

**Inverse kinematics and reaction mechanism at the drip line:  
probing virtual states and the nuclear vacuum**

R.A. Broglia

*Dipartimento di Fisica, Università degli Studi Milano,*

*Via Celoria 16, I-20133 Milano, Italy and*

*The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen, Denmark*

F. Barranco

*Departamento de Física Aplicada III,*

*Escuela Superior de Ingenieros, Universidad de Sevilla,*

*Camino de los Descubrimientos, Sevilla, Spain*

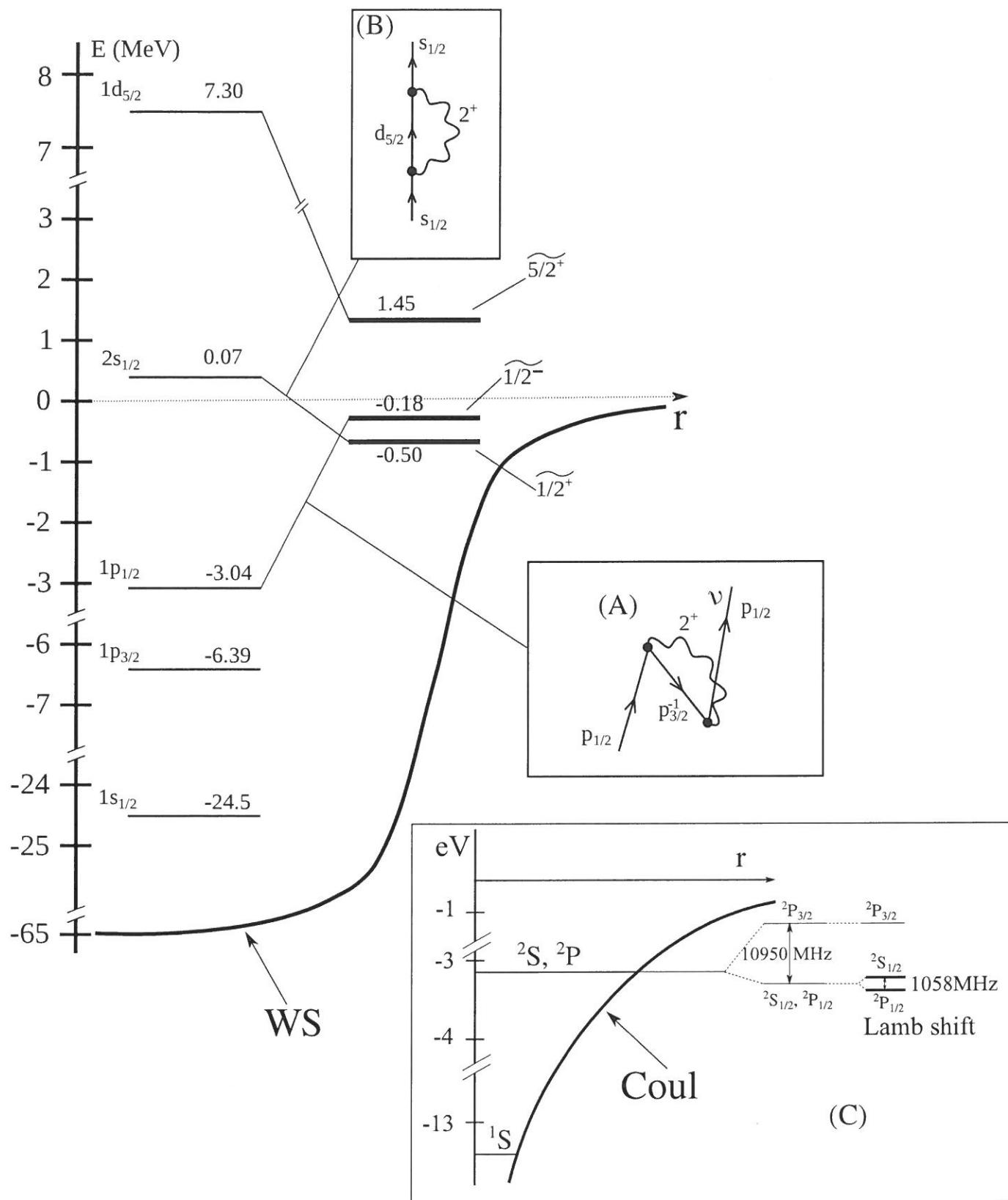
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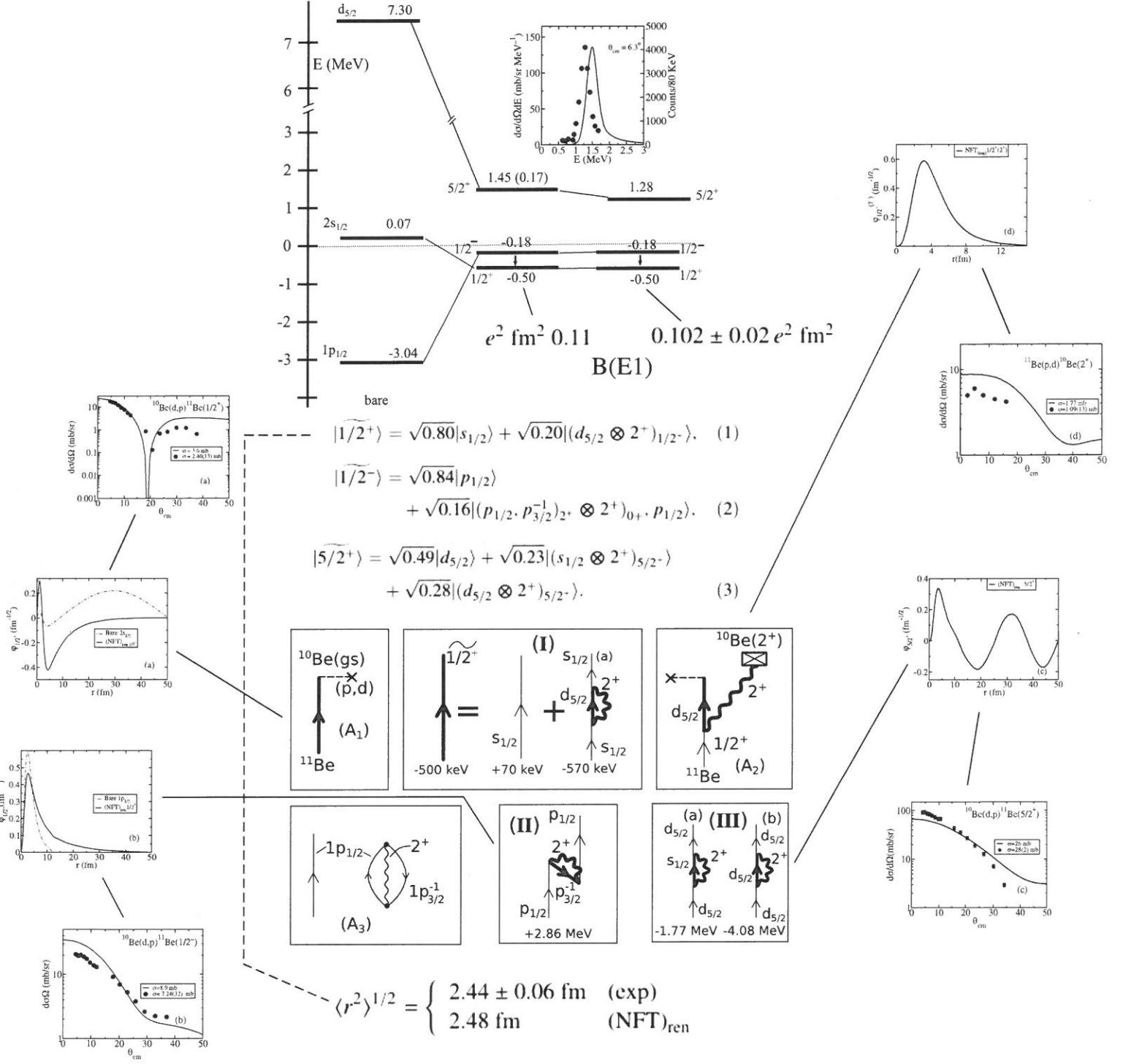
*National Superconducting Cyclotron Laboratory,*

