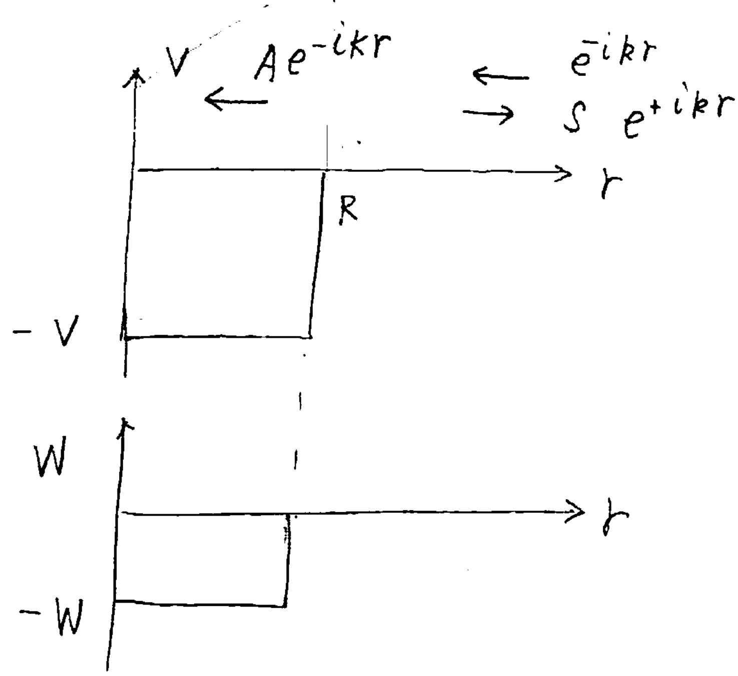
◦ 中性子散乱に対する s-wave 模型



$$\psi(\mathbf{r}) = \frac{u(r)}{r} Y_{00}(\hat{r}) = \frac{1}{\sqrt{4\pi}} \cdot \frac{u(r)}{r}$$

(note) もし自由粒子なら $\frac{u(r)}{r} = j_0(kr)$

$$= \frac{\sin kr}{kr} = \frac{e^{ikr} - e^{-ikr}}{2ikr}$$

↓

$$r \geq R: \quad u(r) = e^{-ikr} - S\, e^{ikr} \qquad \text{— ①}$$

$r < R$ では $U = -V - iW$

$$u(r) = A\, e^{-ikr} + \cancel{B\, e^{ikr}}$$

$$k = \sqrt{\frac{2m}{\hbar^2}(E - U)}$$

$$= \sqrt{\frac{2m}{\hbar^2}(E + V + iW)}$$

(note)
$$K=\sqrt{\frac{2m}{\hbar^2}(E+V)\left(1+\frac{iW}{E+V}\right)}$$

$$\sim\sqrt{\frac{2m}{\hbar^2}(E+V)}\left(1+\frac{iW}{2}\cdot\frac{1}{E+V}\right)$$

もし W が小さいと

$$= k_R + i k_I \qquad (k_R,\ k_I > 0)$$

⇓

$$e^{ikr} = e^{ik_R r}\, e^{-k_I r} \sim 0$$

⇓

$$u(r) = A e^{-ikr} \qquad (r<R) \quad —②$$

①と②の接続 @ $r=R$

$$\begin{cases} A e^{-ikR} = e^{-ikR} - S e^{ikR} \\ -ikA e^{-ikR} = -ik e^{-ikR} - ikS e^{ikR} \end{cases}$$

⇓

$$\frac{1}{\cancel{-i}k} = \frac{e^{-ikR} - S e^{ikR}}{\cancel{-i}k(e^{-ikR} + S e^{ikR})}$$

$$k e^{-ikR} + k S e^{ikR} = K e^{-ikR} - K S e^{ikR}$$

$\Rightarrow$

$$S = \frac{K-k}{k+K} e^{-2ikR}$$

$\Rightarrow$

$$\sigma_{cap} = \frac{\pi}{k^2} \sum_{l} (2l+1) \left(1 - |S_l|^2\right)$$

$$\sim \frac{\pi}{k^2} \left(1 - |S|^2\right)$$

$$= \frac{\pi}{k^2}\left(1 - \left(\frac{K-k}{k+K}\right)^2\right) = \frac{\pi}{k^2} \cdot \frac{4kK}{(k+K)^2} \quad //$$

(note) $V \sim 50$ MeV

$\Rightarrow$ E_nが小さいとすると（遅い中性子）

$k \ll K \sim$ const.

$\downarrow$

$$\sigma_{cap} \sim \frac{4\pi}{kK} \propto \frac{1}{v}$$