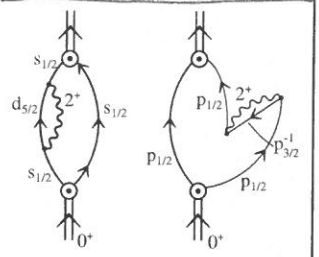
^{11}Li -halo



MeV
$\epsilon_{s_{1/2}} = 1.5$
$\epsilon_{p_{3/2}} = -4.7$
$\epsilon_{d_{5/2}} = 3.5$
$\epsilon_{p_{1/2}} = -1.2$

WS potential $R_0 = 1.2A^{1/3}$ fm=2.7 fm

$U = U_0(1 + 0.4E)$ → (exchange; Pauli)

$R(^{11}\text{Li})$=4.58 ± 0.13 fm

(bare sp)

$\mathcal{O} = \left(\frac{R_0}{R}\right)^3 = \left(\frac{2.7}{4.58}\right)^3 \approx 0.2$

$m_k = \frac{m}{(1+\mathcal{O}\times 0.4)} \approx \frac{m}{1.08} \approx 0.93m$

① ②

$^9_3$Li$_6$; $U_0 = \left(-51 + 30\frac{N-Z}{A}\right)$MeV=-43 MeV

$\hbar\omega_{2^+} = 3.33$ MeV; $\beta_2 = 0.66$

$\langle R_0 \partial U/\partial r \approx 1.4U_0 \approx -60$ MeV; $\langle j||Y_2||1/2\rangle \approx ((2j+1)/4\pi)^{1/2} \approx 0.7$

$\langle H_c\rangle = \frac{\beta_2}{\sqrt{5}}\langle R_0\frac{\partial U}{\partial r}\rangle \mathcal{O}\langle j||Y_2||1/2\rangle \approx \frac{0.7}{\sqrt{5}}(-60\text{MeV}) \times 0.2 \times 0.7 \approx -3$ MeV

$s_{1/2}$, $d_{5/2}$

$$\begin{pmatrix} (6.8-\lambda) & -3 \\ -3 & (1.5-\lambda) \end{pmatrix} = 0$$

MeV

$p_{1/2}$, $p^{-1}_{3/2}$, $p_{1/2}$

$$\begin{pmatrix} (5.6-\lambda) & -3 \\ -3 & (-1.2-\lambda) \end{pmatrix} = 0$$

(dressed sp)

2^+

$\tilde{\epsilon}_{s_{1/2}} = 0.15$ MeV

$\tilde{\epsilon}_{p_{1/2}} = 0.6$ MeV

E (MeV)

$s_{1/2}$

1

^{10}Li

not bound

exp. NFT

WS

-1

$p_{1/2}$

$|\widetilde{1/2^-}\rangle = 0.86|p_{1/2}\rangle + 0.51|((p_{1/2}\cdot p^{-1}_{3/2})\otimes 2^+)_0 \cdot p_{1/2}; 1/2^-\rangle$

$|\widetilde{1/2^+}\rangle = 0.91|s_{1/2}\rangle + 0.41|((d_{5/2}\otimes 2^+)_0 \cdot 1/2^+\rangle$

E(MeV)

4.58 fm

2.7 fm

1^-

0.6

0.15

$p_{1/2}$

$s_{1/2}$

③

Z N

p scenario

s pygmy

halo–anti pairing effect s, p at threshold

E(MeV)

1.5

0.5

1.2 MeV

clarification

1.1 MeV

$\tilde{1s}_{1/2}(0)$

0.3 MeV explication

0.3 MeV

$^{11}_3$Li$_8$ bare short range pairing

not bound

$\langle V_p\rangle \approx G_{scr} \approx rG$

$\approx 0.048 \times \frac{25}{A}$MeV $\approx \frac{1\text{MeV}}{A}$

≈ 0.1 MeV

bare + induced pairing

screening →

$H_D = \kappa_1 \mathbf{D}\cdot\mathbf{D}$

$\kappa_1 = s\kappa_1^0$; $\kappa_1^0 \sim 5V_1 = 125$ MeV

$\kappa_1 \sim 5.6$ MeV ($s \approx 0.045$);

($V_1 = 25$MeV; $sV_1 \approx 1.1$ MeV)

$(8\%)\text{TRK} = \frac{9}{4\pi}\frac{\hbar^2}{2M}\frac{NZe^2}{A}$

$\hbar\omega_{pygmy} = \left((\epsilon_{1/2^+} - \epsilon_{1/2^-})^2 + \kappa_1(2\times 0.08\text{TRK})^2\right)^{1/2} \approx 0.9$ MeV

$\Delta E_{ind} = -0.5$MeV

pygmy

$E_{corr} \approx 2\tilde{\epsilon}_{s_{1/2}} + \Delta E_b + \Delta E_i = \cancel{0.4}\,0.3 - 0.1 - 0.5$ MeV $\approx \cancel{-0.2}\,-0.3$ MeV