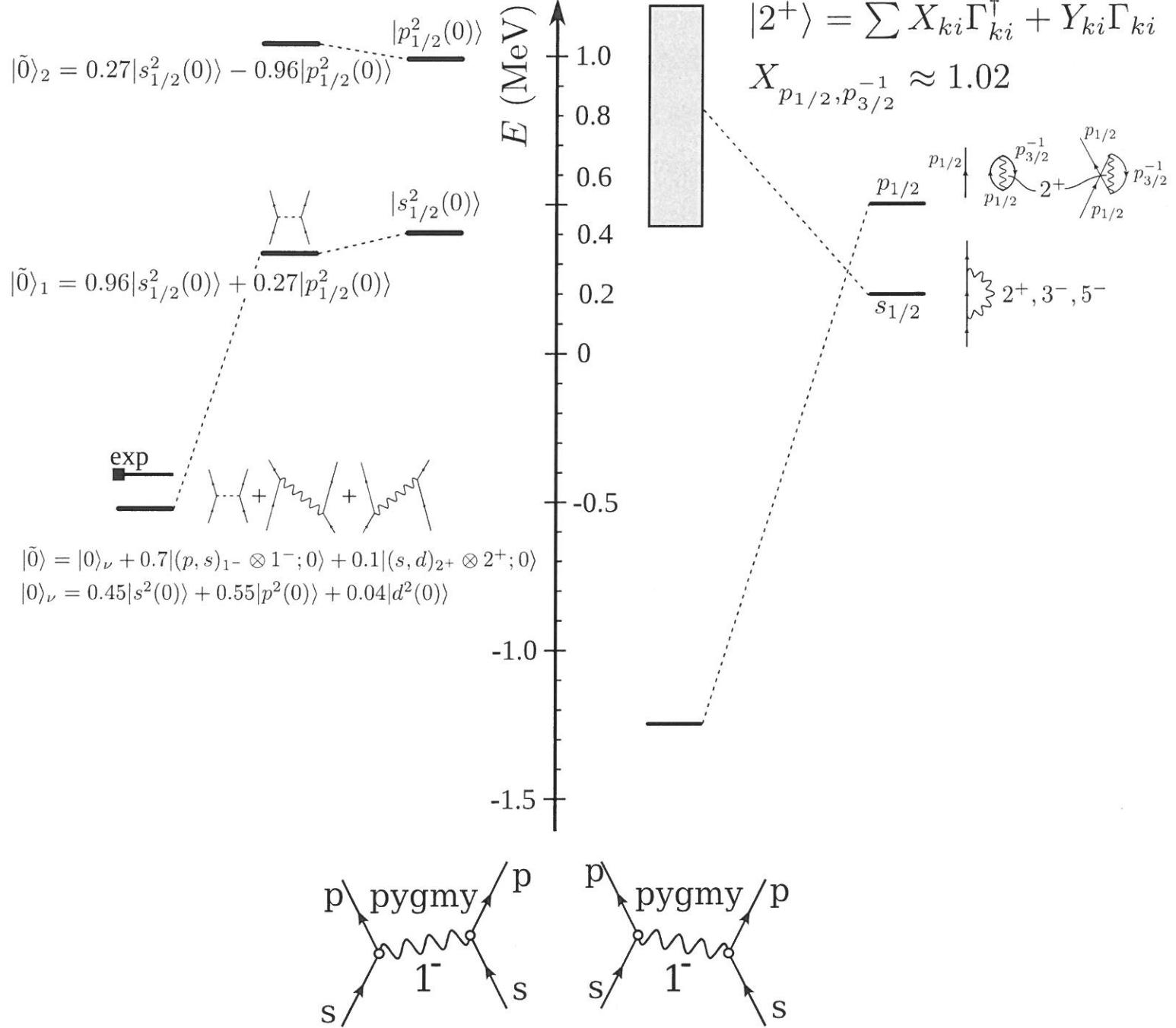
*Michigan State University, East Lansing, Michigan 48824, USA*

