July 7-11
HNP2015
Thailand

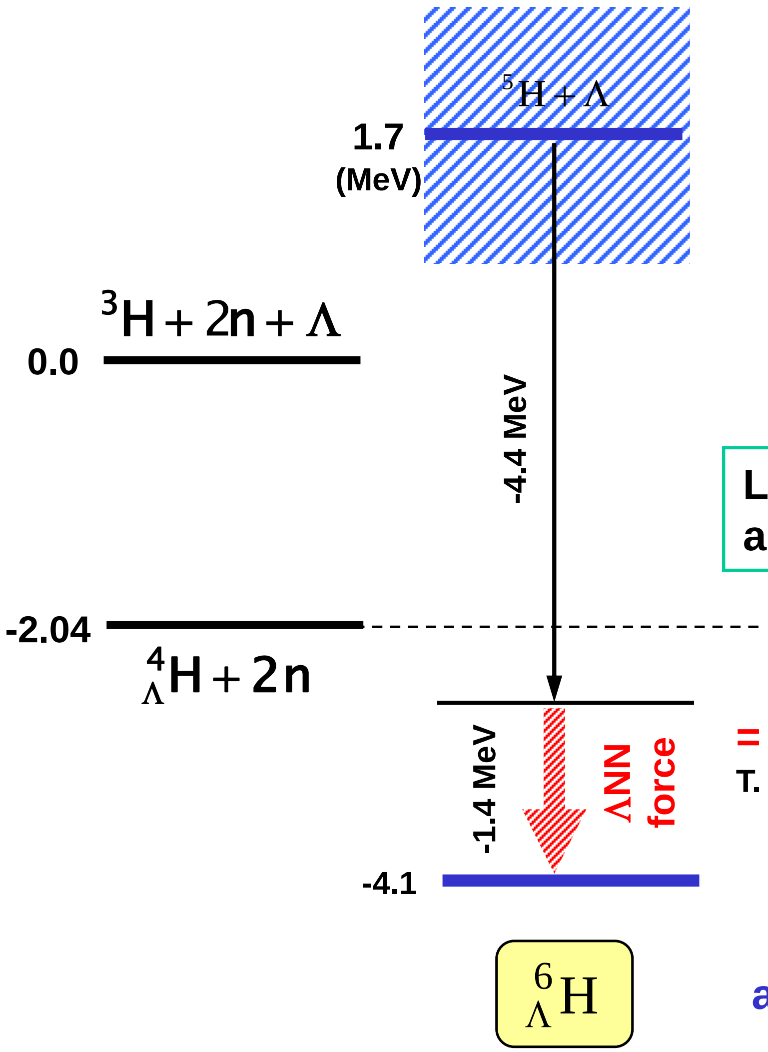
Analysis of Heavy Hyperhydrogen $^{6}_{\Lambda}H$

Theingi
Pakokku University
Myanmar

K.S. Myint

Y. Akaishi

Our Previous Work



$^1H(^6He,\,^2He)\,^5H$

Superheavy hydrogen

A.A. Korsheninnikov et al,
Phys. Rev. Lett. 87 (2001) 092501

Lambda hypernuclei (s-shell) are consistently solved

= Coherent Λ-Σ coupling

T. Harada, S. Shimura, Y. Akaishi & K.S. Myint
Phys. Rev. Lett. 84 (2000) 3539

a significant role in $^6_\Lambda H$

“Hyperheavy hydrogen”

Our Group
Prog. Theor. Phys. Suppl. 146 (2002) 599

More than ten years before the experimental observation

Structure of p-shell hypernuclei, ${}_{\Lambda}^{6}H(0^{+})$ ground state and ${}_{\Lambda}^{6}H(1^{+})$ excited state by using Brueckner-Hartree-Fock method

Spin-isospin weight

Projection operator , $P_{YN}^{+}(S,T)P_{YN}(S,T)$

Λ-channel (I)

$$|I\rangle = \left|{}_{\Lambda}^{6}H\right\rangle_{00} = \sqrt{\frac{1}{2}}\,\Lambda_{\uparrow}^{+}p_{\downarrow}^{+}n_{\uparrow}^{+}n_{\downarrow}^{+}\,\upsilon^{+}|0\rangle - \sqrt{\frac{1}{2}}\,\Lambda_{\downarrow}^{+}p_{\uparrow}^{+}n_{\uparrow}^{+}n_{\downarrow}^{+}\,\upsilon^{+}|0\rangle$$

