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Uncertainties of single-β-decay matrix elements within an effective field theory for spherical collective nuclei

Eduardo Antonio Coello Pérez

Outline

EFT for spherical even-even nuclei

- Effective Hamiltonian and power counting
- E2 properties at LO

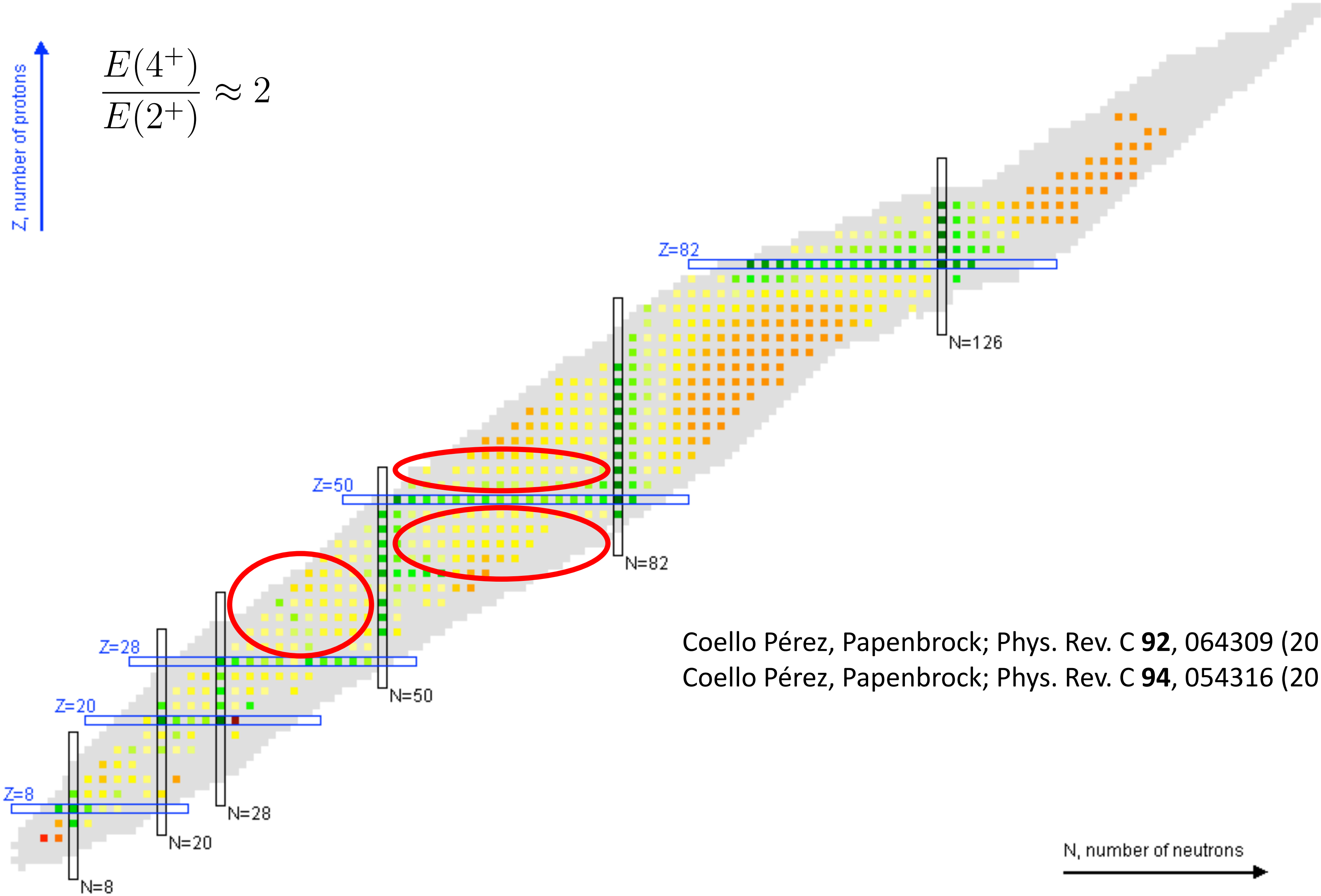
Odd-mass nuclei within the EFT

- Power counting for fermion operators
- Spectra at NNLO
- E2 and M1 properties at LO

