Notes:

Homework : I will post a new HW set later today.

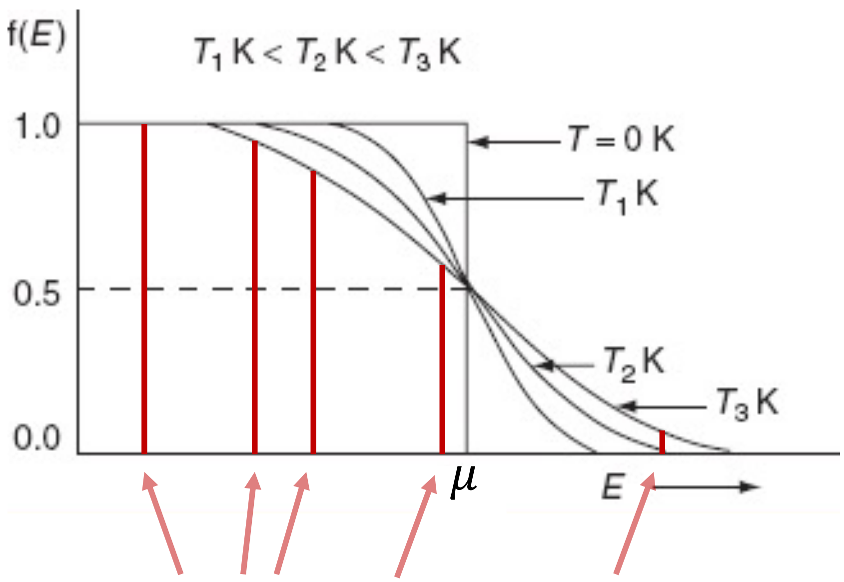
No class tomorrow, we will meet again next Tuesday.

Recall for Fermions:

$$n = \frac{1}{(1 + e^{(E-\mu)/kT})}$$

Fermi-Dirac distribution = $\langle N \rangle$ for a single eigenstate.

Same as "Fermi function"; $f(E)$



Discrete eigenstates, with each $\langle N \rangle$ between 0 and 1 (Pauli exclusion principle).

Or, $f(E)$ maps a continuous probability function, with $D(E)$.

Bosons:

$$Z_g = \prod_i \sum_N e^{-(NE_i - N\mu)/kT}$$
$$\approx \prod_i 1/\left(1 - e^{-(E_i-\mu)/kT}\right)$$

Bose-Einstein product of single-particle states; Converges to lower form if $E_i > \mu$ (no condensation).

