Study of hypernuclear Charge Symmetry Breaking effects using $\not\pi$EFT

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Charge symmetry breaking

Charge independence :

Invariance under any rotation in isospin space.

$\rightarrow$ Charge Independence Breaking (CIB)

Charge symmetry :

Invariance under a rotation by 180° about y axis in isospin space if the positive z direction is associated with the positive charge.

$\rightarrow$ Charge Symmetry Breaking (CSB)

Nuclear charge symmetry breaking

(Phys. Rev. C 63 (2001) 034005)

***NN* interaction, $I = 1$:**

- ${}^1S_0$ scattering lengths (corrected for e.m. effects)

$$
\begin{aligned}
I_z &= 1 &:\ a^0_{pp} &= -17.3 \pm 0.4 \text{ fm} \\
I_z &= 0 &:\ a^0_{pn} &= -23.71 \pm 0.03 \text{ fm} \\
I_z &= \text{-}1 &:\ a^0_{nn} &= -18.95 \pm 0.4 \text{ fm}
\end{aligned}
$$

Three-body, $I = 1/2$:

- $B({}^3\text{H}; I_z = -1/2) - B({}^3\text{He}; I_z = 1/2) = 764$ keV

  $\rightarrow$ CSB in ${}^3\mathrm{H}$ and ${}^3\mathrm{He}$ nuclei $\Delta^{\mathrm{CSB}}_{{}^3\mathrm{H}-{}^3\mathrm{He}} = 68 \pm 9$ keV

Current understanding :

- difference between the up and down quark masses and electromagnetic interaction among the quarks

  $\rightarrow$ difference between hadrons of the same isospin multiplet

  $\rightarrow$meson mixing $(\rho^0 - \omega)$

  ...

Λ-hypernuclear charge symmetry breaking

(AIP Conf. Proc. 2130 (2019) 030003)

ΛN interaction, $I = 1/2$:

- $S = 0$, $S = 1$ scattering lengths

$$I_z = 1/2 \quad : \quad \Lambda p \quad a^0_{\Lambda p},\ a^1_{\Lambda p} \quad ?$$
$$I_z = \text{-}1/2 \quad : \quad \Lambda n \quad a^0_{\Lambda n},\ a^1_{\Lambda n} \quad ?$$

- on the two-body level mostly Λp experimental information

Hypernuclear CSB (here given only up to $A = 8$) :

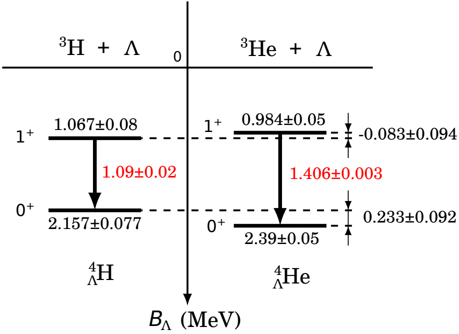
- ${}^4_\Lambda$H - ${}^4_\Lambda$He ($I = 1/2$)
- ${}^7_\Lambda$He - ${}^7_\Lambda$Li*-${}^7_\Lambda$Be ($I = 1$)
- ${}^8_\Lambda$Li - ${}^8_\Lambda$Be ($I = 1/2$)

Why is hypernuclear CSB interesting ?

- underlying mechanism
- neutron-rich hypernuclei Λnn, $\Lambda\Lambda n$, $\Lambda\Lambda nn$, ${}^6_\Lambda$H, ${}^6_\Lambda$He, ${}^7_\Lambda$He, ${}^8_\Lambda$He, ${}^9_\Lambda$He

Charge symmetry breaking in ${}^{4}_{\Lambda}\mathrm{H}/{}^{4}_{\Lambda}\mathrm{He}$

- $B_\Lambda({}^{4}_{\Lambda}\mathrm{H};\,0^+)$ measurement at MAMI
  (Nucl. Phys. A, 954 (2016) 149)
- $B_\Lambda({}^{4}_{\Lambda}\mathrm{He};\,0^+)$ measurement (emulsion)
  (Nucl. Phys. A 754 (2005) 3c)
- $E_\gamma({}^{4}_{\Lambda}\mathrm{H};\,1^+ \rightarrow 0^+)$, $E_\gamma({}^{4}_{\Lambda}\mathrm{He};\,1^+ \rightarrow 0^+)$
  γ-ray energies (J-PARC)
  (Phys. Rev. Lett., 115 (2015) 222501)



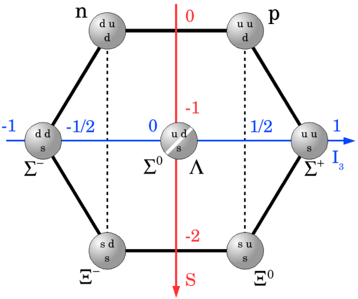
Sizable CSB splitting in 0^+ ground states, while small in 1^+ excited states.

