Quantum Mechanics

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(next semester)

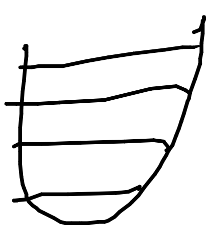
Density of States

$$D(E) = \frac{\overbrace{\#\text{ of states btw. } E \text{ \& } E+dE}^{dg}}{dE}$$

$$\langle E \rangle = \frac{1}{N} \int E \, n(E) \, D(E) \, dE$$

$$N = \int n(E) \, D(E) \, dE$$

$$= \sum_s n(E_s)$$



$$E_j = \left(j + \frac{1}{2}\right)\hbar\omega_0$$

$$D(E) = \frac{1}{\hbar\omega_0}$$

What is distribution of speeds of gas molecules in this room?

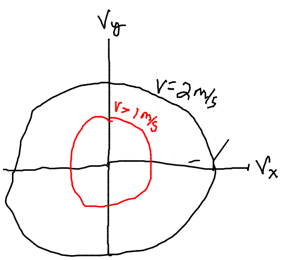
Maxwell Speed Distribution $f(v)$

$f(v)\,dv$ is probability of speed between v & $v+dv$

$$P(v_1 \dots v_2) = \int_{v_1}^{v_2} f(v)\,dv$$

Microstates are velocities $\vec{v}$

$n(\vec{v}) \propto e^{-\frac{m|\vec{v}|^2}{2kT}}$ prob. of 1 microstate



All particles with speed $v = 2\,m/s$

of ~~ve~~ microstates with speed v is

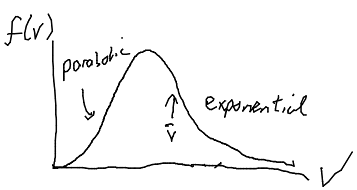
$g(v) \propto 4\pi v^2$

$$f(v) = C\,n(v)\,g(v)$$
$$= C\,e^{-\frac{mv^2}{2kT}}\,4\pi v^2$$

$$1 = \int_0^\infty f(v)\,dv \rightarrow C = \left(\frac{m}{2\pi kT}\right)^{3/2}$$

M.S.D.

$$\boxed{f(v) = \left(\frac{m}{2\pi kT}\right)^{3/2} e^{-\frac{mv^2}{2kT}}\,4\pi v^2}$$



$$\bar{v} = \int_0^\infty v\,f(v)\,dv = \sqrt{\frac{8kT}{\pi m}} = 566\,m/s$$

Nitrogen at room temperature

Suppose I have 2 particles, 1 & 2, that each can be in one of 3 states; A, B, C

How many states can the pair be in? 9

AA AB AC BA BB BC CA CB CC

only if particles are <u>distinguishable</u>

If particles are indistinguishable, then AB & BA describe same state

AA AB AC BB BC CC

6 possible states

subatomic particles ~~of~~ same type are indistinguishable

- bosons: "integer spin"
  - Higgs, photon, Z & W, some atoms
- fermions: "half-integer spin"
  - electron, proton, neutron ← spin $\frac{1}{2}$

Pauli Exclusion Principle

2 fermions can't have the same state

only AB AC or BC allowed

Describe state of a system of indis. particles by "how many particles are in each state"

	fermions			bosons			
A	1	1	0	2	0	0	← occupancy of microstate A
B	1	0	1	0	2	0	
C	0	1	1	0	0	2	

average occupancy $\bar{n}$ in a microstate

For distinguishable particles

$$\bar{n}_s = N \frac{1}{Z} e^{-\beta E_s}$$