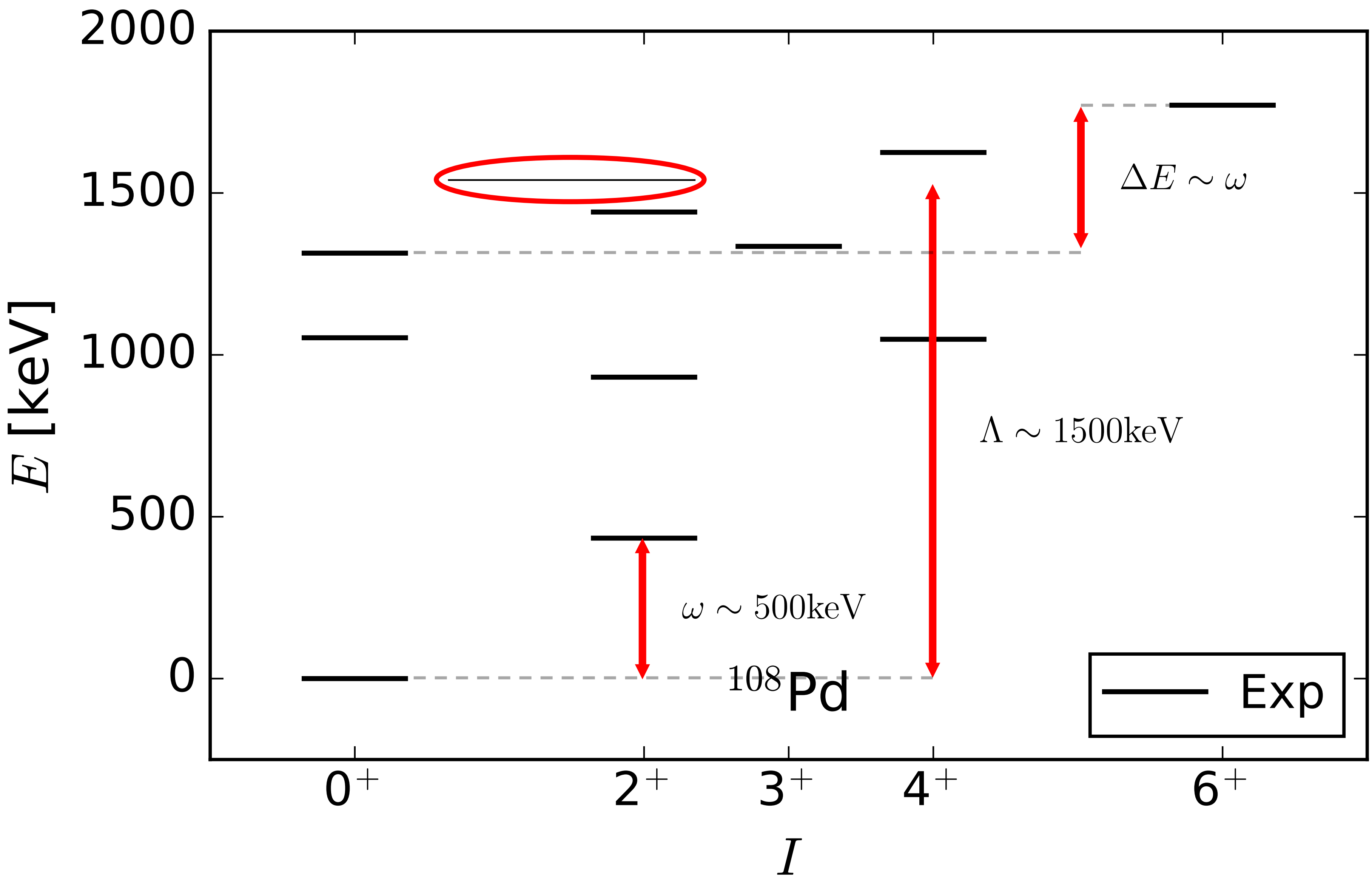
β decays from odd-odd nuclei

- Low-lying odd-odd states within the EFT
- β operator for Gamow-Teller transitions
- Sizes of the matrix elements from the power counting
- Uncertainty estimates