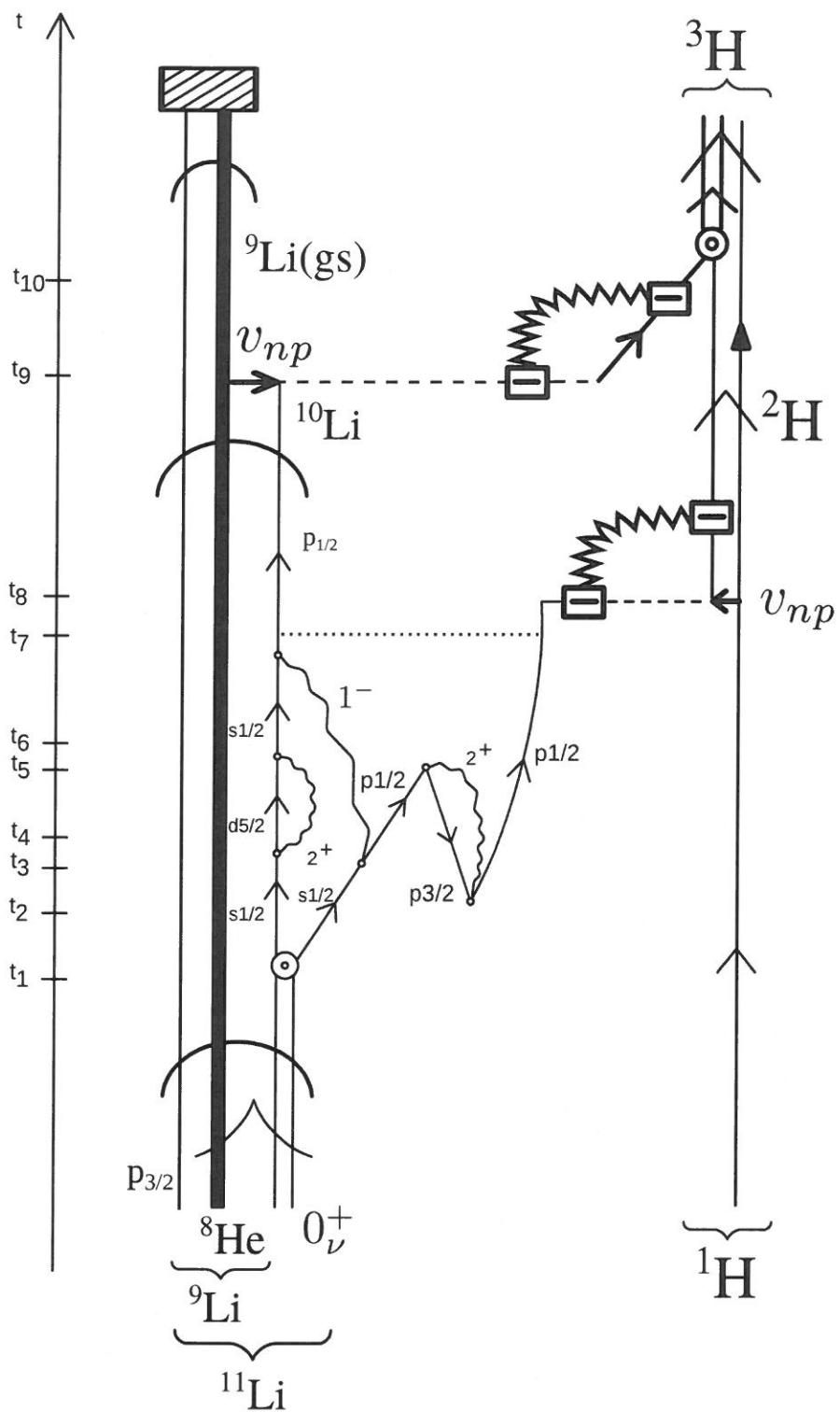
E. Vigezzi

*INFN Sezione di Milano, Milano, Italy*



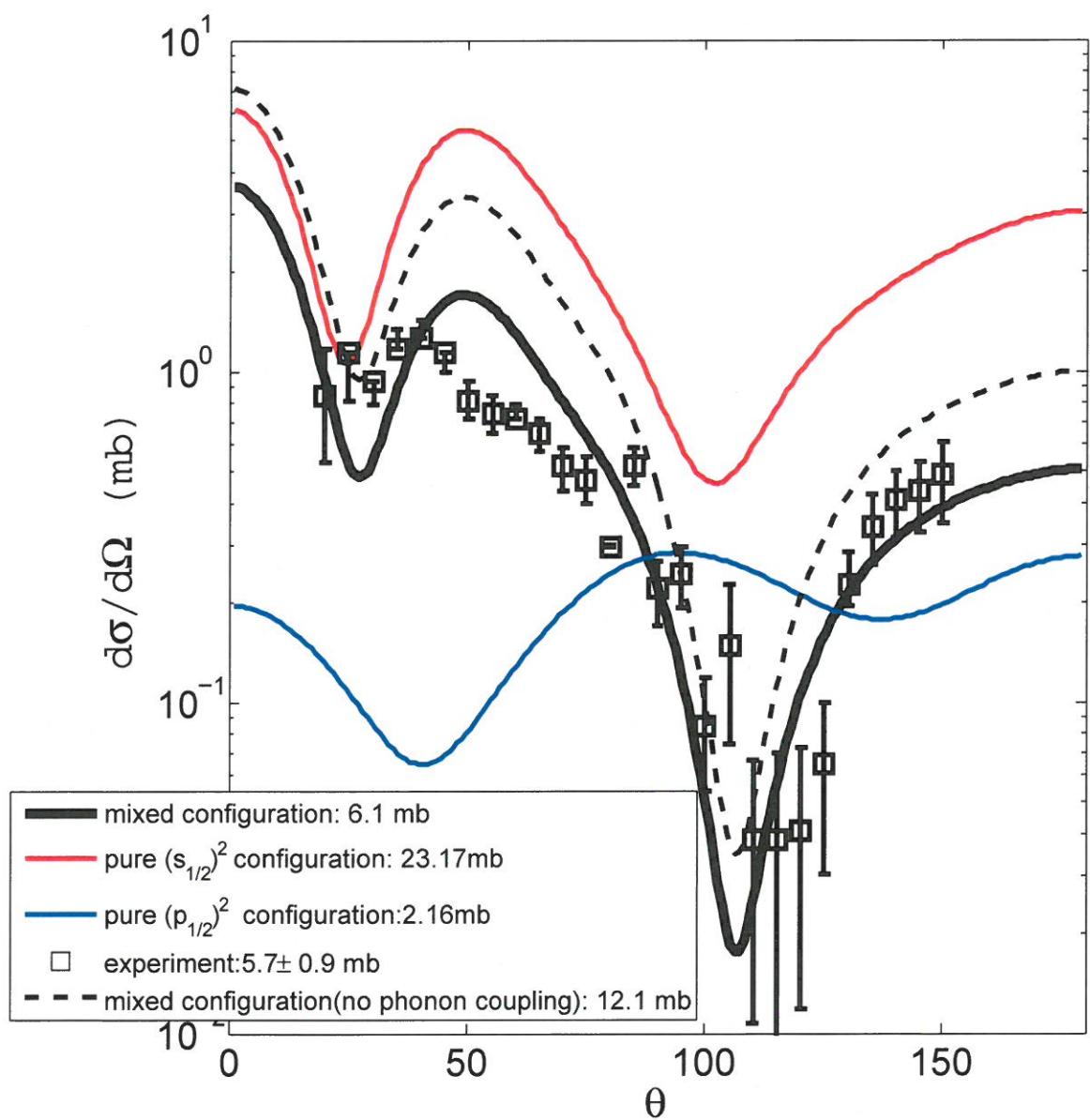


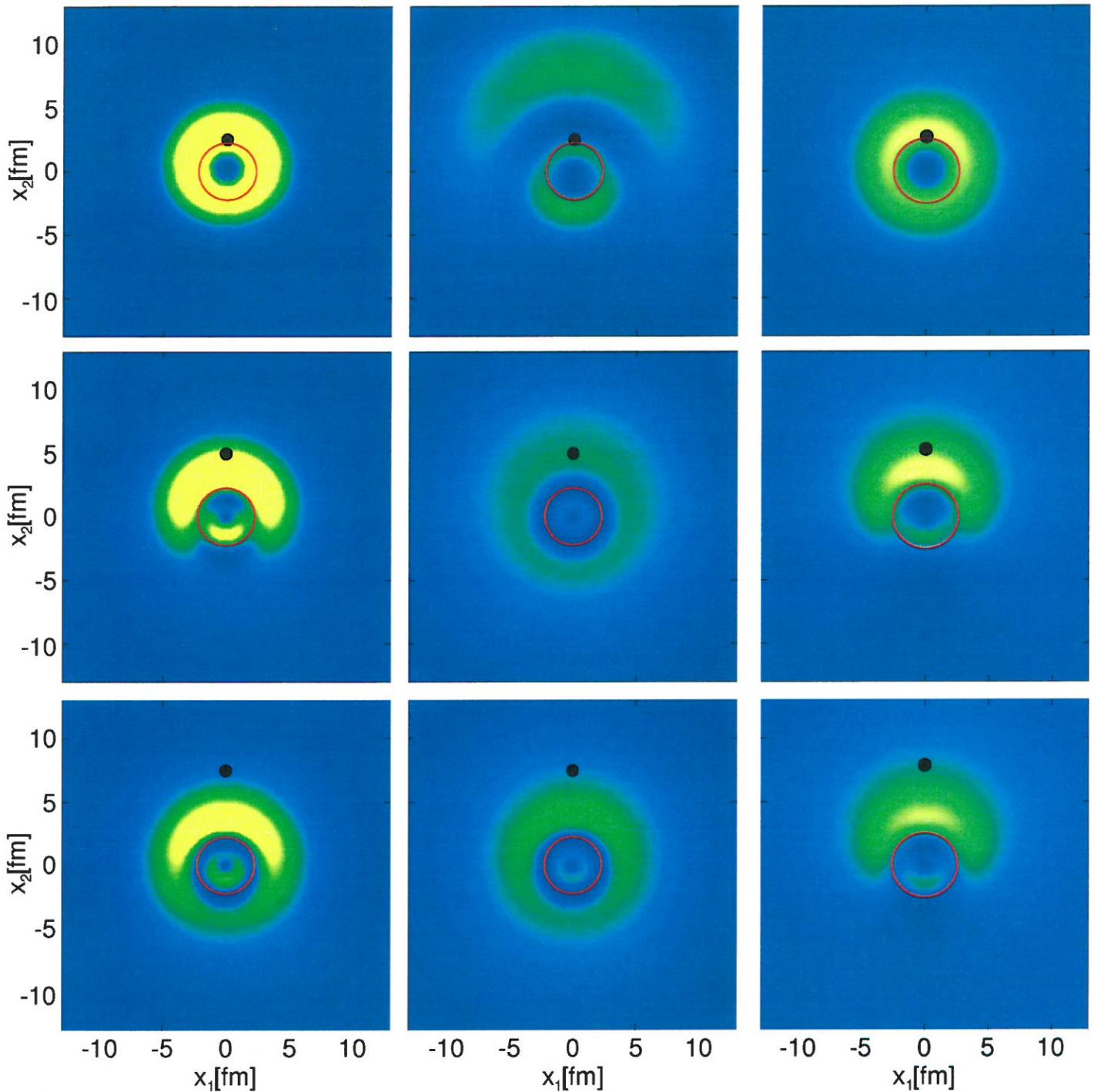




- $\nwarrow$  neutron pair halo
- $\circ$  particle-vibration coupling vertex
- $\odot$  particle-pair vibration coupling vertex
- $v_{np}$  proton-neutron int.
- $\swarrow$  recoil mode

