

**$^{11}\text{Li}$ -halo**

The figure shows two diagrams of the  $^{11}\text{Li}$  halo structure. The left diagram shows a core of two neutrons (0<sup>+</sup> state) with two valence neutrons in s<sub>1/2</sub> states, forming a 2<sup>+</sup> state. The right diagram shows a core of two neutrons (0<sup>+</sup> state) with two valence neutrons in p<sub>1/2</sub> states, forming a 2<sup>+</sup> state, with a wavy line indicating a transition to a p<sub>3/2</sub> state.

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

$$\begin{aligned} \langle R_0 \partial U / \partial r \rangle &\approx 1.44 U_0 \approx -60 \text{ MeV}; \langle j | Y_2 | 1/2 \rangle \approx ((2j+1)/4\pi)^{1/2} \approx 0.7 \\ \langle H_c \rangle &= \frac{\beta_2}{\sqrt{5}} \langle R_0 \frac{\partial U}{\partial r} \rangle \mathcal{O} \langle j | Y_2 | 1/2 \rangle \approx \frac{0.7}{\sqrt{5}} (-60 \text{ MeV}) \times 0.2 \times 0.7 \approx -3 \text{ MeV} \end{aligned}$$

(a) Diagrammatic representation of the dressed  $sp$  interaction. The first equation shows the interaction between  $s_{1/2}$  and  $d_{5/2}$  states, resulting in a dressed  $sp$  interaction. The second equation shows the interaction between  $p_{1/2}$  and  $p_{3/2}^{-1}$  states, also resulting in a dressed  $sp$  interaction. The energy scale  $\tilde{\epsilon}_{s_{1/2}} = 0.15$  MeV and  $\tilde{\epsilon}_{p_{1/2}} = 0.6$  MeV are indicated.

(b) Energy level diagram of  $^{10}\text{Li}$ . The levels are labeled  $s_{1/2}$ ,  $p_{1/2}$ , and  $p_{3/2}^{-1}$ . The experimental levels (exp.) and the No-Core Full Configuration Interaction (NFT) results are shown. The wave function of the pair state  $|1/2^{-}\rangle$  is given by  $|1/2^{-}\rangle = 0.86|p_{1/2}\rangle + 0.51|((p_{1/2}, p_{3/2}^{-1}) \otimes 2^{+})_{0+ p_{1/2}; 1/2^{-}}\rangle$  and  $|1/2^{-}\rangle = 0.91|s_{1/2}\rangle + 0.41|(d_{5/2} \otimes 2^{+})_{0+ 1/2^{+}}\rangle$ .

(c) Pairing potential  $V_p(r)$  and wave function of the pair state  $|1/2^{-}\rangle$ . The potential is shown as a function of distance  $r$  (fm). The wave function is shown as a function of distance  $r$  (fm). The potential is labeled  $V_p(r)$  and the wave function is labeled  $|1/2^{-}\rangle$ . The potential is shown as a function of distance  $r$  (fm). The wave function is shown as a function of distance  $r$  (fm). The potential is labeled  $V_p(r)$  and the wave function is labeled  $|1/2^{-}\rangle$ .

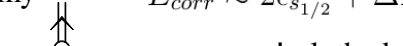
$$H_D = \kappa_1 \mathbf{\bar{D}} \cdot \mathbf{D} \quad \begin{array}{l} \kappa_1 = s\kappa_1^0; \quad \kappa_1^0 \sim 5V_1 = 125 \text{ MeV} \\ \kappa_1 \sim 5.6 \text{ MeV} \ (s \approx 0.045); \end{array} \quad \boxed{\boxed{8}}$$

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

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

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

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



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

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

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

$$|0\rangle_\nu = 0.45|s_{1/2}^2(0)\rangle + 0.55|p_{1/2}^2(0)\rangle + 0.04|d_{5/2}^2(0)\rangle$$

Figure 1 consists of three panels. The left panel shows the excitation energy  $E$  (MeV) on the y-axis (ranging from -0.5 to 1) versus energy  $\epsilon F$  on the x-axis. It displays the WS+clothed sp calculation (solid line), experimental data (dashed line), and NFT results (dotted line). The middle panel shows the squared norm of the transition operator  $V_\nu^2$  on the y-axis (ranging from 0 to 1) versus energy  $\epsilon F$  on the x-axis. It displays the QRPA results for various states:  $s_{1/2}$ ,  $p_{3/2}$ ,  $s_{1/2}$ ,  $p_{1/2}$ , and  $d_{5/2}$ . The right panel shows the QRPA symbiotic bootstrap halo pair addition mode for  $^{11}\text{Li}$  and  $^{12}\text{Be}$ . It includes the ground state (gs) and the first excited state (1<sup>-</sup>) for both nuclei, and a selfconsistency back to (1) loop.