Dictionary

Normal	n- physicists
El. Scattering Total KE	KE of n is preserved
Incoherence; ϕ randomized	diff. nuclei isotopes scatter differently
Scattering Ampl. $e^{i\vec{k}\cdot\vec{r}} + f(\theta)\dfrac{e^{ikr}}{r}$	scattering length $-\dfrac{a}{r}e^{ikr}$

N

Density

n

flux & current

$\phi = \rho v \quad \phi(v) = \rho(v) v$

$\Gamma \cdot r = N\sigma(v\phi)$ $cm^{-3} sec^{-1}$

cross section

Scattering law

$\sigma = a^2 \boxed{S(q, \omega)}$

QED

multi-photon

expand → $\underline{(\vec{p}\cdot\vec{A})}$

$\vec{A} \sim (a + a^{\dagger})e^{i\vec{q}\cdot\vec{r}}$

multipole expan

$e^{i\vec{q}\cdot\vec{r}} \sim (1 + i(\vec{q}\cdot\vec{r}))$

Born Approx

1st order in interaction

Always

multiphonon processes

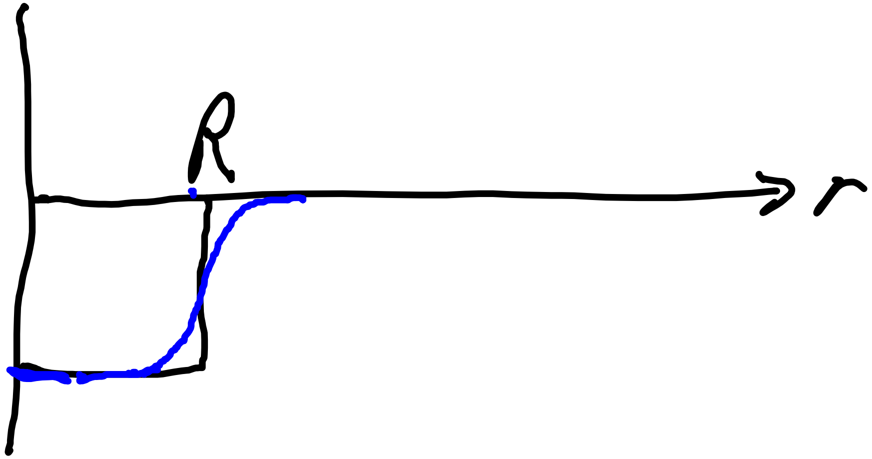
$\vec{r}_i(t) = \vec{R} + \vec{u}_i(t)$

$\vec{u}_i(t) \sim (a + a^{\dagger})$

phonon

$n \longrightarrow O$ nucleus

$$\frac{1}{1+be^{-(r-r_0)k}}$$



$$-\nabla^2\psi + (V-E)\psi = 0$$

$$\nabla^2\psi \to \frac{1}{r^2}\frac{\partial}{\partial r} r^2 \frac{\partial \psi}{\partial r} = \frac{\partial^2\psi}{\partial r^2} + \frac{2}{r}\frac{\partial \psi}{\partial r}$$