Σ-channel (II)

$$\upsilon^{+} = \sqrt{\frac{1}{2}}\left\{n_{3/2}^{+}n_{-3/2}^{+} - n_{1/2}^{+}n_{-1/2}^{+}\right\}$$

$$|II\rangle = \left|{}_{\Sigma}^{6}H\right\rangle_{00} = \sqrt{\frac{1}{6}}\Sigma_{\uparrow}^{0+}p_{\downarrow}^{+}n_{\uparrow}^{+}n_{\downarrow}^{+}\,\upsilon^{+}|0\rangle - \sqrt{\frac{1}{6}}\Sigma_{\downarrow}^{0+}p_{\uparrow}^{+}n_{\uparrow}^{+}n_{\downarrow}^{+}\,\upsilon^{+}|0\rangle + \sqrt{\frac{1}{3}}\Sigma_{\uparrow}^{-+}p_{\uparrow}^{+}p_{\downarrow}^{+}n_{\downarrow}^{+}\,\upsilon^{+}|0\rangle - \sqrt{\frac{1}{3}}\Sigma_{\downarrow}^{-+}p_{\uparrow}^{+}p_{\downarrow}^{+}n_{\uparrow}^{+}\upsilon^{+}|0\rangle$$

Spin-isospin weight of YN interactions

$$\langle V_{ij}\rangle = \sum_{i,j}\langle i|P_{ij}^{+}(S,T)\,P_{ij}(S,T)V_{ij}(S,T)\,|j\rangle$$

i, j=I, II

Spin-isospin weights of YN interaction in s-shell

$^{6}_{\Lambda}\mathrm{H}(0^+)$

	S=0,T=1/2	S=0,T=3/2	S=1,T=1/2	S=1,T=3/2
$V_{\Lambda N\text{-}\Lambda N}$	$\frac{3}{2}$	0	$\frac{3}{2}$	0
$V_{\Sigma N\text{-}\Sigma N}$	$\frac{1}{6}$	$\frac{4}{3}$	$\frac{3}{2}$	0
$V_{\Sigma N\text{-}\Lambda N}$	$-\frac{1}{2}$	0	$\frac{3}{2}$	0

$^{6}_{\Lambda}\mathrm{H}(1^+)$

	S=0,T=1/2	S=0,T=3/2	S=1,T=1/2	S=1,T=3/2
$V_{\Lambda N\text{-}\Lambda N}$	$\frac{1}{2}$	0	$\frac{5}{2}$	0
$V_{\Sigma N\text{-}\Sigma N}$	$\frac{1}{2}$	0	$\frac{7}{6}$	$\frac{4}{3}$
$V_{\Sigma N\text{-}\Lambda N}$	$\frac{1}{2}$	0	$\frac{1}{2}$	0

