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need to remember QM & SM

① schrödinger equation:

$$i\hbar\partial_t\psi = H\psi = (H_0+V)\psi = \left(-\frac{\hbar^2}{2m}\nabla^2+V\right)\psi.$$

$$[X,p] = i\hbar. \quad p = -i\hbar\frac{\partial}{\partial x}.$$

② $dU = TdS - pdV + \mu dN + \sigma dA.$

$$H = U+pV. \quad G = U+pV-TS. \quad F = U-TS$$

③ $W = \prod_i (dp_i dq_i)/h \qquad dW = g\cdot\frac{d\Omega}{h^r} = D(\varepsilon)d\varepsilon/\cancel{h^r}.$

~~Fermion. $j=\frac{1}{2}(2s+1)$. Bosons $j=s$. Pauli's law for Fermions~~

~~单能级单粒子~~ ~~单能级多粒子~~

④ $\sum a_l = N$. $\sum a_l\varepsilon_l = U$. $\delta\left(\ln\Omega + \alpha(\sum a_l - N) + \beta(\sum a_l\varepsilon_l - U)\right) = 0.$

$$Z_1 = \sum w_l \exp(-\beta\varepsilon_l) = \sum \exp(-\beta\varepsilon_\alpha) = \int\frac{d\Omega}{h^r}e^{-\beta\varepsilon} \qquad f_1 = -\ln Z_1$$

$$Y = \sum a_l\frac{\partial\varepsilon_l}{\partial y} = \frac{N}{\beta}\cdot\partial_y f_1. \quad S = Nk(\beta\partial_\beta f_1 - f_1).$$

⑤. Bosons: $\Xi = \prod\Xi_l = \prod[1-\exp(-\alpha-\beta\varepsilon_l)]^{-1}$

$$\ln\Xi = \int\frac{d\Omega}{\cancel{N!}h^r}\ln[1-\exp(-\alpha-\beta\varepsilon_l)]^{-1}$$

$$= \frac{1}{\cancel{N!}h^r}\int D(\varepsilon)\ln[1-\exp(-\alpha-\beta\varepsilon_l)]\,d\varepsilon.$$

Fermions: $\Xi = \prod\Xi_l = \prod[1+\exp(-\alpha-\beta\varepsilon_l)]$

$$\ln\Xi = \frac{1}{\cancel{N!}h^r}\int D(\varepsilon)\ln[1+\exp(-\alpha-\beta\varepsilon_l)]\,d\varepsilon.$$

⑥. BEC. $n = n_{\varepsilon=0} + \frac{1}{V}\int_0^{+\infty}\frac{D(\varepsilon)d\varepsilon}{\exp(\beta(\varepsilon-\mu))-1} = n_{\varepsilon=0} + \bar{n}(T).$

$\bar{n}(T_c) = n. \Rightarrow n_{\varepsilon\neq0} = \bar{n}(T) = n\cdot\left(\frac{T}{T_c}\right)^{3/2}$ numberical.

⑦ photon and radiation. (Bosons). ~~and [illegible]~~

$$\vec{p} = \hbar\vec{k}. \quad \varepsilon = \hbar\omega = c\hbar k = c|\vec{p}|.$$

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⑧ Debye. (N.) $\begin{cases} D(\omega) = B\omega^2 = \frac{V}{2\pi^2}\cdot(C_l^{-3} + 2C_t^{-3})\,\omega^2 \\ \int_0^{\omega_D} B\omega^2 d\omega = 3N \Rightarrow \omega_D^3 = \frac{9N}{B}. \end{cases}$

~~ε_F~~ $T = 0K.$, $\varepsilon_F = \mu(0) = \frac{\hbar^2}{2m}(3\pi^2\frac{N}{V})^{2/3}$ $\qquad p_F = (2m_e\mu_0)^{1/2}$?