$(E_{corr})_{exp} = -0.380$MeV

clothed sp states $\widetilde{1/2^+}$, $\widetilde{1/2^-}$

$\Delta E_{bare} = -0.1$ MeV

$|\tilde{0}\rangle = |0\rangle_\nu + 0.7|(p_{1/2}, p^{-1}_{3/2})_{1^-}\otimes 1^-; 0\rangle + 0.1|(s_{1/2}, d_{5/2})_{2^+}\otimes 2^+; 0\rangle$

$|0\rangle_\nu = 0.45|s^2_{1/2}(0)\rangle + 0.55|p^2_{1/2}(0)\rangle + 0.04|d^2_{5/2}(0)\rangle$

E(MEV)

1

0.5

WS+clothed sp

+0.3 explication

-0.5

NF

EXP

-0.380

-0.3

v^2_ν

$s_{1/2}$ $p_{3/2}$ $s_{1/2}$ $p_{1/2}$ $d_{5/2}$

1

0

ε_F

QRPA symbiotic boostrap

halo pair addition mode

1^- 1^-

gs 0^+

^{11}Li

selfconsistency

gs

^{12}Be

back to ①

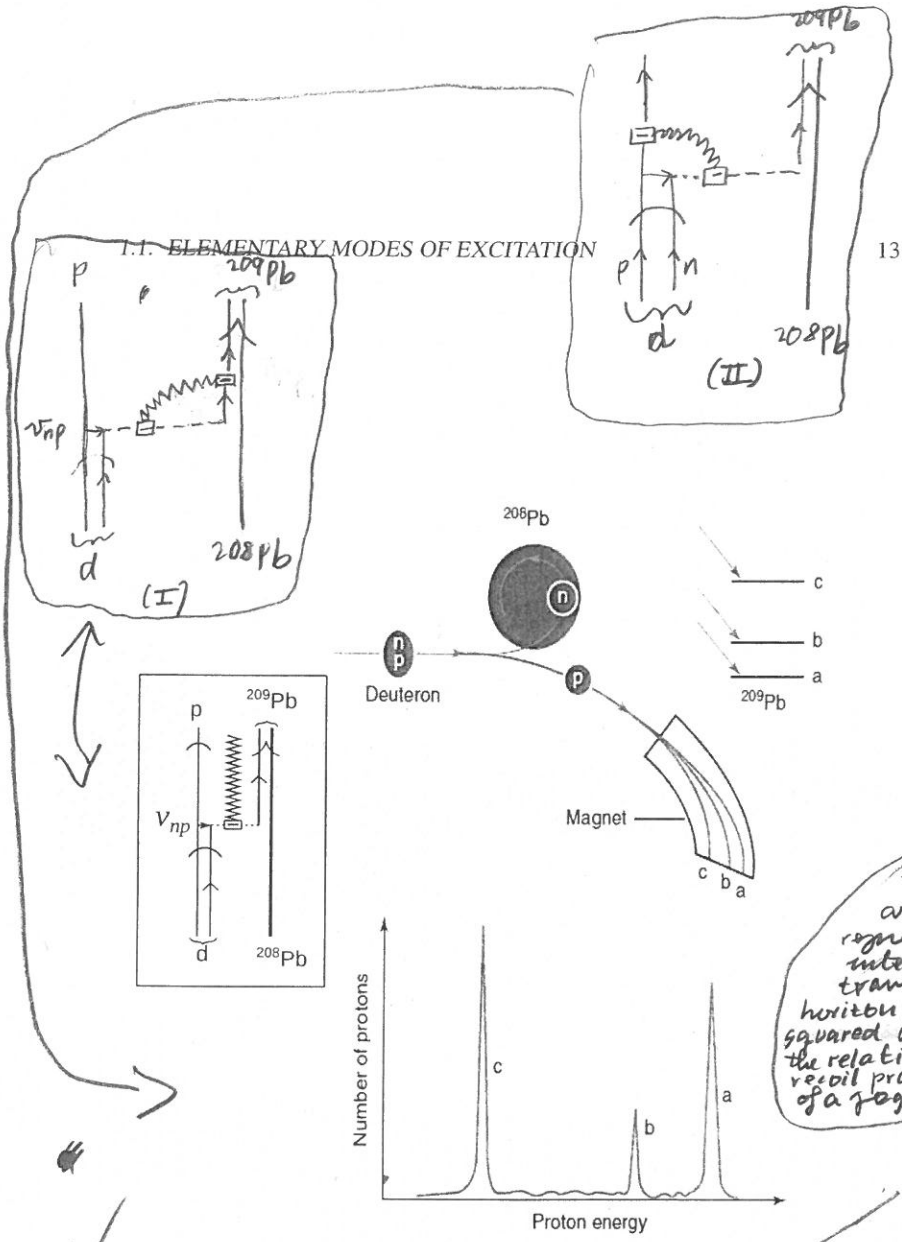


Figure 1.1.2: (Color online) Schematic representation of the one–nucleon transfer reaction ^{208}Pb$(d, p)^{209}$Pb populating the valence single–particle states of ^{209}Pb. In the inset a NFT(r+s) diagram describing the process is shown. The energy of the outgoing proton reflects ~~both~~ the ~~ground state~~ Q–value of the reaction and the excitation energy of the final state (after Mottelson (1976b)).