STAR collaboration (Phys. Lett. B 834 (2022) 137449):

$$\Delta B_\Lambda(0^+_{\mathrm{g.s.}}) = -\Delta B_\Lambda(1^+_{\mathrm{exc.}}) = 160 \pm 140(\mathrm{stat}) \pm 100(\mathrm{syst})\ \mathrm{keV}$$

DvH mechanism (R. H. Dalitz and F. von Hippel, Phys. Lett. 10 (1964) 153)

- e.m. mass splitting in the baryon multiplet
- appreciable mixing between the isospin-pure Σ^0 and Λ states

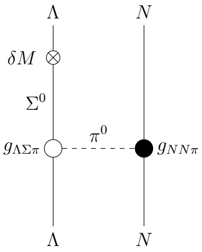


$$\Lambda_{\text{phys}} = \Lambda \cos(\alpha) + \Sigma^0 \sin(\alpha)$$
$$\Sigma^0_{\text{phys}} = -\Lambda \sin(\alpha) + \Sigma^0 \cos(\alpha)$$

$I = 1$ isospin admixture amplitude :

$$\mathcal{A}^{(0)}_{I=1} = \tan(\alpha) = -\frac{\langle \Sigma^0 | \, \delta M \, | \Lambda \rangle}{M_{\Sigma^0} - M_\Lambda} = -0.0148(6)$$

$$< \Sigma^0 | \delta M | \Lambda >= [m_{\Sigma^0} - m_{\Sigma^+} + m_p - m_n] / \sqrt{3}$$



$\rightarrow$ CSB one-pion-exchange $g_{\Lambda\Lambda\pi} = 2\mathcal{A}^{(0)}_{I=1} g_{\Lambda\Sigma\pi}$ (opposite contribution for Λp and Λn)

Theoretical works - DvH mechanism

- **R. H. Dalitz and F. von Hippel** (Phys. Lett. 10 (1964) 153)
  → CSB OPE contribution by allowing $\Lambda - \Sigma^0$ mixing in SU(3)$_f$

$$g_{\Lambda\Lambda\pi} = 2\mathcal{A}^{(0)}_{I=1} g_{\Lambda\Sigma\pi}; \qquad \mathcal{A}^{(0)}_{I=1} = -\frac{\langle \Sigma^0 | \, \delta M \, | \Lambda \rangle}{M_{\Sigma^0} - M_\Lambda} = -0.0148(6)$$

  → $\Delta B_\Lambda(0^+_{\mathrm{g.s.}}) \approx 210 \pm 50$ keV (back then $\mathcal{A}^{(0)}_{I=1} = -0.019 \pm 0.006$)

- **A. Gal** (Phys. Let. B 744 (2015) 352)
  → generalization of DvH

$$\langle N\Lambda | \, V^{CSB}_{\Lambda N} \, | N\Lambda \rangle = -\frac{2}{\sqrt{3}} \mathcal{A}^{(0)}_{I=1} \tau_{N_z} \langle N\Lambda | \, V \, | N\Sigma \rangle$$

  → $\Delta B_\Lambda(0^+_{\mathrm{g.s.}}) \approx 240$ keV $\qquad \Delta B_\Lambda(1^+_{\mathrm{exc.}}) \approx 35$ keV

- **D. Gazda and A. Gal**
  (Phys. Rev. Lett. 116 (2016) 122501; Nucl. Phys. A 954 (2016) 161)
  → generalized DvH; LO χEFT *YN* interaction; NSCM

  → $\Delta B_\Lambda(0^+_{\mathrm{g.s.}}) \approx 180 \pm 130$ keV $\qquad \Delta B_\Lambda(1^+_{\mathrm{exc.}}) \approx -200 \pm 30$ keV

Theoretical works - χEFT J. Haidenbauer et al., Few-Body Syst. 62 (2021) 105

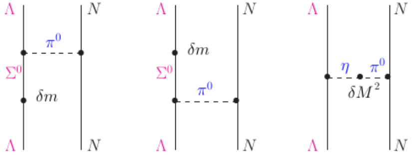


Fig. 1 CSB contributions involving pion exchange, according to Dalitz and von Hippel [1], due to $\Lambda - \Sigma^0$ mixing (left two diagrams) and $\pi^0 - \eta$ mixing (right diagram).

