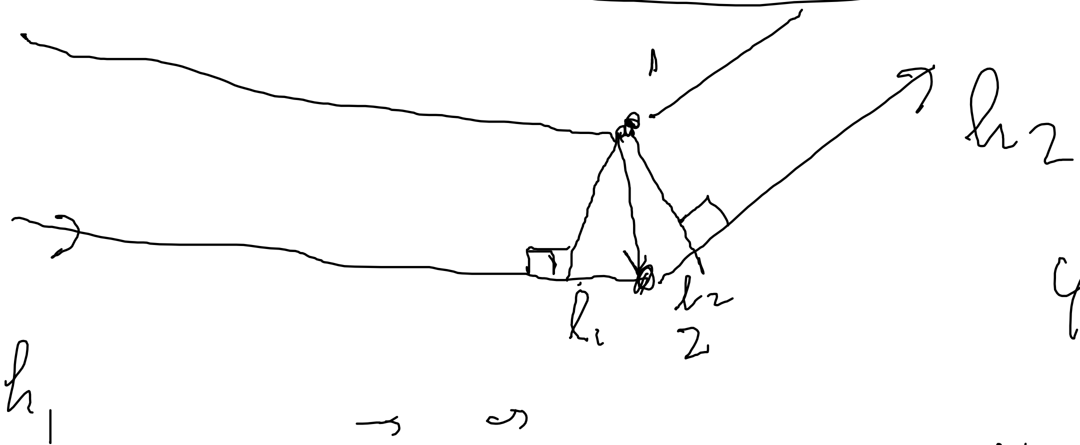
$ik|\vec r - \vec R|$

$$|\vec r - \vec R| = \sqrt{(\vec r - \vec R)\cdot(\vec r - \vec R)}$$

$$k\left(r^2 - 2\vec r\cdot\vec R + R^2\right)^{1/2}$$



$\vec R_{12}$

$$\varphi_{12} = k_1 l_1 + k_2 l_2$$

$$l_1 = \vec k_1\cdot\vec R_{12} \qquad l_2 = -\vec k_2\cdot\vec R_{12}$$

$$\varphi_{12} = (\vec k_1 - \vec k_2)\cdot\vec R_{12} = \vec Q\cdot\vec R_{12}$$

$$a_1 + a_2 e^{i\vec Q\cdot\vec R_{12}}$$

$$\sum_{i,j} a_i a_j \boxed{e^{iQ\cdot(R_i-R_j) - \Delta\omega(t_i-t_j)}}$$

$$\int d^3r_i\, d^3r_j\, dt_i\, dt_j \; a^2 \rho(r_i,t_i)\, e^{i(Q\cdot R_i - \Delta\omega t_i)}\, \rho(r_j,t_j)$$

$$G(\beta,\tau)$$

$$a^2 \int d^3r_i\, d^3r_j \cdots dt_i \left\langle \rho(r_i,t_i)\, \rho(r_j,t_j) \right\rangle e^{i(Q\cdot\beta - \Delta\omega\tau)}$$

$$\Downarrow$$

$$f(\overbrace{r_i - r_j}^{\beta},\ \overbrace{t_i - t_j}^{\tau})$$

$$\vec{\beta} = \vec{r}_i - \vec{r}_j$$

$$\tau = t_i - t_j$$

$$\int d^3\beta\, d\tau \int \left\langle \rho(r_i,t_i)\, \rho(r_i-\beta,\ t_i-\tau) \right\rangle d^3r_i\, dt_i$$

$$\underbrace{\int d^3\rho\, d\tau}\ \int \boxed{\langle \rho(r_i, t_i)\, \rho(r_i - \rho, t_i - \tau)\rangle\, d^3 r_i\, dt_i}$$

$\tau = t_i - t_j$

$$|f|^2 = a^2 \times e^{i(Q\cdot\rho - \Delta\omega\tau)}$$

$$= a^2 \int d^3\rho\, d\tau\, e^{i(Q\cdot\rho - \Delta\omega\tau)}\ G(\rho, \tau)$$

$S(Q, \omega)$

Scattering Cross Section for a collection of moving nuclei

$\langle \vec{x} | k \rangle = e^{i\vec{k}\cdot\vec{r}}$ $\quad E_k = \hbar^2 k^2 / 2m$ neutro

$|n\rangle$ $\quad E_n$ $\quad$ sample

$$|0\rangle = e^{i\vec{k}_{0_f}\cdot\vec{r}_n} |n_{0_f}\rangle$$

$$|f\rangle$$

$$\frac{m}{2\pi\hbar^2} V(r, R_i) = \sum_i a_i \delta(r - R_i)$$

$$f_{sc} = \frac{m}{2\pi\hbar^2} \langle f | V | i \rangle$$

$$\sum_i a_i \delta(\vec{r} - \vec{R}_i)$$

$$W = \frac{2\pi}{\hbar} |\langle f | V | i \rangle|^2 \rho_f \, \delta(E_f - E_i)$$

$$|k\rangle = \frac{e^{i\vec{k}\cdot\vec{r}}}{L^{3/2}} \qquad \left(\frac{1}{L^3} \frac{\hbar k}{m}\right) = J_{inc}$$

$$\rho_f \, dE = \frac{L^3 (\cancel{\hbar} k)^2 \, \cancel{\hbar} \, \cancel{dk}}{(2\pi\hbar)^3} d\Omega \frac{dE\, m}{\hbar^2} \qquad \Delta\Phi \to \frac{\Delta p \Delta x}{h}$$

$$E = \frac{\hbar^2 k^2}{2m}$$

$$dE = \frac{\hbar^2 k}{m} dk$$

$$\rho_f \, \cancel{dE_f} = \frac{L^3 m k_f}{\hbar^2 (2\pi\hbar)^3} d\Omega_f \, \cancel{dE}$$

$$d\sigma = \frac{2\pi}{\hbar} \frac{|\langle f | V | i \rangle|^2}{\hbar k_i} \delta(E_f - E_i) \frac{(m L^3) k_f}{\hbar^2 (2\pi)^3} d\Omega_f$$

$$\frac{d\sigma}{d\Omega} = \frac{k_f}{k_i} \frac{\cancel{m^2} L^3}{\cancel{\hbar^4} (\cancel{2\pi})^2} \left| \frac{\cancel{2\pi\hbar^2}}{\cancel{m}} a_i \delta(r - R_i) \right|^2 \delta(E_f - E_i)$$

$$= \frac{k_f}{k_i} L^3 \left| \langle n_f | \int \frac{e^{-ik_f\cdot r}}{L^{3/2}} a_i \delta(r - R_i(t)) \frac{e^{ik_i\cdot r}}{L^{3/2}} d^3r \, | n_i \rangle \right|^2 \delta(E_f - E_i)$$

$$= \frac{k_f}{k_i} \frac{1}{L^3} \sum_{i,j} a_i a_j \left| \langle n_f | e^{iQ\cdot R_i(t)} | n_i \rangle \right|^2 \delta(E_f' - E_i')$$

$$\delta(x) = \int e^{ixy} dy$$

$$e^{iQ\cdot R_i(t)} = e^{iHt} e^{i\vec{Q}\cdot\vec{R}_i(0)} e^{-iHt}$$