⑨. system. $\frac{d\Omega}{h^{Nr}} = d\left(\frac{1}{N!}\int\left(\frac{dx\,dp}{h^r}\right)^N\right) = \frac{1}{N!}\cdot\frac{1}{h^{Nr}}\cdot\int(dx\,dp).$

microca $\rho = \text{const} = \frac{1}{\Omega}$. $\quad E = \text{const}.$ $\qquad \Omega(E) = \frac{V^N}{N!\,h^{3N}}\frac{(2\pi mE)^{\frac{3N}{2}}}{\Gamma(3N/2)}\frac{\Delta E}{E}.$

canonical. $E_0 = E + E_r$ $\qquad \rho_s = \frac{1}{Z}e^{-\beta E_s}$ $\quad Z = \sum e^{-\beta E_s} = \frac{1}{N!\,h^{Nr}}\int e^{-\beta E}d\Omega$

grantca. $E_s + E_r = E_0.$ $\quad N + N_r = N_0.$ $\qquad \rho \propto e^{-\alpha N - \beta E_s}.$

$\Xi = \sum \frac{e^{-\alpha N}}{N!\,h^{rN}}\int e^{-\beta E}d\Omega.$

⑩. Ising. $H = E = \sum_{ij} -J\,\sigma_i\sigma_j$ ~~走~~. $-\mu B\sum\sigma_i \left(\overset{\text{aver.}}{=\!=} \beta\mu\bar{B}(\sum\sigma_i)\right)$

⑪. $\frac{\partial f}{\partial t} = -\vec{v}\cdot\nabla_r f - \vec{F}\cdot\nabla_{\vec{v}} f - \frac{f - f^{(0)}}{\tau_0}.$

⑫. 平均场. $\bar{\mu} = \frac{1}{N}\sum\mu_i = \mu_0\sum S_i/N.$

$\mu = \frac{1}{\beta}\frac{\partial}{\partial B}f_1 \overset{\text{should}}{=\!=} \bar{\mu}.$

⑬. 一些关系. 强简并 Fermion 气体 $n\cdot\lambda^3 = n\cdot\left(\frac{h^2}{2\pi mkT}\right)^{\frac{3}{2}} >> 1.$

(say. ε_F 处理).

对应是非简并之条件. $\left(\frac{V}{N}\right)^{1/3} >> \frac{h}{\sqrt{2\pi mkT}}$ (Boltzman 处理).

⑭. quantum scattering

$\frac{d\sigma}{d\Omega} = \frac{j_s\cdot r^2}{j_0} = |f|^2 = \left|\frac{m}{2\pi\hbar^2}\int U(r')e^{-i(k-k_0)\cdot r'}dr'\right|^2$

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Sth. about Scattering.

$d\sigma/d\Omega$ = flux of scattered paticles per angle / flux of incident particles.

$\psi_0 = a_0 e^{i\vec{k}_0\cdot\vec{r}}$ (plane wave). $\vec{j}_0 = |a_0|^2\cdot\frac{\hbar}{m}\vec{k}_0$ (current).

$(E-H_0)\psi = U\psi$. (schrödinger). where $H_0 = -\frac{\hbar^2}{2m}\nabla^2$ $E = \frac{\hbar^2k^2}{2m} = \frac{\hbar^2k_0^2}{2m}$.

$\psi \triangleq \psi_0 + \psi_s$ (omit). $(E-H_0)\psi_s = U\psi_0$. (Born approximation).

$\psi_s(\vec{r}) = -\frac{m}{2\pi\hbar^2}\int U(r')\psi_0(r')\cdot\frac{1}{R}e^{ikR}d^3r'$ (Green + $R = |\vec{r}-\vec{r}'|$).

$\psi_s(\vec{r}) = -\frac{m}{2\pi\hbar^2}\cdot\frac{a_0}{r}e^{ikr}\int U(r')e^{-i(\vec{k}-\vec{k}_0)\cdot\vec{r}'}d^3r' \triangleq a_0\cdot\frac{f(\vec{k},\vec{k}_0)}{r}e^{ikr}$

$(R \approx r - \vec{n}_r\cdot\vec{r}')$.

$\vec{j}_s(\theta) = \frac{\hbar}{m}\cdot\psi^*\nabla\psi = \frac{\hbar}{m}|a_0|^2\cdot\frac{|f|^2}{r^2}\vec{k}$ ($\because$ $j \sim \psi^*\nabla\psi$).

$\frac{d\sigma}{d\Omega} = \frac{j_s\cdot r^2}{j_0} = |f|^2$.

各种散射.

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