$$S(R_f) = \int_0^{R_{match}} K_{fi}(R_f, R_i) u(R_i) dR_i$$

$$K_{fi}(R_f, R_i)$$

$$D_{fi} = R_f - R_i$$

R_f

D_{fi}

$K'_{fi}(R_f, D_{fi})$

K'_{fi}

$u(R_i)$

$$\ell_f + \ell_i$$

R_i

10^{-15}

<

R_f

$$J_{total} \geq$$

>

$\geq$

$$A(m'M' : mM; L)$$

< 0

$$\ell = \boldsymbol{J}_{total}$$

$$\ell = L_{in}$$

ℓ

–|

I

$$L = J_{total}$$

$$L = L_{in}$$

0^+

$k = 0$

2

k

-1

$\hbar^2 k^2 / 2m$

$$k = f'/f$$

r

S_{el}

$$0.05 < Re(S_{el}) < 0.95$$

$\neq$

T_{10}

iT_{11}

T_{20}

T_{21}

T_{22}

iT_{30}

iT_{31}

$$K_{fi}(R_f, D_{fi})$$

土

$$((G - iF) - S.(G + iF)).i/2$$

$$f(m'M' : mM; \theta)$$

θ

f

A

$$L = 0$$

$$\exp i(\sigma_L - \sigma_0))$$

J, π

S

$S_\ell < 0.1$

$$J - L$$

total

$$r = h$$

$\neq$

=

$$\exp(-i\delta(k))$$

$$\sin(\delta(k))\exp(-i\delta(k))$$

$$k \exp(-i\delta(k))$$

$$k \sin(\delta(k)) \exp(-i\delta(k))$$

Q

$\leq$

$180 - \theta$

$f(\theta)$

$$f(m'M' : mM)$$

$1/3$

r_0

β

T

j_0

sin

3

$\times r$

$$\hbar^2/(m_\pi^2 c^2)$$

$$j(j+1)-l(l+1)-s(s+1)=2\mathbf{l}.\mathbf{s}$$

S

J

L

J_T/π

J_T

$$int(J_T) + 1$$

π

J_T

$^1S_0$

$^3S_1$

$$^3S-{}^3D$$

$^3D_1$

$^{1}P_{1}$

$^3P_0$

$^3P_1$

$^3P_2$

$$^3P - ^3F$$

$^3F_2$

$^1D_2$

$^3D_2$

LS

$e.fm^k$

$$\langle I' || Ek || I \rangle$$

K

$$Mn(Ek) = \langle I' || Ek || I \rangle / (\sqrt{2I+1} \langle IKk0 | I'K \rangle) \ .$$

$$0 \to k$$

$$Mn(Ek) = \langle k||Ek||0\rangle$$

$$Mn(Ek) = Q_0 \sqrt{5/16\pi}$$

R

β_k

$$Mn(Ek) = \frac{3\ Z\ \beta_k\ R^k}{4\pi}\ .$$

Q_0

$$
\begin{aligned}
M(Ek) &= i^{I-I'+|I-I'|}\,\langle I'||Ek||I\rangle \\
&= \pm\sqrt{(2I+1)\,B(Ek, I \to I')}\,,
\end{aligned}
$$

$$I \leftrightarrow I'$$

$$Q_2 = \sqrt{16\pi/5}\,(2I+1)^{-1/2}\,\langle II20|II\rangle\,\langle I||E2||I\rangle\,.$$

$$M(Ek) = Mn(Ek)\ (-1)^{[I-I'+|I-I'|]/2}\ \sqrt{2I+1}\langle IKk0|I'K\rangle$$

I, I'

Z

$\beta_k \times R$

$$B(Ek, 0 \to k)$$

$$K = 0$$

$$< IB|M(Ek)|IA >$$

→

$$
\begin{aligned}
RDEF(k, I \rightarrow I') &= DEF(k)(-1)^{[I-I'+|I-I'|]/2}\sqrt{2I+1}\,\langle IKk0|I'K\rangle \\
&= M(Ek) * 4\pi/[3ZR^{k-1}]
\end{aligned}
$$

$$F(r) = M(Ek)\, e^2\, \frac{\sqrt{4\pi}}{(2k+1)}\, r^{-k-1}$$

$$e^2 = 1.440$$

$$-1/\sqrt{4\pi}$$

$$F(r) = -DEF(k)\ \frac{1}{\sqrt{4\pi}}\ \frac{dU(r)}{dr}$$

$$(-1)^{[I-I'+|I-I'|]/2}$$

←

$$|L_n, (SN, J_{core})S; J_{com}\rangle$$

$$\left|(LN,SN)Jn,J_{core};J_{com}\right\rangle$$

$$|L_{nn},(\ell,S_{12})j_{12};J_{12}\rangle$$

$$(.5, .5)T$$

$$|(L_{nn},\ell)L_t,(S_{12},J_{core})S_t;J_{com}\rangle$$

$$|(.5,.5)T, T_{core}; T_{com}\rangle$$

$$(L_{nn},(\ell,S_{12})j_{12})J_{12},J_{core};J_{com}\rangle$$

$(.5, .5)T, T_{core}; T_{com}$

J_{core}

J_{com}

K_{core}

K_{com}

T_{core}

T_{com}

core

$$L_{nn} + \ell$$

$$T(k)$$

$$\sqrt{NAM} \times AMPL$$

$$5 \times |NAM|$$

$L_n, (SN, J_{core})S; J_{com}$

L_n

n

$(l_n, SN)JN, K$

com

$$K = K_{com} - K_{core}$$

n

$$l + s$$

ℓ_{min}

ℓ_{max}

min

12

max

$u_{12}(r)$

$$u(R) = < u_{12}(r) | U(r,R) >$$

$\leq$

$U(r,R)\times$

l_{min}

l_{max}

S_{min}

$$\left|(l_1, s_1) j_1, (l_2, s_2) j_2; J_{12}, T\right\rangle$$

$(l_1, s_1)j_1$

$$u_1(r_1)$$

$(l_2, s_2) j_2$

$u_2(r_2)$

(r_1, r_2)