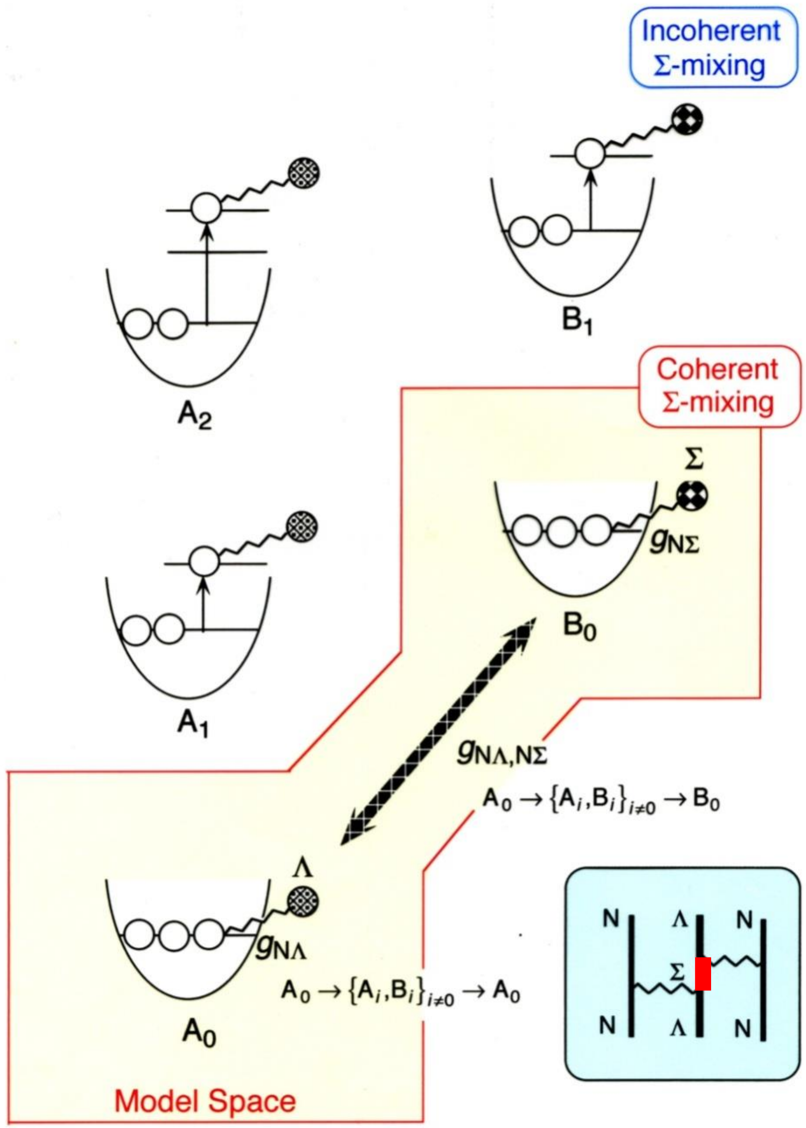
In $_{\Lambda}^{6}\mathrm{H}(0^+)$ state, $V_{\Sigma N\text{-}\Lambda N}$ =3/2 and In $_{\Lambda}^{6}\mathrm{H}(1^+)$ state, $V_{\Sigma N\text{-}\Lambda N}$ =1/2

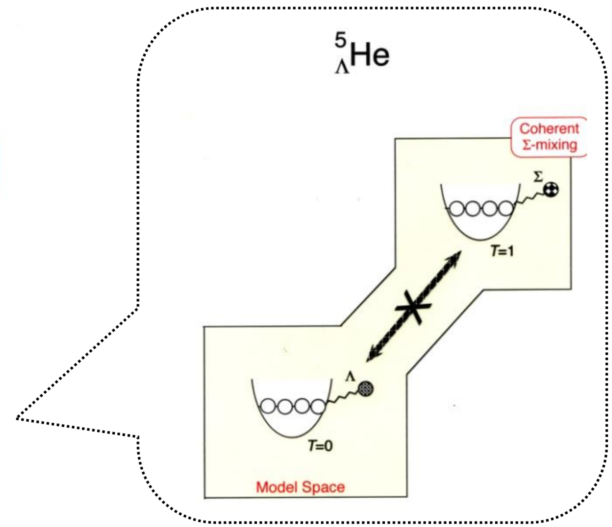
- **Λ-Σ coupling effect in $_{\Lambda}^{6}\mathrm{H}(0^+)$ is about 3^2 times larger than that of $_{\Lambda}^{6}\mathrm{H}(1^+)$ state.**

Spin-isospin weights of YN interaction in p-she

	S=0, T= $\frac{1}{2}$	S=0, T= $\frac{3}{2}$	S=1, T= $\frac{1}{2}$	S=1, T= $\frac{3}{2}$
$V_{\Lambda N\text{-}\Lambda N}$	$\frac{1}{4}$	0	$\frac{3}{4}$	0
$V_{\Sigma N\text{-}\Sigma N}$	$\frac{1}{36}$	$\frac{2}{9}$	$\frac{1}{12}$	$\frac{2}{3}$
$V_{\Sigma N\text{-}\Lambda N}$	$\frac{1}{12}$	0	$\frac{1}{4}$	0