- $\uparrow$  neutron  
 $\downarrow$  proton } bound
- $^{2+} \swarrow$   $^{9}\text{Li}$  core quadr. vibr. mode
- $^{1+} \swarrow$   $^{11}\text{Li}$  giant dipole pygmy resonance mode
- $\square$  particle-recoil mode coupling vertex (PRCV)
- $\begin{array}{c} \diagup \\ \diagdown \end{array}$   $^1\text{H}$  active target
- ..... bare pairing interaction

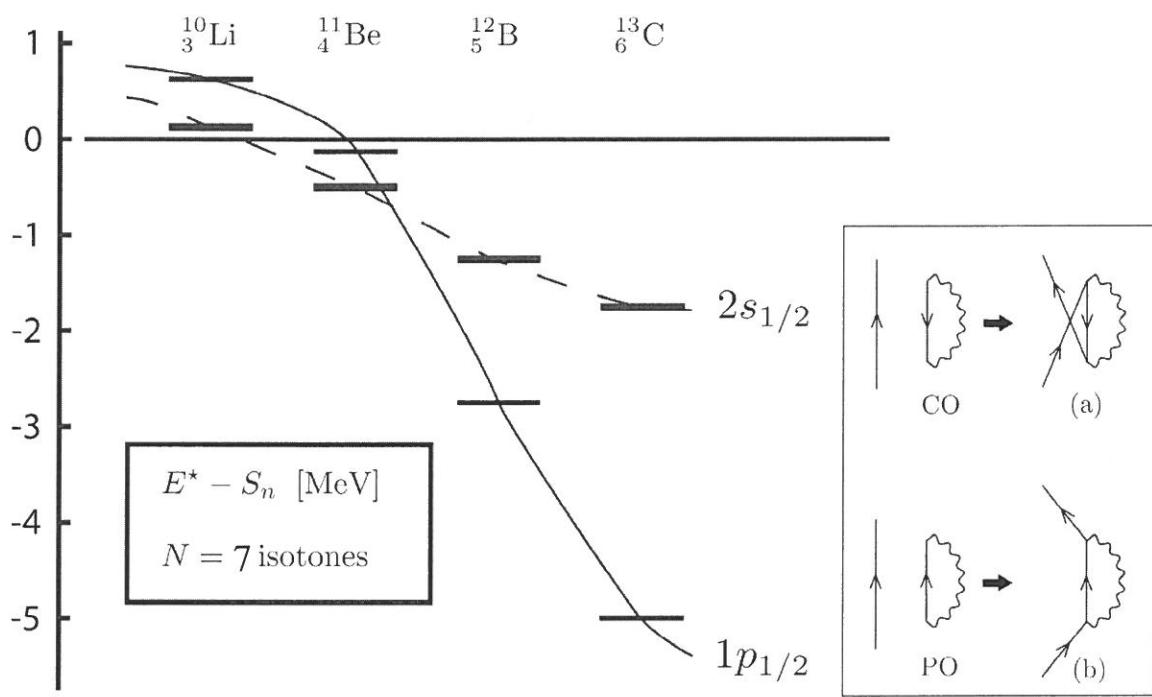


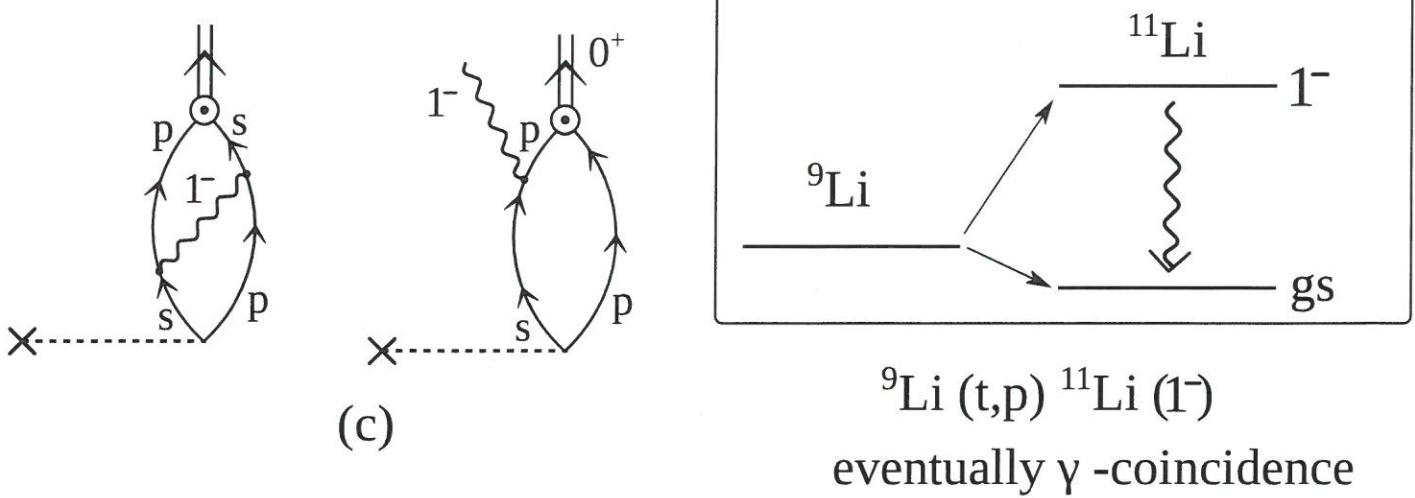
$^{12}\text{Be}(\text{gs})$  $^{12}\text{Be}(\text{exc})$  $^{11}\text{Li}(\text{gs})$ 