$$\frac{E(4^+)}{E(2^+)} \approx 2$$



Coello Pérez, Papenbrock; Phys. Rev. C **92**, 064309 (2015)
Coello Pérez, Papenbrock; Phys. Rev. C **94**, 054316 (2016)


2000
1500
1000
500
0
E [keV]
$\Delta E \sim \omega$
$\Lambda \sim 1500\mathrm{keV}$
$\omega \sim 500\mathrm{keV}$
^{108}Pd
Exp
0^+
2^+
3^+
4^+
6^+
I

Boson quadrupole operators

Hamiltonian in terms of boson quadrupole operators

$$\left[d_\mu, d^\dagger_\nu\right] = \delta_{\mu\nu}\,,$$

$$d^\dagger_\mu \quad \text{and} \quad \tilde{d}_\mu = (-1)^\mu d_{-\mu}$$

rank-two tensors

Most simple rotational-invariant Hamiltonian

$$H_{\rm LO} \equiv \omega_1 \hat{N}\,,$$

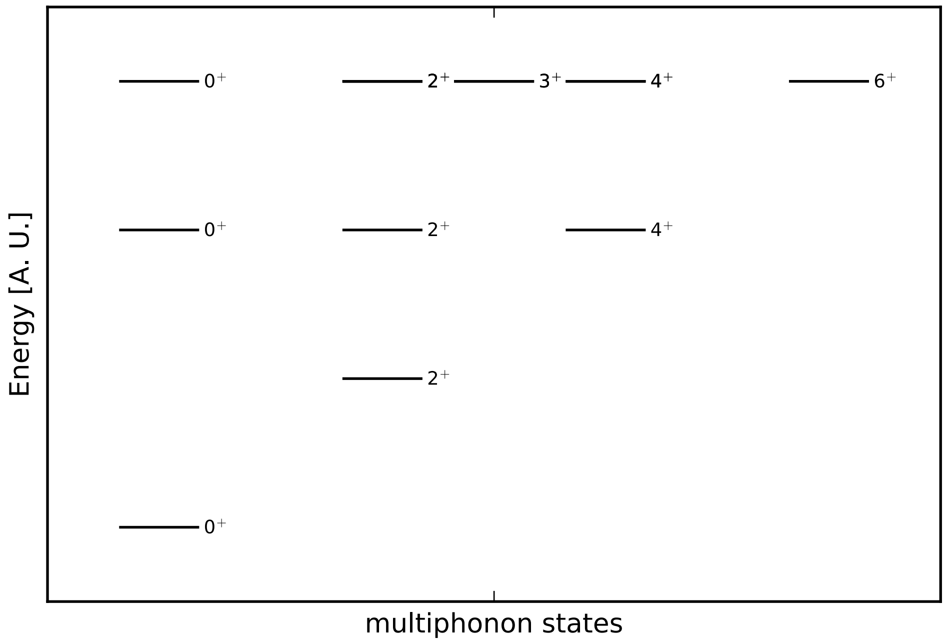
$$\hat{N} \equiv d^\dagger \cdot \tilde{d}$$

$$\omega_1 \sim \omega$$

The states are constructed as phonon excitations of the even-even ground state

$$\left(d^{\dagger n}\right)^{(I)}_M |0\rangle$$

Spectrum up to three-phonon excitations



Coello Pérez, Papenbrock; Phys. Rev. C **92**, 064309 (2015)