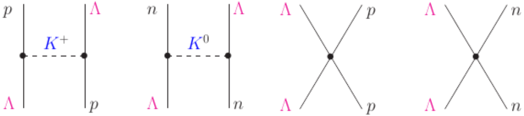
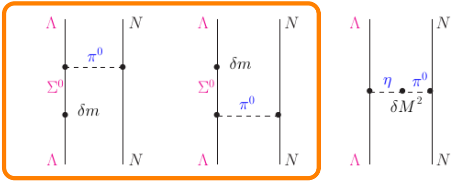


Fig. 2 CSB contributions from $K^\pm/K^0$ exchange (left) and from contact terms (right).

Contact terms fitted to experimental CSB in ${}^4_\Lambda$He and ${}^4_\Lambda$H.

$\Delta B_\Lambda(0^+_{\rm g.s.}) = 233 \pm 92$ keV $\qquad \Delta B_\Lambda(1^+_{\rm exc.}) = -83 \pm 94$ keV

Theoretical works - χEFT J. Haidenbauer et al., Few-Body Syst. 62 (2021) 105



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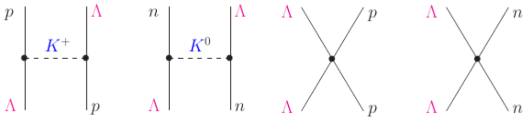

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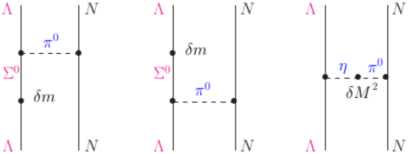

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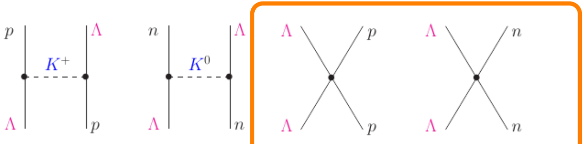

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Theoretical works - χEFT J. Haidenbauer et al., Few-Body Syst. 62 (2021) 105

Table 2 Comparison of different CSB scenarios, based on the YN interactions NLO13 and NLO19 with cutoff $\Lambda = 600$ MeV

	$a_s^{\Lambda p}$	$a_t^{\Lambda p}$	$a_s^{\Lambda n}$	$a_t^{\Lambda n}$	$\chi^2(\Lambda p)$	$\chi^2(\Sigma N)$	χ^2(total)	$\Delta E(0^+)$	$\Delta E(1^+)$
NLO13	− 2.906	− 1.541	− 2.907	− 1.517	4.47	12.34	16.81	58	24
CSB-OBE	− 2.881	− 1.547	− 2.933	− 1.513	4.39	12.43	16.83	57	20
CSB1	− 2.588	− 1.573	− 3.291	− 1.487	3.43	12.38	15.81	256	− 53
CSB2	− 3.983	− 1.281	− 2.814	− 0.948	4.51	12.31	16.82	299	161
CSB3	− 2.792	− 1.666	− 3.027	− 1.407	9.52	12.41	21.93	370	56
NLO19	− 2.906	− 1.423	− 2.907	− 1.409	3.58	12.70	16.28	34	10
CSB-OBE	− 2.877	− 1.415	− 2.937	− 1.419	3.30	13.01	16.31	− 6	− 7
CSB1	− 2.632	− 1.473	− 3.227	− 1.362	3.45	12.68	16.13	243	− 67
CSB2	− 3.618	− 1.339	− 3.013	− 1.117	4.02	12.09	16.12	218	129
CSB3	− 2.758	− 1.546	− 3.066	− 1.300	7.49	12.64	20.14	359	45

Results are shown for the original NLO interactions, with addition of OBE contribution to CSB, and for the scenarios CSB1, CSB2, CSB3 with added CSB contact terms. CSB1 corresponds to the present experimental status. Note that the χ^2 for the NLO interactions differs slightly from the ones given in Refs. [20,21] because there the small differences between Λp and Λn have not been taken into account. Small deviations of the CSB from values of the three scenarios are due to using perturbation theory for fitting and using a smaller number of partial waves for fitting