$$|0\rangle_\nu = |0\rangle + \alpha|(p,s)_{1^-} \otimes 1^-; 0\rangle + \beta|(s,d)_{2^+} \otimes 2^+; 0\rangle + \gamma|(p,d)_{3^-} \otimes 3^-; 0\rangle$$

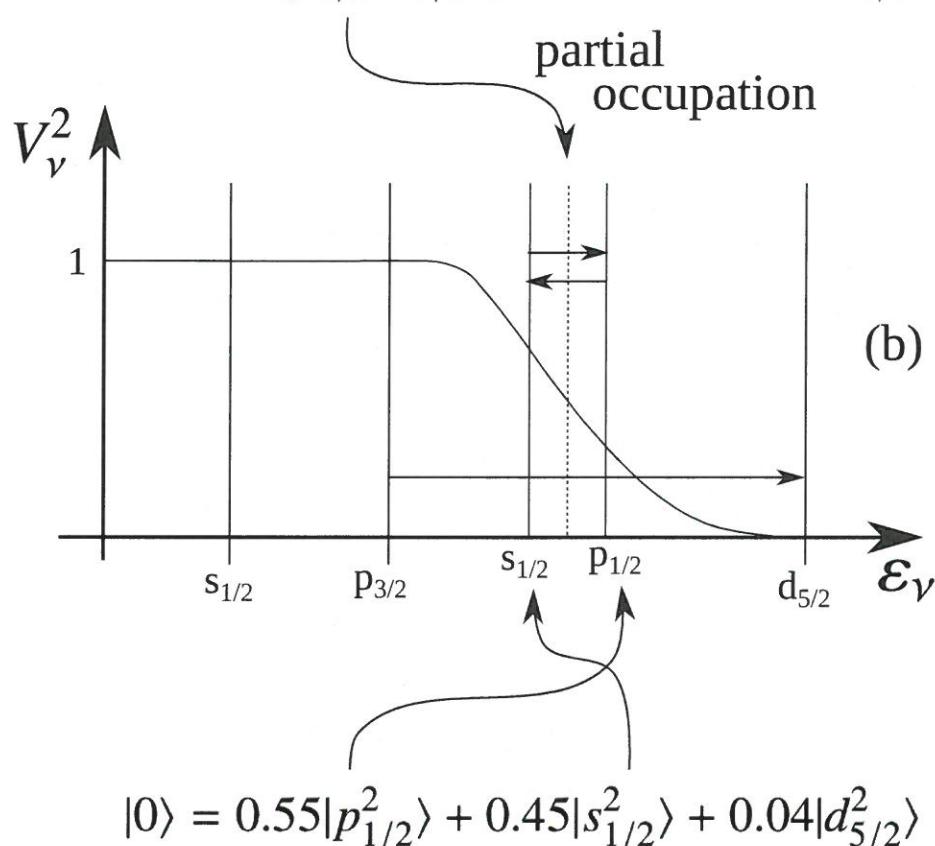
$$|0\rangle_\nu = a|s^2(0)\rangle + b|p^2(0)\rangle + c|d^2(0)\rangle$$

	$^{11}\text{Li}(gs)$	$^{12}\text{Be}(gs)$	$^{12}\text{Be}(exc)$
$\alpha$	0.7	0.10	0.08
$\beta$	0.1	0.30	-0.39
$\gamma$	-	0.37	-0.1
$a$	0.45	0.37	0.89
$b$	0.55	0.50	0.17
$c$	0.04	0.60	0.19





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



$$|1^-, \text{pigmy}\rangle = \alpha \Gamma_{\text{pigmy}}^+ |\text{halo}\rangle + \beta \Gamma_{\text{GDR}}^+ |\text{core}\rangle$$

(a)