Power counting for the boson operators

At low energy scales and the breakdown scale the LO Hamiltonian scales as

$$H_{\mathrm{LO}} \sim N\omega$$

and

$$H_{\mathrm{LO}} \sim \Lambda$$

The boson DOF scale as

$$d \sim \sqrt{N}$$

and

$$d \sim \sqrt{\frac{\Lambda}{\omega}}$$

Example: A term with four boson operators shift the energies by ω at breakdown. Thus

$$C_2 d^4 \sim \omega \quad \text{or} \quad C_2 \sim \left(\frac{\omega}{\Lambda}\right)^2 \omega$$

At low energies

$$C_2 d^4 \sim \left(\frac{N\omega}{\Lambda}\right)^2$$

NNLO Hamiltonian

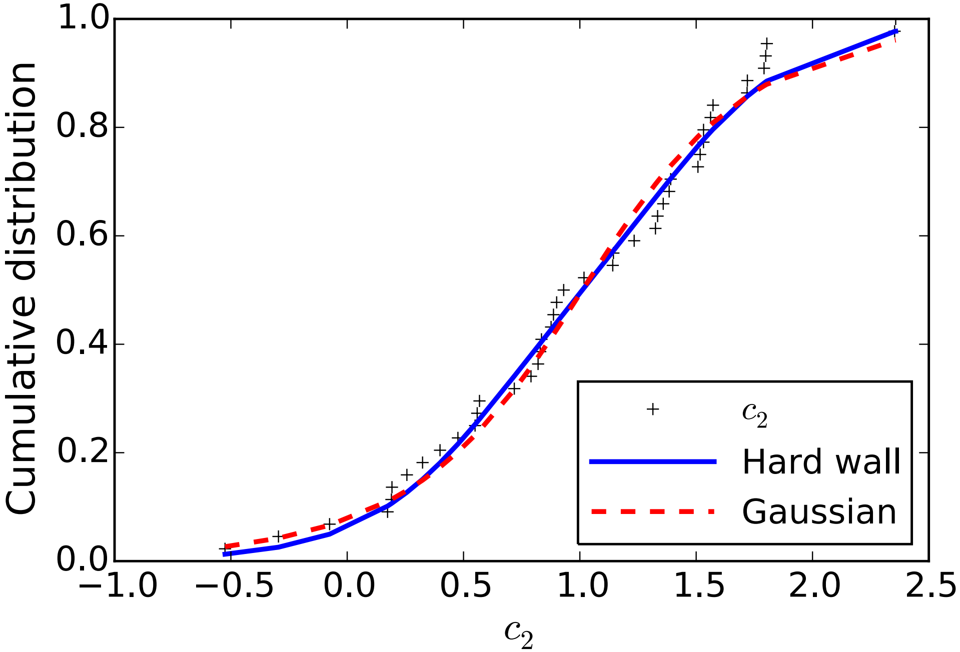
$$H_{\mathrm{NNLO}} \equiv g_N \hat{N}^2 + g_v \hat{\Lambda}^2 + g_J \hat{J}^2$$

With

$$\hat{\Lambda}^2 \equiv -\left(d^\dagger \cdot d^\dagger\right)\left(\tilde{d} \cdot \tilde{d}\right) + \hat{N}^2 - 3\hat{N},$$

$$\hat{\mathbf{J}} = \sqrt{10}\left(d^\dagger \otimes \tilde{d}\right)^{(1)}$$

Cumulative distribution for the c_2 coefficient



Observables (energy as an example)

$$E = \omega \sum_{n}^{\infty} c_n \varepsilon^n ,$$

$$\varepsilon \equiv \frac{N\omega}{\Lambda}$$

Expansion coefficients of order one

Assumption encoded into priors*

$$\mathrm{pr}^{(\mathrm{G})}(\tilde{c}_i|c) = \frac{1}{\sqrt{2\pi} s c} e^{-\frac{\tilde{c}_i^2}{2s^2c^2}}$$

$$\mathrm{pr}(c) = \frac{1}{\sqrt{2\pi}\sigma c} e^{-\frac{\log^2 c}{2\sigma^2}}$$