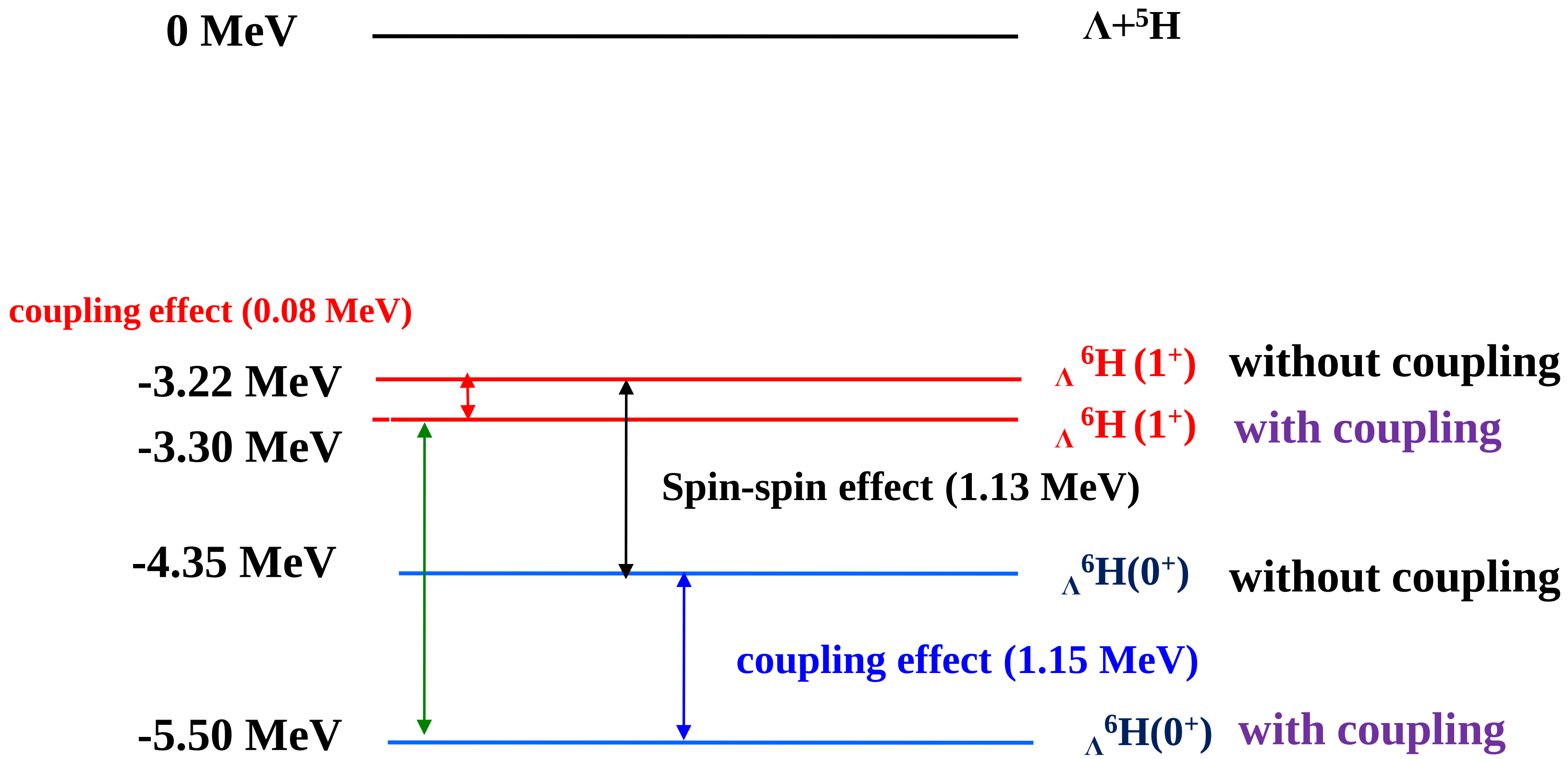
Coherent Λ-Σ coupling





Λ *T*=0 **1116 MeV/c^2**

Σ *T*=1 **1193 MeV/c^2**



Energy levels for $_{\Lambda}^{6}H(0^{+})$ and $_{\Lambda}^{6}H\,(1^{+})$

Level splitting = spin-spin effect +coupling effect

(2.20 MeV) (1.13 MeV) + (1.07 MeV)

The coupling effect is significant in $_{\Lambda}^{6}H$ system.