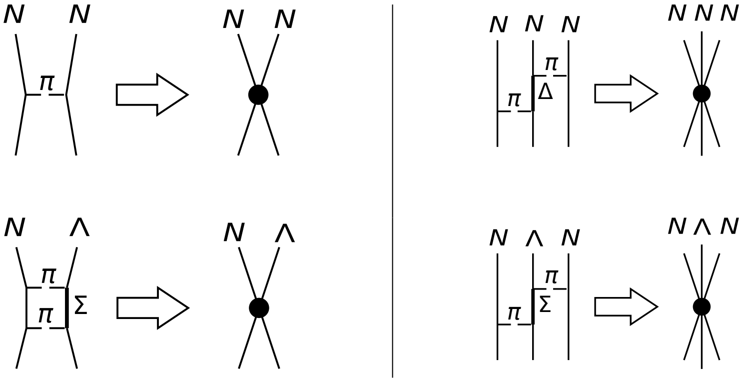
Theoretical works - χEFT H. Le et al., Phys. Rev. C 107 (2023) 024002

TABLE IV. Contributions to CSB in the $A = 7$ and 8 isospin multiplets, based on the YN potentials NLO13(500) and NLO19(500) (including 3N forces and SRG-induced YNN interactions). The results are for the original potentials (without CSB force) and for the scenario CSB1, see text. Results by Gal [37] and by Hiyama *et al.* [13] are included for the ease of comparison. All energies are in keV. The estimated uncertainties for $A = 7$ and 8 systems are 30 and 50 keV, respectively.

		ΔT	ΔV_{NN}	ΔV_{YN}			ΔB_Λ
				$^1S_0$	$^3S_1$	Total	
$^7_\Lambda$Be - $^7_\Lambda$Li*	NLO13	7	−24	−1	0	0	−17
	NLO13-CSB	8	−24	−49	26	−24	−40
	NLO19	6	−40	−1	0	0	−34
	NLO19-CSB	6	−41	−43	42	9	−35
	Hiyama [13]		−70			200	150
	Gal [37]	3	−70			50	−17
	Experiment [6]						−100 ± 90
$^7_\Lambda$Li* - $^7_\Lambda$He	NLO13	8	−13	0	0	0	−5
	NLO13-CSB	7	−14	−49	26	−24	−31
	NLO19	5	−22	−43	42	0	−17
	NLO19-CSB	5	−21	−38	37	−1	−16
	Hiyama [13]		−80			200	130
	Gal [38]	2	−80			50	−28
	Experiment [6]						−20 ± 230[a]
							−50 ± 190
$^8_\Lambda$Be - $^8_\Lambda$Li	NLO13	12	8	−2	0	−4	16
	NLO13-CSB	12	7	100	56	159	178
	NLO19	7	−11	−1	0	−2	−6
	NLO19-CSB	6	−11	62	79	147	143
	Hiyama [13]		40				160
	Gal [37]	11	−81			119	49
	Experiment [4]						40 ± 60

[a]The difference between $B_\Lambda(^7_\Lambda\text{Li}^*)$ and $B_\Lambda(^7_\Lambda\text{He})$ is −20 ± 230 keV for the FINUDA and JLab results, but −50 ± 190 keV when the revised SKS and JLab results are used [6].

$\not{\pi}$EFT



Hypernuclear CSB within $\not{\pi}$EFT (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

Charge Symmetric (CS) LO $\not{\pi}$EFT

Nuclear :

$$V_{NN} = \sum_{S} C^{S}_{NN}(\lambda)\mathcal{P}^{S} e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}$$

$$V_{NNN} = D^{1/2\ 1/2}_{\lambda}\mathcal{Q}^{1/2\ 1/2}\sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

Hypernuclear :

$$V_{\Lambda N} = \sum_{S} C^{S}_{\Lambda N}(\lambda)\mathcal{P}^{S} e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}$$

$$V_{\Lambda NN} = \sum_{IS} D^{IS}_{\Lambda NN}(\lambda)\mathcal{Q}^{IS}\sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

Fitted to explicit CS input :

- $\rightarrow B(^{2}\mathrm{H})$
- $\rightarrow a^{0}_{nn/pp} = -18.13$ fm
- $\rightarrow$ several sets of $(a^{0}_{\Lambda N};\ a^{1}_{\Lambda N})$

