively described by all ensembles with the understanding that
  - In Microcanonical ensemble total energy $\tilde{E}$ and number of particles $\tilde{N}$ are constant.
  - In the Canonical ensemble, the average energy $\langle E \rangle \cong \tilde{E} \cong E_*$, the most probable energy.
  - In the Grand Canonical ensemble, the average energy $\langle E \rangle \cong \tilde{E} \cong E_*$, as well as $\langle N \rangle \cong \tilde{N} \cong N_*$.
- In the quantum regime $\hbar \neq 0$, so the phase space is no longer the appropriate approach. Instead we deal with a mostly discrete system.

1.2 Discrete systems

1.2.1 Microcanonical ensemble

- Here the relevant function for relating micro-to-macro state is the number of microstates Ω . This is related to the entropy of the system via $S = k \ln(\Omega)$. And the probability of any one state is just $Pr = 1/\Omega$.