*Cacciari, Houdeau; Nucl. J. High Energy Phys. **09** (2011) 039

*Furnstahl, et al.; J. Phys. G **42**, 034028 (2015)

Most general rank-two tensor

$$\hat{Q} = Q_0 \left(d^\dagger + \tilde{d} \right) + Q_1 \left(d^\dagger \otimes \tilde{d} \right)^{(2)}$$

From the power counting

$$Q_1 \sim \sqrt{\frac{\omega}{\Lambda}} Q_0$$

LO term:

•One LEC

•Phonon-annihilating transition strengths

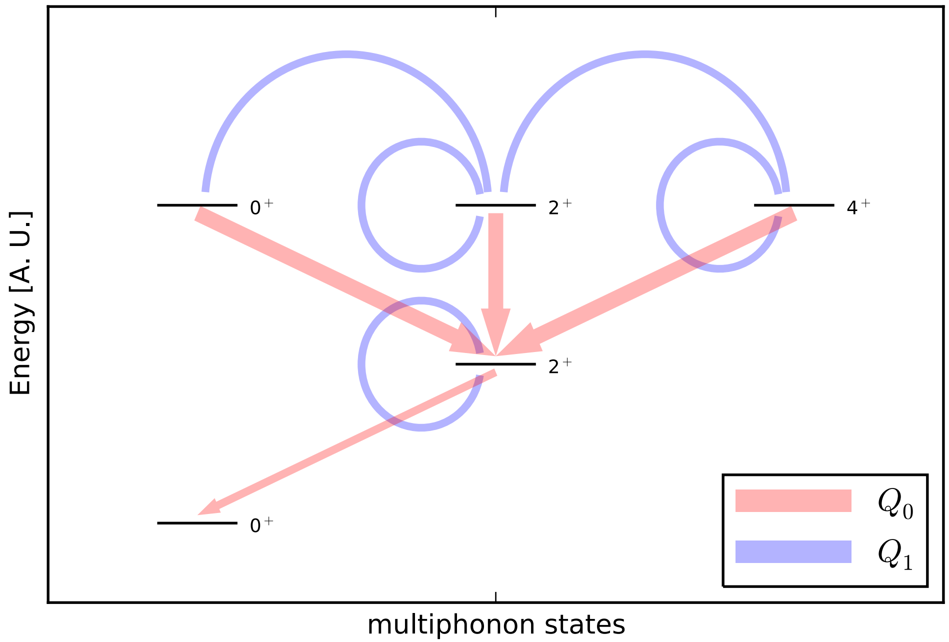
NLO term:

•One LEC

•Phonon-conserving transition strengths

•Static E2 moments

States coupled by the E2 operator



LO matrix elements for phonon-annihilating E2 transitions in [W. u.]