- $\rightarrow B_{\Lambda}(^{3}_{\Lambda}\mathrm{H})$
- $\rightarrow$ CS average $B(^{3}\mathrm{H}/^{3}\mathrm{He})$
- $\rightarrow$ CS average $B_{\Lambda}(^{4}_{\Lambda}\mathrm{H}/^{4}_{\Lambda}\mathrm{He})$

Hypernuclear CSB within $\not\pi$EFT (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

Charge Symmetric (CS) LO $\not\pi$EFT

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$$V_{NNN} = D^{1/2\ 1/2}_\lambda \mathcal{Q}^{1/2\ 1/2} \sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

Hypernuclear :

$$V_{\Lambda N} = \sum_S C^S_{\Lambda N}(\lambda)\mathcal{P}^S e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}$$

$$V_{\Lambda NN} = \sum_{IS} D^{IS}_{\Lambda NN}(\lambda)\mathcal{Q}^{IS} \sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

CSB in NN interaction (spin singlet)

$$C^{S=0}_{NN}\mathcal{P}^{S=0} \to (C^{S=0}_{pp}\mathcal{P}^{pp} + C^{S=0}_{pn}\mathcal{P}^{pn} + C^{S=0}_{nn}\mathcal{P}^{nn})\mathcal{P}^{S=0}$$

$$C^{S=0}_{NN} = \frac{1}{2}(C^{S=0}_{pp} + C^{S=0}_{nn}), \qquad \delta C^{S=0}_{NN} = \frac{1}{2}(C^{S=0}_{pp} - C^{S=0}_{nn})$$

$$V_{NN} = \overbrace{\sum_S C^S_{NN}(\lambda)\mathcal{P}^S e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}}^{\text{part of LO CS }\not\pi\text{EFT}} + \overbrace{\delta C^{S=0}_{NN}(\lambda)\mathcal{P}^{S=0}\left(\mathcal{P}^{pp} - \mathcal{P}^{nn}\right) e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}}^{\text{perturbative CSB}}$$

Nuclear CSB within $\not\pi$EFT (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

$$\delta C_{NN}^{S=0}(\lambda)$$

$$\downarrow$$

Fit to $\Delta^{CSB}_{^3\mathrm{H}-^3\mathrm{He}} = 68 \pm 9$ keV

$$\downarrow$$

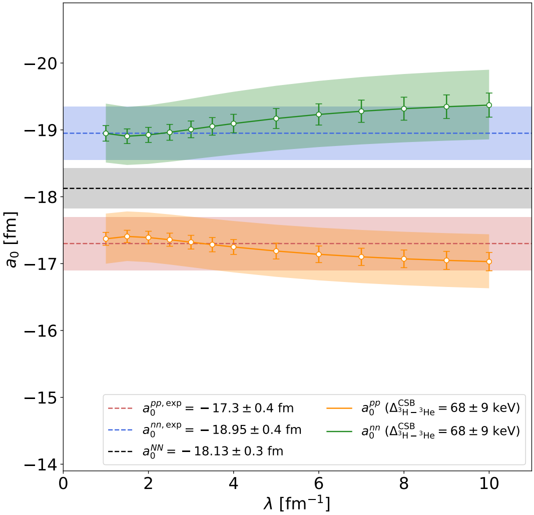
CSB + DWBA
$(a^0_{pp/nn} = -18.13 \pm 0.3$ fm$)$

$$\downarrow$$

a^0_{pp} and a^0_{nn} scattering lengths

$$\updownarrow$$

$a^0_{nn} = -18.95 \pm 0.4$ fm
$a^0_{pp} = -17.3 \pm 0.4$ fm



Hypernuclear CSB within $\not\pi$EFT (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

Charge Symmetric (CS) LO $\not\pi$EFT

Nuclear :

$$V_{NN} = \sum_S C^S_{NN}(\lambda)\mathcal{P}^S e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}$$

$$V_{NNN} = D_\lambda^{1/2\ 1/2}\mathcal{Q}^{1/2\ 1/2}\sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

Hypernuclear :

$$V_{\Lambda N} = \sum_S C^S_{\Lambda N}(\lambda)\mathcal{P}^S e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}$$

$$V_{\Lambda NN} = \sum_{IS} D^{IS}_{\Lambda NN}(\lambda)\mathcal{Q}^{IS}\sum_{\mathrm{cyc}} e^{-\frac{\lambda^2}{4}(\mathbf{r}^2_{12}+\mathbf{r}^2_{23})}$$

