1

Neutron-Proton System

$$\Psi = \frac{u(r)}{r}\frac{\chi_{-1}}{\sqrt{4\pi}} + \frac{v(r)}{r}\Psi_{-1}$$

$$\frac{\hbar^2}{M}\frac{d^2u}{dr^2} + \left\{E + \left(g_1^2 + \frac{2}{3}g_2^2\right)\frac{e^{-\varkappa r}}{r}\right\}u$$

$\frac{2}{3}(4-3$

$$-\frac{2\sqrt{2}}{3}g_2^2\left(1+\frac{3}{\varkappa r}+\frac{3}{\varkappa^2 r^2}\right)\frac{e^{-\varkappa r}}{r}v = 0$$

$$\frac{\hbar^2}{M}\frac{d^2v}{dr^2} - \frac{6}{r^2}v + \left\{E + \left[g_1^2 + \frac{2}{3}g_2^2 - \frac{2}{3}g_2^2\left(\frac{3}{\varkappa r} + \frac{1}{\varkappa^2 r^2}\right)\right]\frac{e^{-\varkappa r}}{r}\right\}v$$

$$-\frac{2\sqrt{2}}{3}g_2^2\left(1+\frac{3}{\varkappa r}+\frac{3}{\varkappa^2 r^2}\right)\frac{e^{-\varkappa r}}{r}u = 0$$

$$\left(g_1^2+\frac{2}{3}g_2^2\right)\frac{e^{-\varkappa r}}{r} = U$$

$$\frac{2}{3}g_2^2\left(1+\frac{3}{\varkappa r}+\frac{3}{\varkappa^2 r^2}\right)\frac{e^{-\varkappa r}}{r} = V$$

$$\left.\begin{aligned}&\frac{\hbar^2}{M}\frac{d^2u}{dr^2} + \{E+U\}u - \sqrt{2}\,V v = 0\\ &\frac{\hbar^2}{M}\left(\frac{d^2v}{dr^2} - \frac{6}{r^2}v\right) + \{E+U-V\}v - \sqrt{2}\,V u = 0\end{aligned}\right\}$$

$E<0$

$$\sqrt{\frac{-ME}{\hbar^2}} = \sqrt{\varepsilon} \qquad \sqrt{\frac{MU}{\hbar^2}} = \alpha \qquad \sqrt{\frac{MV}{\hbar^2}} = \beta$$

$$\varkappa = \frac{m_U c}{\hbar} = \sqrt{\frac{M_U m_U^2 c^2}{\hbar^2 M_U}}$$

$$\left.\begin{aligned}&\frac{d^2u}{dr^2} + (\alpha^2 - \varepsilon)u - \sqrt{2}\,\beta^2 v = 0\\ &\frac{d^2v}{dr^2} - \frac{6}{r^2}v + (\alpha^2 - \varepsilon - \beta^2)v - \sqrt{2}\,\beta^2 u = 0\end{aligned}\right\}$$

$r > r_0$: $\quad \frac{d^2u}{dr^2} - \varepsilon u = 0 \qquad u = C_1 e^{-\sqrt{\varepsilon}\cdot r}$

$$\frac{d^2v}{dr^2} - \frac{6}{r^2}v - \varepsilon v = 0.$$

$$v = v' e^{-\sqrt{\varepsilon} r} \qquad \frac{dv}{dr} = \frac{dv'}{dr}e^{-\sqrt{\varepsilon} r} - \sqrt{\varepsilon}\, v' e^{-\sqrt{\varepsilon} r}$$

$$\frac{d^2v}{dr^2} = \frac{d^2v'}{dr^2}e^{-\sqrt{\varepsilon} r} - 2\sqrt{\varepsilon}\frac{dv'}{dr}e^{-\sqrt{\varepsilon} r} + \varepsilon e^{-\sqrt{\varepsilon} r} =$$