Nucleus	$\lvert Q_0 \rvert$	$\lvert\langle 0_1 \lvert\lvert \hat{Q} \rvert\rvert 2_1 \rangle\rvert$		$\lvert\langle 2_1 \lvert\lvert \hat{Q} \rvert\rvert 0_2 \rangle\rvert$		$\lvert\langle 2_1 \lvert\lvert \hat{Q} \rvert\rvert 2_2 \rangle\rvert$		$\lvert\langle 2_1 \lvert\lvert \hat{Q} \rvert\rvert 4_1 \rangle\rvert$	
^{62}Ni	3.4(11)	7.8	7.5(25)		4.8(16)	8.6(2)	10.7(36)	13.7(2)	14.3(48)
^{64}Ni	3.4(11)	6.2	7.6(25)	3.3(9)	4.8(16)		10.7(36)	7.8(1)	14.3(48)
^{66}Zn	4.3(14)	9.3	9.6(32)		6.0(20)	12.8(5)	13.5(45)	12.7(1)	18.1(60)
^{68}Zn	3.9(13)	8.6	8.7(29)	2.3(2)	5.5(18)	12.0(1)	12.3(41)	9.9(1)	16.5(55)
^{70}Ge	4.5(15)	10.2	10.0(33)	6.9(5)	6.3(21)	17.9(3)	14.2(47)	15.0	19.0(63)
^{78}Se	6.2(21)	12.9	13.9(46)	1.1(1)	8.8(29)	10.5(1)	19.7(66)	21.1(1)	26.5(88)
^{80}Se	5.3(17)	11.1	11.8(39)	2.6(2)	7.4(25)	9.6	16.6(55)	17.8	22.3(74)
^{78}Kr	7.2(24)	18.4(1)	16.0(53)	6.9(3)	10.1(34)	5.3(2)	22.7(76)	28.1(1)	30.4(101)
^{80}Kr	5.8(19)	13.7(1)	12.9(43)		8.1(27)	11.2(2)	18.2(61)	25.1(2)	24.4(81)
^{82}Kr	4.1(14)	10.3	9.2(31)	3.9(6)	5.8(19)		13.0(43)	17.0(3)	17.5(58)

LEC fitted to even-even and odd-mass nuclei E2 transitions strengths

LO E2 moments

From the power counting

$$Q_1 \sim \sqrt{\frac{\omega}{\Lambda}} Q_0$$

Uncertainty due to LEC

$$B \sim A \quad \Rightarrow \quad B \in \left[A\sqrt{\frac{\omega}{\Lambda}}, A\sqrt{\frac{\Lambda}{\omega}} \right]$$

LO E2 static moments for even-even first excited states in [eb]

Nucleus	$\|Q_1\|$	$\|Q(2_1)\|$	
^{62}Ni	$0.071(^{+52}_{-30})$	$0.050(120)$	$0.121(^{+88}_{-51})$
^{64}Ni	$0.055(^{+40}_{-23})$	$0.400(200)$	$0.093(^{+68}_{-39})$
^{64}Zn	$0.082(^{+60}_{-35})$	$0.140(20)$	$0.139(^{+102}_{-59})$
^{66}Zn	$0.089(^{+65}_{-37})$	$0.081(13)$	$0.150(^{+110}_{-63})$
^{68}Zn	$0.072(^{+53}_{-31})$	$0.106(16)$	$0.123(^{+90}_{-52})$
^{70}Zn	$0.085(^{+62}_{-36})$	$0.240(30)$	$0.144(^{+106}_{-61})$
^{70}Ge	$0.111(^{+81}_{-47})$	$0.030(60)$	$0.188(^{+138}_{-79})$
		$0.090(60)$	
^{78}Se	$0.0106(^{+78}_{-45})$	$0.260(90)$	$0.180(^{+132}_{-76})$
^{80}Se	$0.099(^{+73}_{-42})$	$0.310(70)$	$0.169(^{+123}_{-71})$
^{78}Kr	$0.0152(^{+111}_{-64})$		$0.258(^{+189}_{-109})$
^{80}Kr	$0.142(^{+104}_{-60})$		$0.240(^{+176}_{-101})$
^{82}Kr	$0.106(^{+78}_{-45})$		$0.180(^{+132}_{-76})$