CSB in ΛN interaction

$$C^S_{\Lambda N}\mathcal{P}^S \to (C^S_{\Lambda p}\frac{1+\tau_{Nz}}{2} + C^S_{\Lambda n}\frac{1-\tau_{Nz}}{2})\mathcal{P}^S$$

$$C^S_{\Lambda N} = \frac{1}{2}(C^S_{\Lambda p} + C^S_{\Lambda n}), \qquad \delta C^S_{\Lambda N} = \frac{1}{2}(C^S_{\Lambda p} - C^S_{\Lambda n})$$

$$\mathrm{V}_{\Lambda N} = \overbrace{\sum_S C^S_{\Lambda N}(\lambda)\mathcal{P}^S e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}}^{\text{part of LO CS } \not\pi\text{EFT}} + \overbrace{\sum_S \delta C^S_{\Lambda N}(\lambda)\mathcal{P}^S \tau_{N_z} e^{-\frac{\lambda^2}{4}\mathbf{r}^2_{12}}}^{\text{perturbative CSB}}$$

Fitting CSB LECs (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

→ perturbatively
→ two experimental constraints ($^4_\Lambda$He and $^4_\Lambda$H)

$$\Delta B_\Lambda(0^+_{\mathrm{g.s.}}) = 233 \pm 92 \text{ keV} \qquad \Delta B_\Lambda(1^+_{\mathrm{exc.}}) = -83 \pm 94 \text{ keV}$$

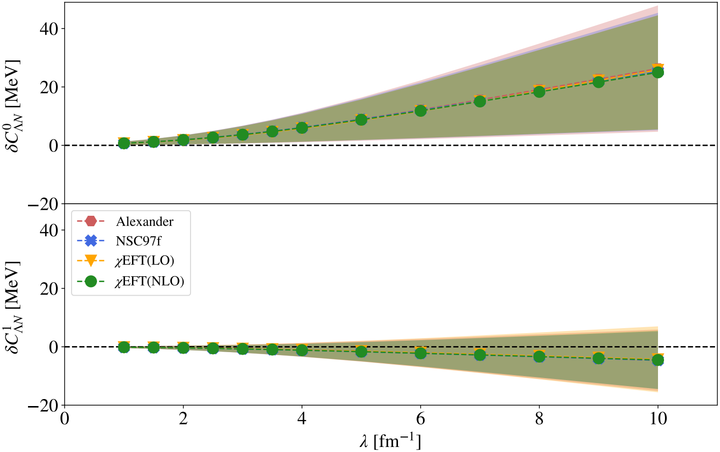
System of two linear equation for $\delta C^0_{\Lambda N}$ and $\delta C^1_{\Lambda N}$:

$$2\,\delta C^0_{\Lambda N}\,\Delta V^0_{\Lambda N;\,0^+} + 2\,\delta C^1_{\Lambda N}\,\Delta V^1_{\Lambda N;\,0^+} = \Delta B_\Lambda(0^+_{\mathrm{g.s.}})$$
$$2\,\delta C^0_{\Lambda N}\,\Delta V^0_{\Lambda N;\,1^+} + 2\,\delta C^1_{\Lambda N}\,\Delta V^1_{\Lambda N;\,1^+} = \Delta B_\Lambda(1^+_{\mathrm{exc.}})$$

where

$$\Delta V^S_{\Lambda N;\,J^\pi} = \underbrace{\langle {}^4_\Lambda\mathrm{H};\,J^\pi | \tau_{Nz}\mathcal{P}_S\delta_\lambda(\boldsymbol{r}_{\Lambda N}) | {}^4_\Lambda\mathrm{H};\,J^\pi \rangle}_{\text{CS LO }\pi\!\!\!/\text{EFT wave function}}$$

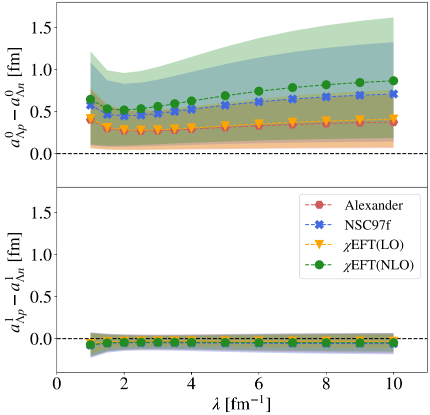
Fitting CSB LECs (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