- **By using Brueckner-Hartree-Fock method with Shinmura's Y-N interactions which are phase shift equivalent potential of Nijmegen model NSC97f(S).**

Evidence for $^{6}_{\Lambda}H$

M. Agnello et al,
Nucl. Phys. A 881(2012) 269

$$v_{t(nn)} = -13.3\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{2.2_{fm}}\right)^2\right\}$$

***E*=- 0.35 MeV**

$$v_{t\Lambda} = -45.4\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{1.53_{fm}}\right)^2\right\}$$

***E*=- 2.4 MeV**

$$v_{(nn)\Lambda} = -11.5\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{1.8_{fm}}\right)^2\right\}$$

$E_{t(nn)\Lambda}$= - 4.54 MeV

$$v_{t(nn)} = -10.5\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{2.2_{fm}}\right)^2\right\}$$

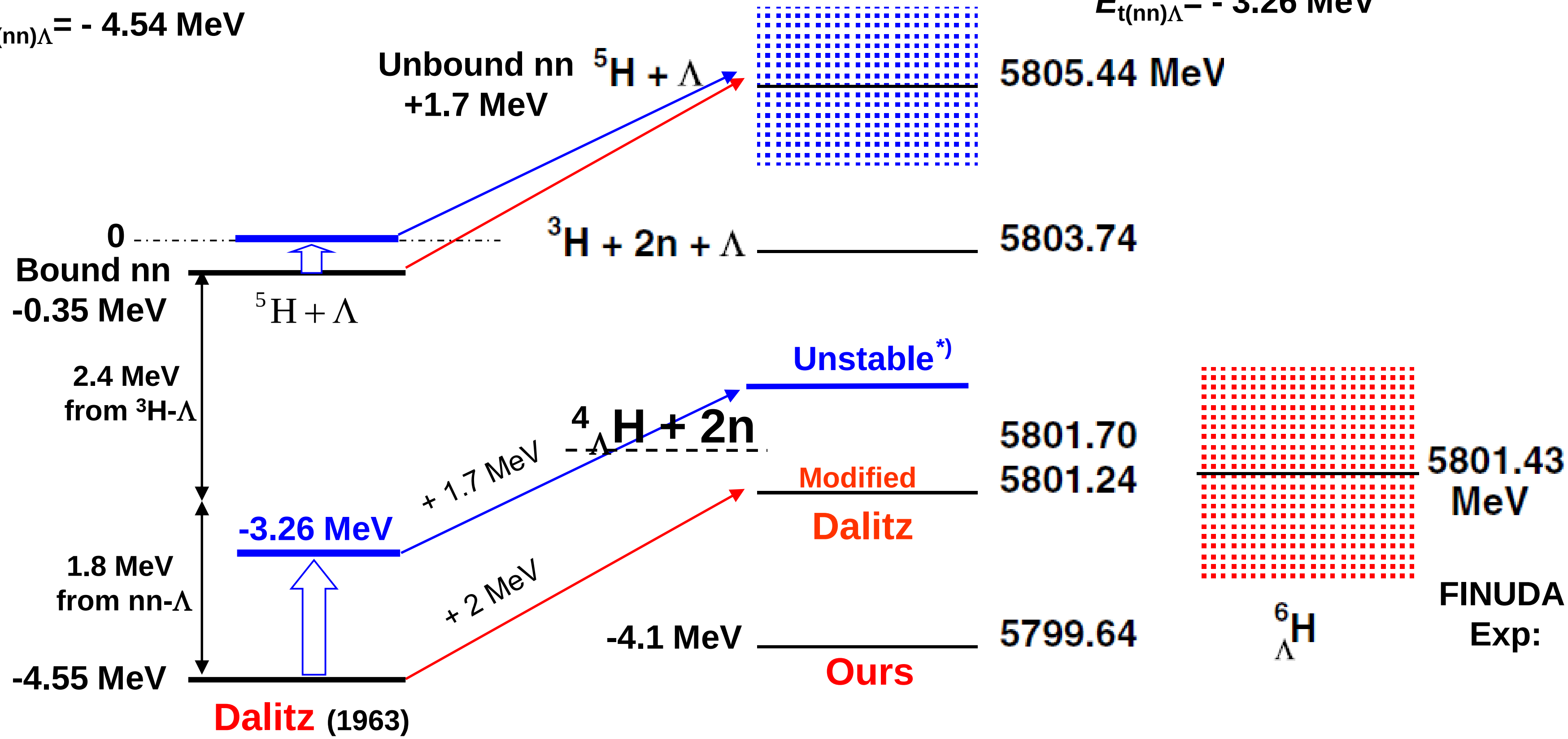
***E*= 0**

$$v_{t\Lambda} = -43.8\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{1.53_{fm}}\right)^2\right\}$$