Relevant energy scales in odd-mass spherical nuclei with ½-ground states

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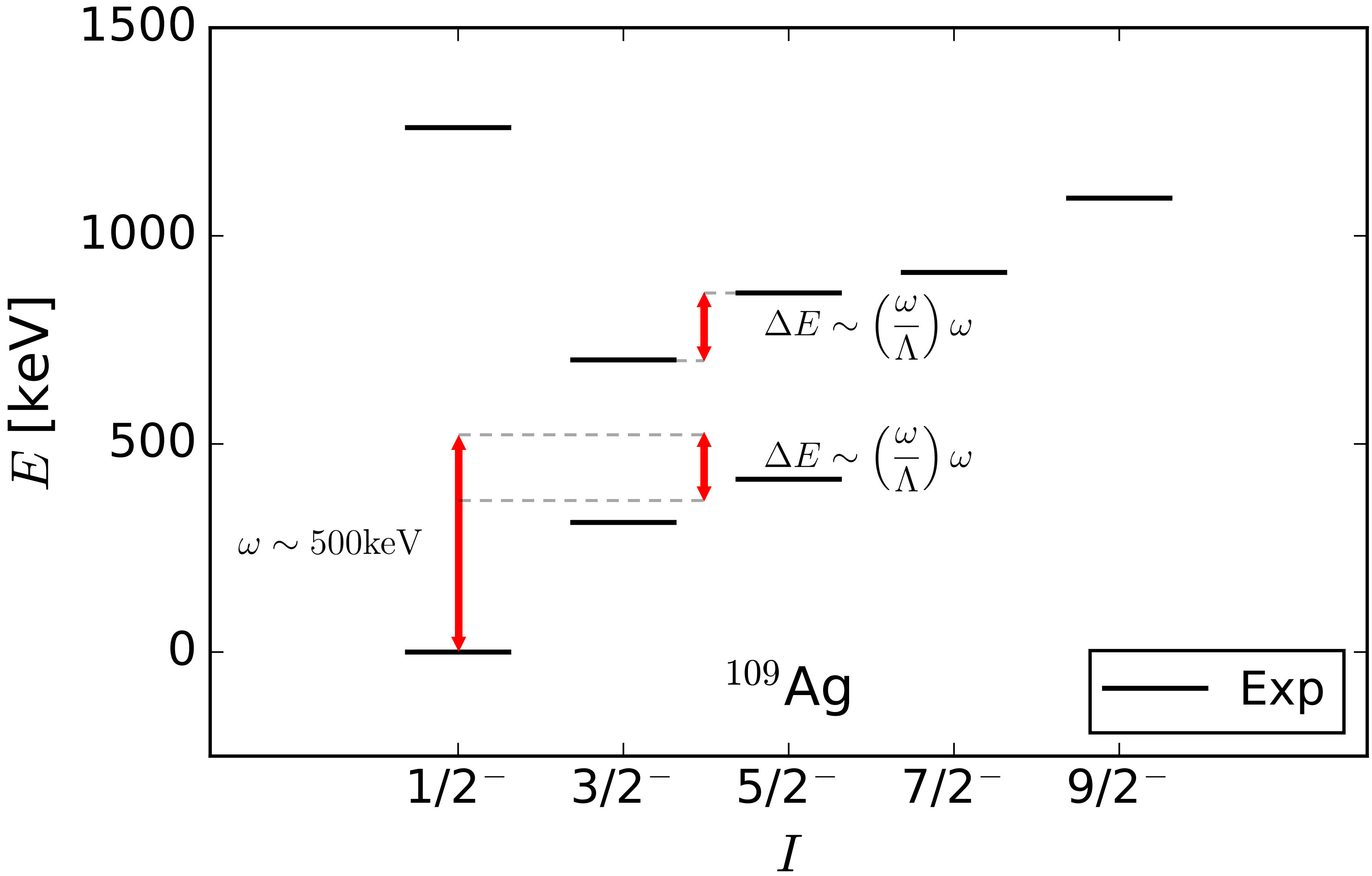

Power counting for the fermion operators

The fermion operators

$$\{a_\mu, a_\nu^\dagger\} = \delta_{\mu\nu}$$

create and annihilate a fermion in a $j^\pi = {}^1\!/_2{}^-$ orbital

Base on the energy scales, the following power counting for fermionic n-body operators is proposed

$$\langle \hat{O}_n \rangle \sim \langle \hat{O}_{n-1} \rangle \frac{\omega}{\Lambda}$$