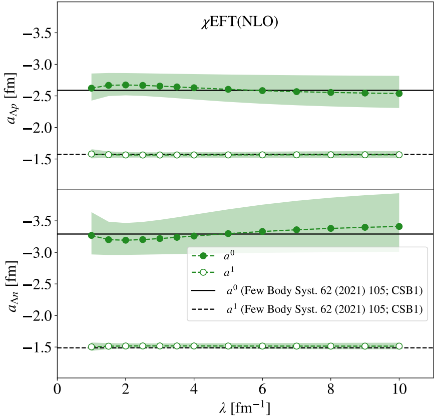


$|\delta C^1_{\Lambda N}| < |\delta C^0_{\Lambda N}|$;   predominantly opposite sign

Λp and Λn scattering lengths (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

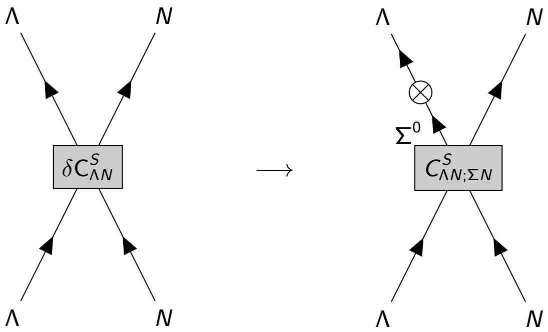
→ CSB propagated into ΛN scattering length (perturbatively; DWBA)





$S = 0$: Stronger Λn and weaker Λp interaction
$S = 1$: Hardly affected; mostly stronger Λp and weaker Λn interaction

In-medium Λ isospin impurity (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)



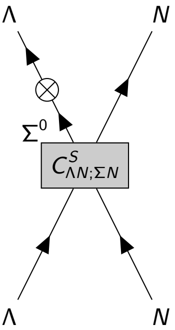
In-medium Λ isospin impurity (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

DvH ansatz :
(A. Gal, Phys. Lett. B 744 (2015) 352)

$$\langle \Lambda N | V_{\rm CSB} | \Lambda N \rangle = -\frac{2}{\sqrt{3}}\, \mathcal{A}^{(0)}_{I=1}\, \langle \Sigma N | V_{\rm CS} | \Lambda N \rangle\, \tau_{Nz}$$

$$\downarrow$$

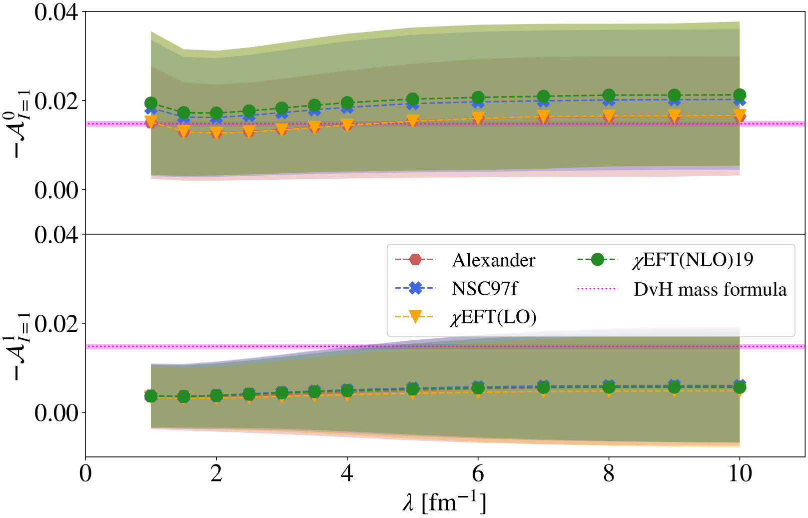
$$\delta C^{S}_{\Lambda N} = -\frac{2}{\sqrt{3}}\, \mathcal{A}^{S}_{I=1}\, C^{S}_{\Lambda N;\Sigma N}$$



SU(3)$_f$ symmetry:
(C.B. Dover, H. Feshbach, Ann. Phys. (NY) 198 (1990) 321)

$$\left.\begin{array}{l} C^{0}_{\Lambda N,\Sigma N} = -3(C^{0}_{NN} - C^{0}_{\Lambda N}) \\ C^{1}_{\Lambda N,\Sigma N} = (C^{1}_{NN} - C^{1}_{\Lambda N}) \end{array}\right\} \longrightarrow \begin{array}{l} -\mathcal{A}^{0}_{I=1} = (\sqrt{3}/2)\delta C^{0}_{\Lambda N}/[-3(C^{0}_{NN} - C^{0}_{\Lambda N})] \\ -\mathcal{A}^{1}_{I=1} = (\sqrt{3}/2)\delta C^{1}_{\Lambda N}/[(C^{1}_{NN} - C^{1}_{\Lambda N})] \end{array}$$