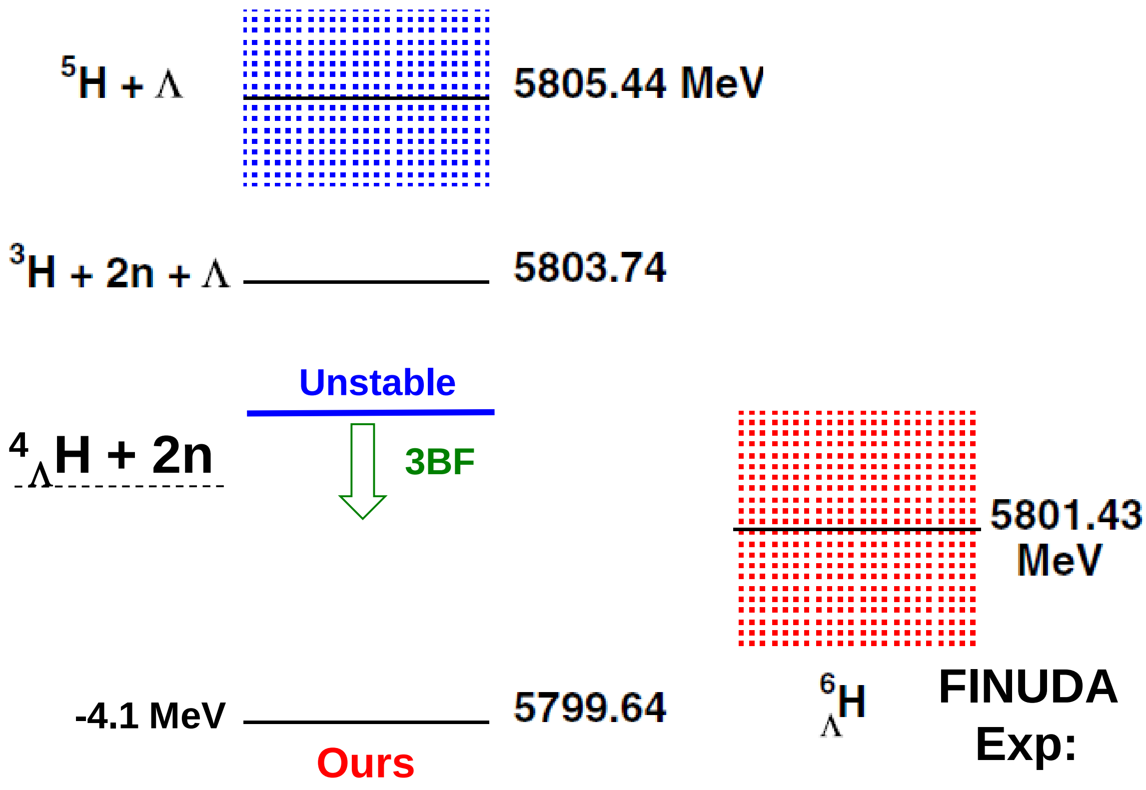
***E*=-2.04 MeV**

$$v_{(nn)\Lambda} = -11.5\,\mathrm{MeV}\exp\left\{-\left(\frac{r}{1.8_{fm}}\right)^2\right\}$$