$$\frac{1}{1-x} = \sum_{n=0}^{\infty} x^n$$

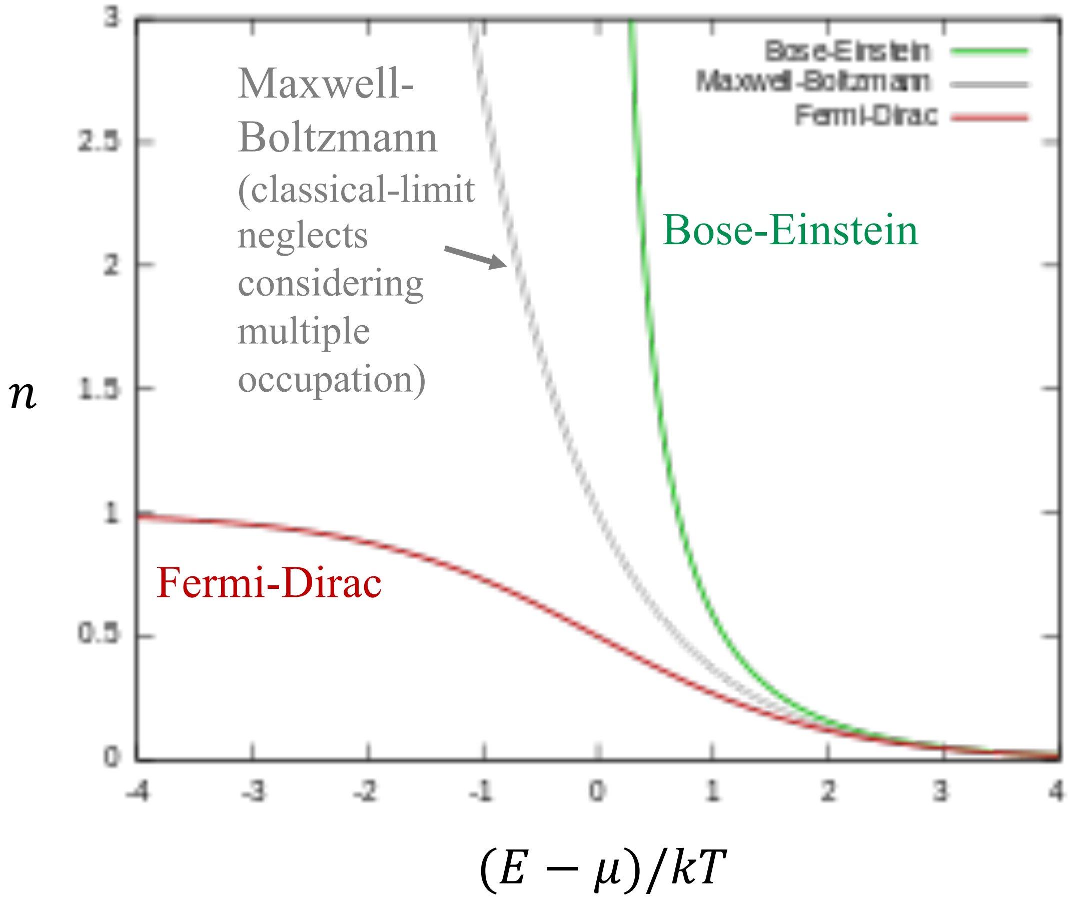
$$n = \frac{1}{(e^{(E-\mu)/kT} - 1)}$$

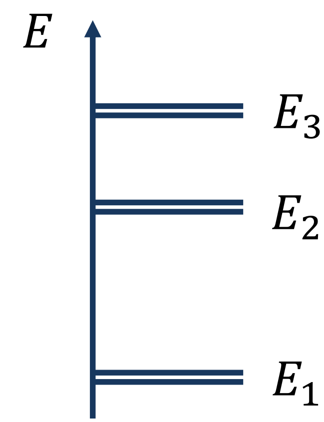
Bose-Einstein distribution = $\langle N \rangle$ for a single eigenstate.

Bosons:

$$n = \frac{1}{\left(e^{(E-\mu)/kT} - 1\right)}$$

Bose-Einstein distribution = $\langle N \rangle$ for a single eigenstate.





4 particles, 6 states where is μ?

Fermions, Bosons:

$$n_{BE} = \frac{1}{(e^{(E-\mu)/kT} - 1)}$$

Bose-Einstein distribution

$$n_{FD} = \frac{1}{(1 + e^{(E-\mu)/kT})}$$

Fermi-Dirac distribution

$$n_{MB} \approx e^{-(E-\mu)/kT}$$

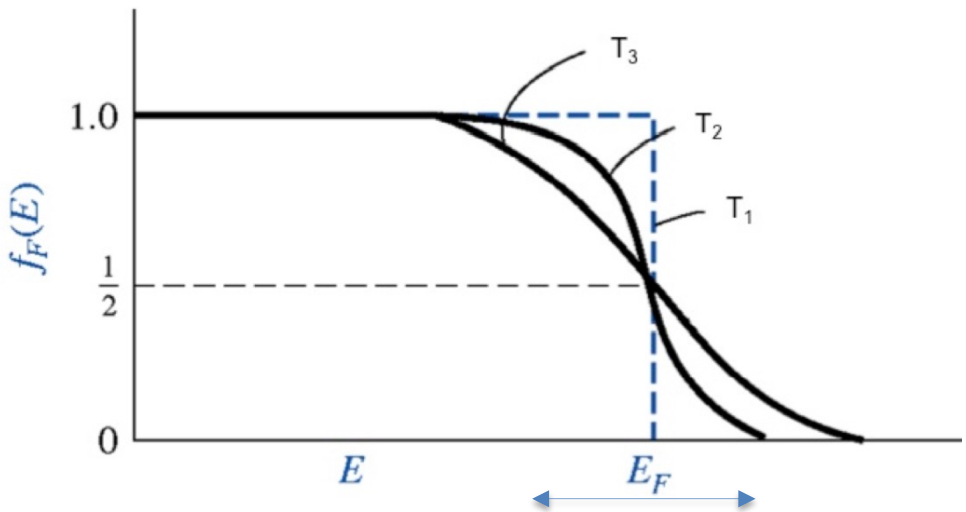
Maxwell-Boltzmann = high T classical limit for both particle types
(μ becomes large & negative)