$$\psi = (r\,u)$$

$$-\frac{\partial^2 u}{\partial r^2} + (V-E)u = 0$$

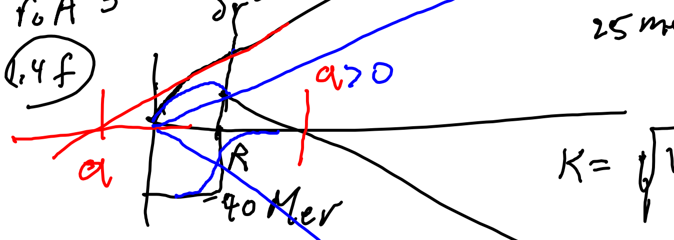
$\cancel{\psi}$ u

$u = r\psi$

$r_0 A^{1/3}$

1.4 f

25 meV



$K = \sqrt{\frac{V 2m}{\hbar^2}}$

$u = A \sin Kr$ $\quad r<R$

$r>R$

$= A \sin k(r-a)$

$\to A k (r-a)$

25 meV $\quad \lambda = 1.8\ A^\circ$

25 MeV $\to 1.8/3\times10^4\ A$

$.6\times10^{-12}$

$8\ \cancel{6}\times10^{-13}$ cm

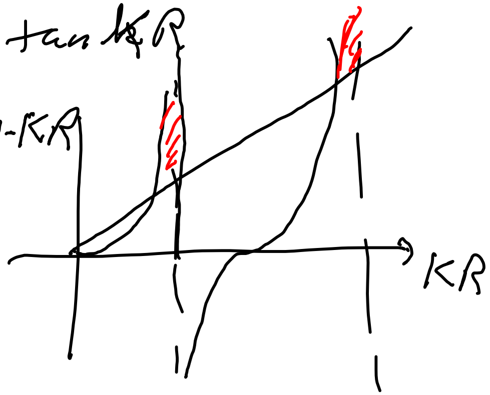
$$\frac{1}{\psi}\frac{\partial\psi}{\partial r} \longrightarrow \frac{1}{u}\frac{du}{dr}\Big|_R$$

$r<R$

$$\frac{\cancel{KA}K\cos KR}{\sin KR} = \frac{Ak}{Ak(R-a)} = \frac{1}{(R-a)}$$

$K(R-a) = \tan KR$

$-aK = \tan KR - KR$

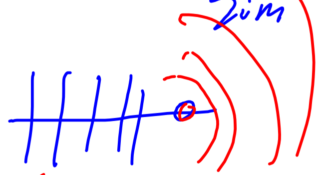


$$\psi = e^{ikr} + \boxed{\underset{-a}{f(\theta)}\,\frac{e^{ikr}}{r}}$$

$\hbar k R \ll \hbar$

$$\vec{j}_r = \frac{\hbar}{2im}\left(\psi^* \nabla_r \psi - \psi \nabla \psi^*\right)$$

$$\frac{\partial}{\partial r} \quad |f(\theta)|^2 \left(ik\frac{e^{ikr}}{r^2} - \frac{e^{ikr}}{r^3} \right)$$

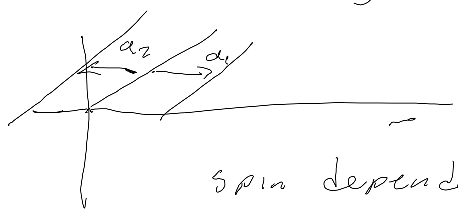


$$\left(\frac{\hbar}{m} |f(\theta)|^2 \frac{k}{r^2} \right) = j_r$$

$e^{i\vec{k}\cdot\vec{r}}$

$$dP = j_r\, r^2\, d\Omega$$
$$= v\,|f(\theta)|^2\, d\Omega$$

$$\frac{dP}{v} = d\sigma = |f(\theta)|^2\, d\Omega$$
$$(a^2)$$



spin dependence

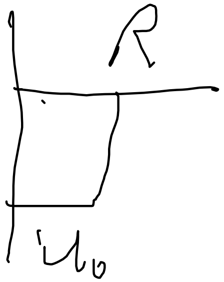
$$a = a_0 + a_1(\vec{\sigma}\cdot\vec{I})$$

$\mathrm{Im}\, a \ll \mathrm{Re}\, a$

^{149}Sm	$a = -1.9 + i4.5$
^{157}Gd	$4.3 + i4$

$$f(\theta) = -a \qquad -\frac{\hbar^2}{2\mu}\nabla^2\psi + \cdots$$

$$f(\theta) = -\frac{\mu}{2\pi\hbar^2}\langle k_f | U | k_i \rangle = -a$$



$$\int d^3r\, e^{i(\vec{k}_f - \vec{k}_i)\cdot\vec{r}}\, U(r)$$

$$(k_f - k_i)\cdot r \ll 1$$

$$= \cancel{a}\ \delta(r)\,\alpha \quad \cancel{z}$$

$$-\frac{\mu}{2\pi\hbar^2}\alpha = a$$

$$= \delta(r)\left(\frac{2\pi\hbar^2}{\mu}a\right)$$

$$\psi \sim e^{ik\cdot r} - a\frac{e^{ikr}}{r}$$

$$\psi^{(i)}_{scatt} \sim \frac{a}{r} e^{ikr} e^{i\vec{k}_0 \cdot \vec{R}_i}$$

i^{th} nucleus $$\frac{a}{|r-R_i|} e^{ik|r-R_i|} \left(e^{ik_0 \cdot R_i} \right)$$