(r, R)

nn

$$u_1(r_1) \times u_2(r_2)$$

$u_3(r)$

×

$$u_1(r)u_2(R)$$

u_2

$$L_{nn}, ((\ell, (s_1, s_2) S_{12}) j_{12}; J_{12}, T\rangle$$

L_{nn}

D_0

D

D_0

(R, R')

$$1/\sqrt{4\pi}$$

$$\mathbf{S}(\ell) = Y_\ell(\hat{\mathbf{R}})$$

$$\mathbf{S}(\ell) = \ell$$

$E\lambda$

$M\lambda$

λ

$\lambda >$

g

$Q > 0$

$Q_{\max}$

Λ_{max}

$$\sqrt{(D/D_0 - 1)/k^2}$$

$$\theta = \pi$$

$$\theta = 0$$

$$r' =$$

$r =$

p

c

v

/

$$\langle c | c + v = t \rangle$$

$$\langle c | c + p = t' \rangle$$

$$\sqrt{N}$$

$$(\ell, s)\, j, J_{core}; J_{com}$$

$\ell s j$

$$e^2$$

$$2 * amu/\hbar^2$$

16

$h.K$

h

$$\langle \mathtt{KN} | KQ\lambda | \mathtt{KNP} \rangle$$

$K Q \lambda$

Λ

$$\langle \mathtt{KN} | \Lambda | \mathtt{KNP} \rangle$$

$$\langle \mathtt{IB} | \Lambda | \mathtt{IBP} \rangle$$

$$\Lambda \leq q$$

$K_{\max}$

$$0 \to Q$$

± 1

$$k \propto \sqrt{E}$$

$$\chi^2$$

i

$$\mathbf{S}([\ell, s_p]s_t, s_t)$$

s_p

I_p

s_t

I_t

$$(F_{\lambda_1} G_{\lambda_2})_{\lambda\mu} = \sum_{\mu_1\mu_2} \langle \lambda_1\mu_1, \lambda_2\mu_2 | \lambda\mu \rangle F_{\lambda_1\mu_1} G_{\lambda_2\mu_2} \ ,$$

$$F_{s_t} = [\ell, s_p] s_t$$

$$G_{s_t} = s_t$$

S

$$(F_\lambda G_\lambda)_{00} = (2\lambda+1)^{-1/2} \sum_\mu (-1)^{\lambda-\mu} F_{\lambda\mu} G_{\lambda-\mu} \,.$$

$$(-1)^{\lambda}(2\lambda+1)^{-1/2}$$

$$\langle L' \parallel Y_\ell \parallel L \rangle = \frac{\hat{\ell}\hat{L}}{\sqrt{4\pi}} \langle L0, \ell 0 | L'0 \rangle$$

$$\lambda = 1$$

$$\langle L' \parallel \ell_\lambda \parallel L \rangle = \delta_{LL'}\ (-1)^\lambda \sqrt{2\lambda+1}\ \sqrt{L(L+1)(2L+1)}\,.$$

$$\ell \equiv \mathtt{LTR} = 1$$

$$s_p \equiv \mathtt{PTR} = 1$$

$$\langle (LI_p)J, I_t; J_T M_T |\, \mathbf{S}([\ell, s_p]s_t, s_t)\, |(L'I'_p)J', I'_t; J_T M_T\rangle.$$

$$= (-1)^{s_t+J_T+J'+I_t} \left\{ \begin{array}{ccc} J' & I'_t & J_T \\ I_t & J & s_t \end{array} \right\} \hat{J}\hat{J}' \left\{ \begin{array}{ccc} L' & I'_p & J' \\ \ell & s_p & s_t \\ L & I_p & J \end{array} \right\} \langle L' \parallel \mathbf{S}(\ell) \parallel L \rangle$$

$$\times \ \langle I_p || s_p || I'_p \rangle \ \ \langle I_t || s_t || I'_t \rangle$$

$$\langle I_p || s_p || I'_p \rangle \langle I_t || s_t || I'_t \rangle$$

$$\langle I_p || s_p = 0 || I_p \rangle = \hat{I}_p$$

$$((2I'_t+1)(2I_t+1))^{1/4}$$

$$\langle I_t || s_t = 0 || I_t \rangle = \hat{I}_t$$

γ

$$\Gamma = 2\gamma^2 P$$

$1/2$

$$P_{\mathrm{leff}}(E - \mathtt{energy})/P_{\mathrm{leff}}(e_{\mathrm{pole}} - \mathtt{energy})$$

T_{kq}

T_{00}

$\sigma(\theta)$

χ