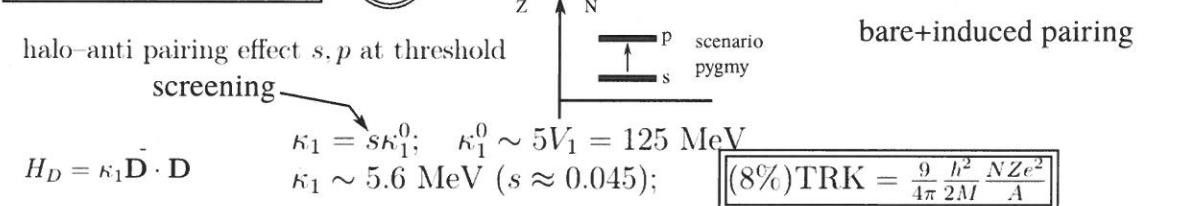
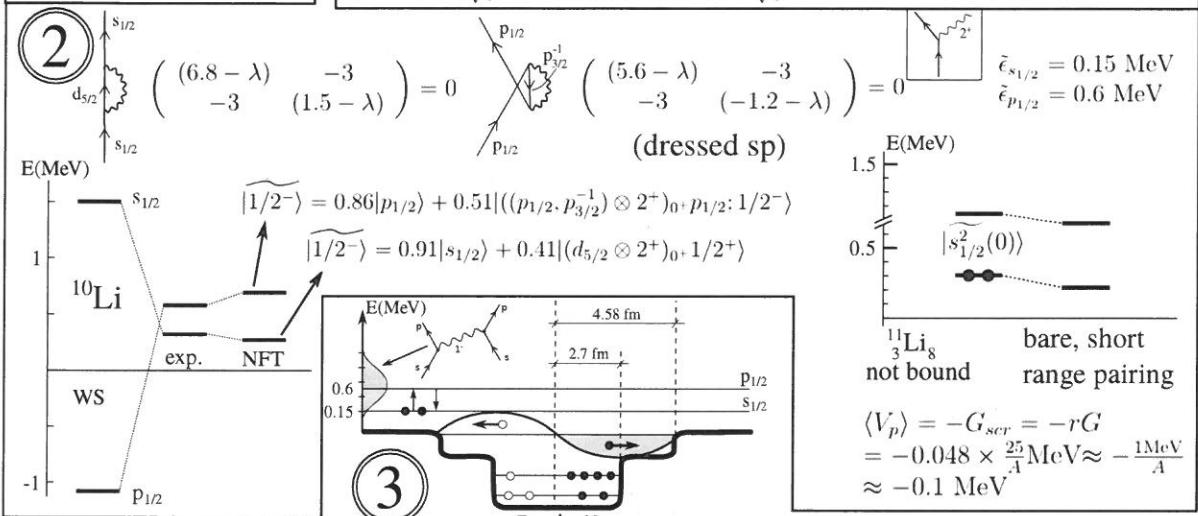
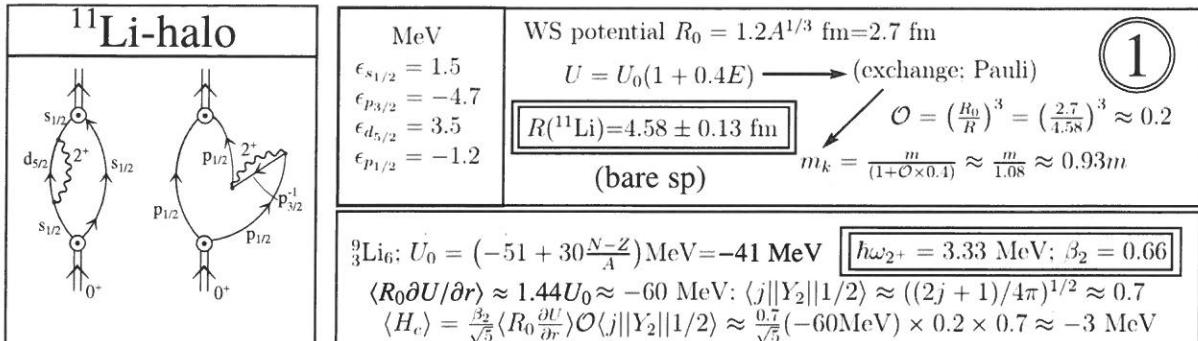
$$\alpha^2 \gg \beta^2$$

Table (a) shows the expansion coefficients  $X$  and  $Y$  for various states, with a note indicating 8% EWSR and a calculated energy  $E_{1^-} \approx 0.7$  MeV.

	$1p_{1/2}^{-1} 2s_{1/2}$	$1p_{1/2}^{-1} 3s_{1/2}$	$1p_{1/2}^{-1} 4s_{1/2}$	$1p_{1/2}^{-1} 1d_{3/2}$	$1p_{3/2}^{-1} 5d_{5/2}$	$1p_{3/2}^{-1} 6d_{5/2}$	$1p_{3/2}^{-1} 7d_{5/2}$
$X$	0.847	-0.335	0.244	0.165	0.197	0.201	0.157
$Y$	0.088	0.060	0.088	0.008	0.165	0.173	0.138

8% EWSR

$E_{1^-} \approx 0.7 \text{ MeV}$



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

