$\Rightarrow A_p^{-1} = \int dp\, e^{-E(p)/k_B T}$

$\Rightarrow A_q^{-1} = \int dq\, e^{-U(q)/k_B T}$

Connect Class. to quantum

$dw = A_Q e^{-\beta E(p,q)} \dfrac{dp\,dq}{(2\pi\hbar)^3} \equiv d\Gamma$

$Z = \int d\Gamma\, e^{-\beta E(p,q)}$

$F = -\dfrac{1}{\beta} \ln \int e^{-\beta E[p,q]} d\Gamma$

identity of particles

two levels

level 1: cannot track, loose lab lev

level 2: wave function symmetry

level 1.

$Z \longrightarrow \dfrac{1}{N!} Z$ similarly for F

Mawell distribution (classical gas)

$U(q) \longrightarrow 0 \quad H = K$

each atom can then be a SUBSYSTEM

$dw_p\, dw_q$ subsystem index $(a) \longrightarrow i$ (27)

$K(\vec{p}) = \sum_{i=1}^{N} \dfrac{\vec{p}_i^{\,2}}{2m} = \sum_{i=1}^{N} \dfrac{p_{x_i}^2 + p_{y_i}^2 + p_{z_i}^2}{2m}$

$dw_{\vec{p}} = dw_{\vec{p}_1}\, dw_{\vec{p}_2}\, dw_{\vec{p}_3} \cdots dw_{\vec{p}_N}$

i^{th} part

$dw_{\vec{p}_i} = A_{p_i} e^{-\beta(p_{x_i}^2 + p_{y_i}^2 + p_{z_i}^2)/2m}\, dp_{x_i} dp_{y_i} dp_{z_i}$

each part a subsystem

$\longrightarrow p_{x_i}, p_{y_i}, p_{z_i}$ seperate system

$dw_{p_{x_i}}$

$\int dw_{p_i} = 1 \qquad \int_{-\infty}^{\infty} dx\, e^{-\alpha x^2} dx = \sqrt{\dfrac{\pi}{\alpha}}$

$dw_{\vec{p}_i} = \left(\dfrac{\beta}{2\pi m}\right)^{3/2} e^{-\beta(p_{x_i}^2 + p_{y_i}^2 + p_{z_i}^2)/2m}\, dp_{x_i} dp_{y_i} dp_{z_i}$

Maxwell distribution

$dw_{\vec{v}_i} = \left(\dfrac{\beta m}{2\pi}\right)^{3/2} e^{-\frac{1}{2}\beta m v^2} d^3 v$

$dv_x\, dv_y\, dv_z \quad \circ \quad v^2 dv \sin\theta d\theta d\varphi$