Fermi-Dirac statistics & **Fermi ideal gas**

$$n_{FD} = \frac{1}{(1 + e^{(\varepsilon_i - \mu)/kT})} = f(\varepsilon_i)$$

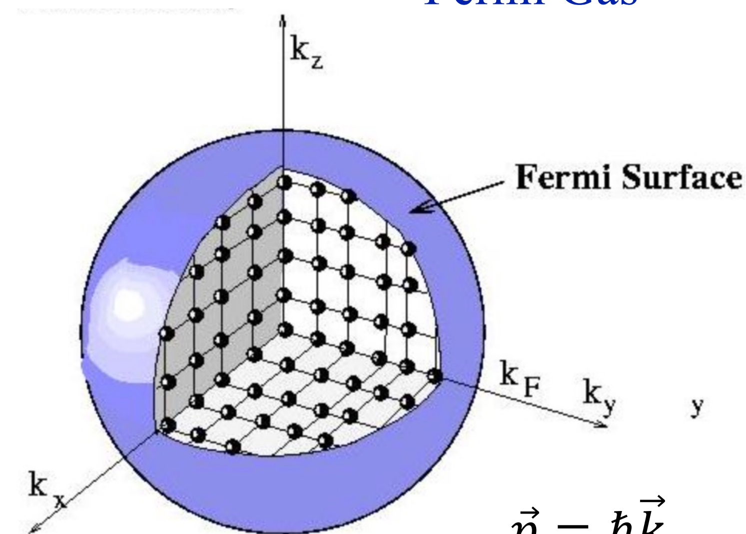
Fermi-Dirac distribution

"Fermi function"



10-90% width ≈ $4kT$

"Fermi Gas"



$\vec{p} = \hbar\vec{k}$

set of identical particles: refers actually to a specific spin state

- Metals: electron gas typically strongly degenerate.
- White dwarf stars: degenerate electrons + nuclei ~ classical gas
- Neutron stars
- Etc.

Fermi-Dirac statistics & Fermi ideal gas

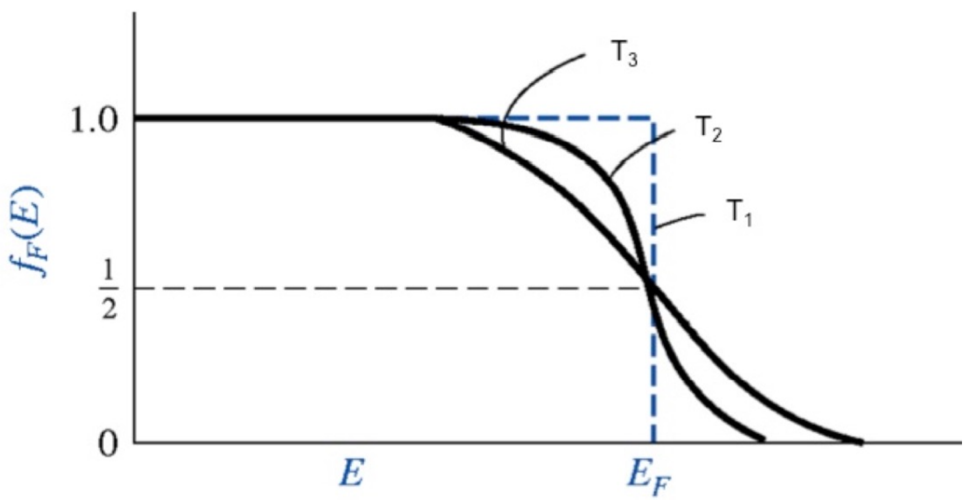
$$n_{FD} = \frac{1}{(1 + e^{(\varepsilon_i - \mu)/kT})} = f(\varepsilon_i)$$

Fermi-Dirac distribution

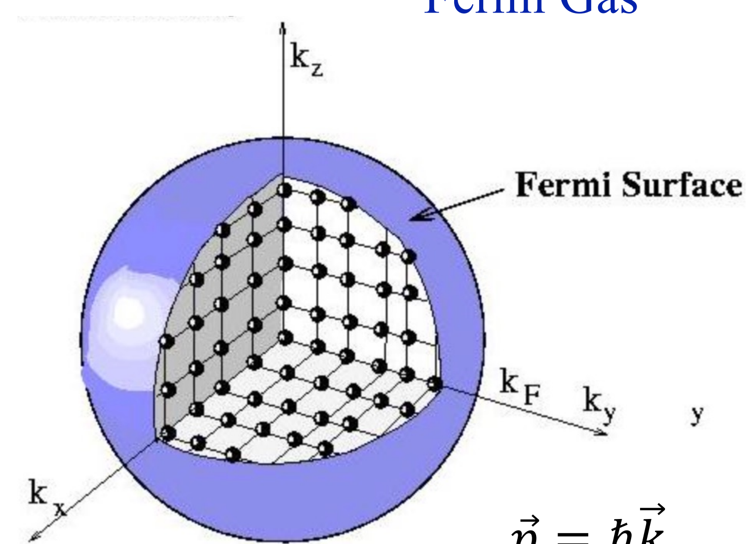
"Fermi function"

$$\langle N \rangle = \sum_i f(\varepsilon_i) \qquad U = \sum_i \varepsilon_i f(\varepsilon_i)$$

Total # particles — Total (average) energy



"Fermi Gas"



$\vec{p} = \hbar \vec{k}$

set of identical particles: refers actually to a specific spin state