In-medium Λ isospin impurity (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)



In-medium Λ isospin impurity (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)

→ considering more precise $\Delta E_\gamma = 316 \pm 20$ keV

Relation between CSB LECs and ΔE_γ :

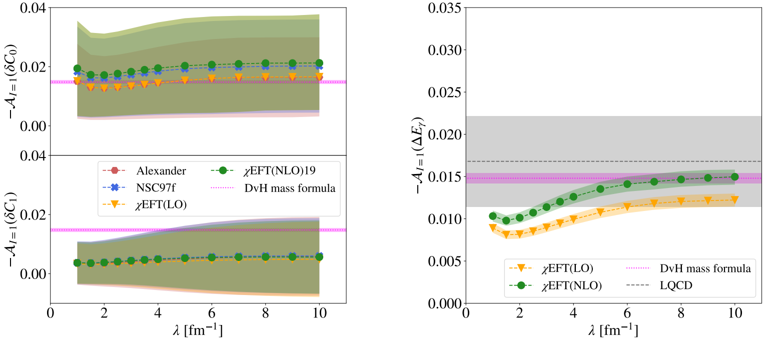
$$2\ \delta C^0_{\Lambda N}\left[\Delta V^0_{\Lambda N;\ 0^+} - \Delta V^0_{\Lambda N;\ 1^+}\right] + 2\ \delta C^1_{\Lambda N}\left[\Delta V^1_{\Lambda N;\ 0^+} - \Delta V^1_{\Lambda N;\ 1^+}\right] = \Delta E_\gamma$$

→ assuming DvH ansatz, SU(3)$_f$ symmetry, and $\mathcal{A}^0_{I=1} = \mathcal{A}^1_{I=1}$

Relation between $I = 1$ admixture amplitude and ΔE_γ :

$$-\mathcal{A}_{I=1} = \frac{\sqrt{3}}{2}\Delta E_\gamma\left(-6(C^0_{NN} - C^0_{\Lambda N})[\Delta V^0_{\Lambda N;\ 0^+} - \Delta V^0_{\Lambda N;\ 1^+}]\right.$$
$$\left.+2\ (C^1_{NN} - C^1_{\Lambda N})[\Delta V^1_{\Lambda N;\ 0^+} - \Delta V^1_{\Lambda N;\ 1^+}]\right)^{-1}$$

In-medium Λ isospin impurity (Schäfer, Barnea, Gal, Phys. Rev. C 106 (2022) L031001)



Method/Input	B	$-\mathcal{A}_{I=1}$
SU(3)$_f$ (Phys. Lett 10 (1964) 153)	1	0.0148 ± 0.0006
LQCD (Phys. Rev. D 101 (2020) 034517)	1	0.0168 ± 0.0054
$\not\pi$EFT (LO)/[χEFT(LO); $\Lambda \to \infty$]	4	0.0139 ± 0.0013
$\not\pi$EFT (LO)/[χEFT(NLO); $\Lambda \to \infty$]	4	0.0168 ± 0.0014

Summary

- DvH mechanism; EFT-based approach using CSB contact terms
- perturbative inclusion of CSB in LO $\not\pi$EFT (fitted to CSB in ${}^{4}_{\Lambda}\mathrm{H}/{}^{4}_{\Lambda}\mathrm{He}$)
- microscopic calculations of CSB in A=4, 7, 8 hypernuclei
- Spin-singlet : Stronger Λn and weaker Λp interaction
  Spin-triplet : Hardly affected; mostly stronger Λp and weaker Λn

LO $\not\pi$EFT - assumtion of DvH ansatz and SU(3)$_f$ symmetry

- extraction of in-medium Λ isospin impurity $\mathcal{A}_{I=1}$; all cases in agreement with free-space LQCD prediction and in most cases with free-space DvH value
- using $\mathcal{A}^{(0)}_{I=1}$ DvH value the procedure can be applied in reverse thus predicting experimental CSB in ${}^{4}_{\Lambda}\mathrm{H}/{}^{4}_{\Lambda}\mathrm{He}$