$E_{t(nn)\Lambda}$= - 3.26 MeV



***)This state comes above the threshold and cannot survive till weak decay.**



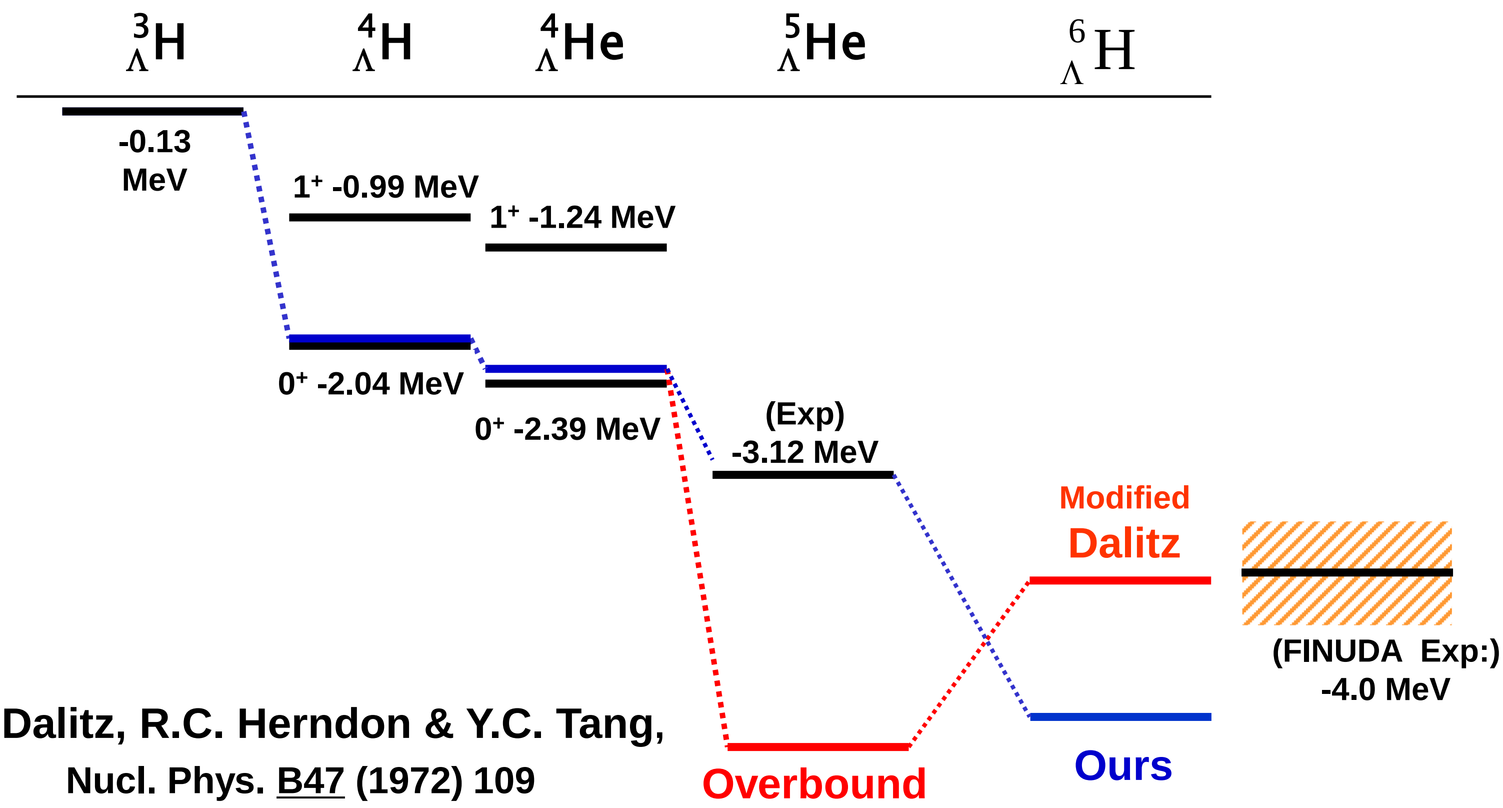
Thus, the coherent Λ-Σ coupling is necessitated.

J-PARC E-10 showed that there is no peak structure corresponding to the $^6_\Lambda$H

$\sigma(^6_\Lambda H)$ =1.2nb/sr at 90% confidence level

H. Sugimura et al., arXiv:1310.6104v1 [nucl-exp] 23 Oct 2013

The overbinding problem



R.H. Dalitz, R.C. Herndon & Y.C. Tang,
Nucl. Phys. B47 (1972) 109

Conclusions

- **Significance of coherent Λ-Σ coupling**
- **Spin-spin is half and Λ-Σ coupling effect is half**
- **More experimental data are awaited**

Thank you very much

K.S. Myint

Y. Akaishi