From the power counting, the NLO contribution to the Hamiltonian is

$$H_{\mathrm{NLO}} \equiv g_{Jj} \hat{\mathbf{J}} \cdot \hat{\mathbf{j}} + \omega_2 \hat{N} \hat{n}$$

where

$$\hat{\mathbf{j}} = \frac{1}{\sqrt{2}} \left(a^\dagger \otimes \tilde{a} \right)^{(1)}$$

and

$$\hat{n} \equiv a^\dagger \cdot \tilde{a}$$

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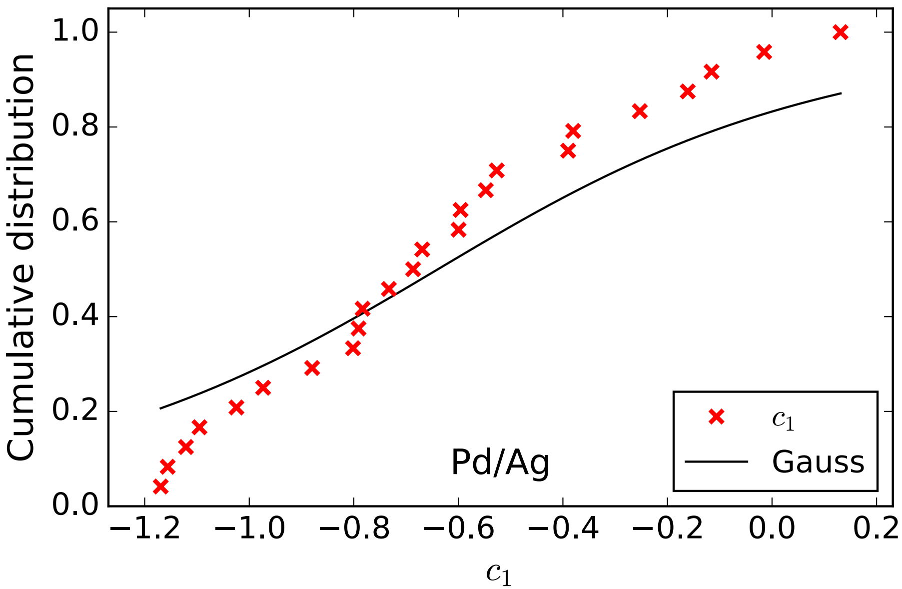
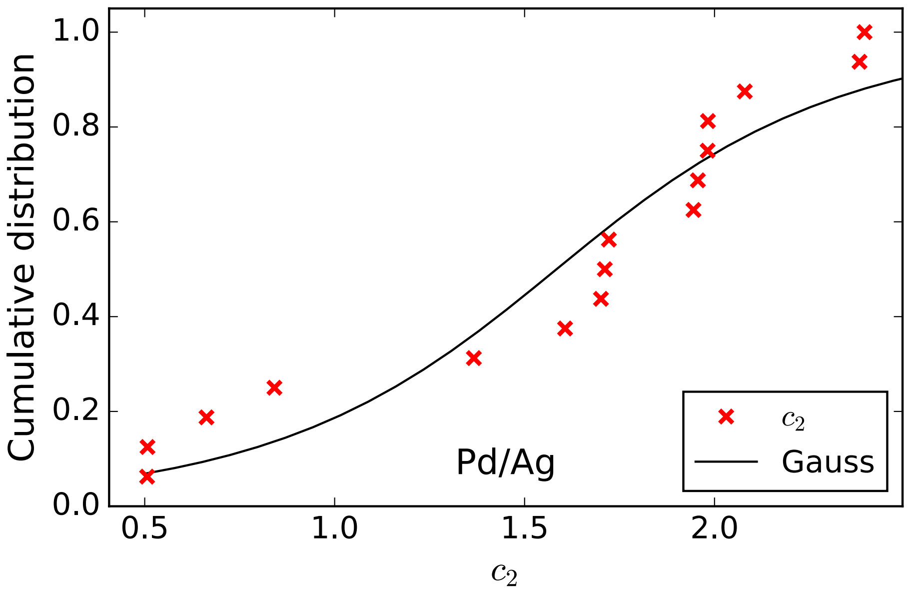
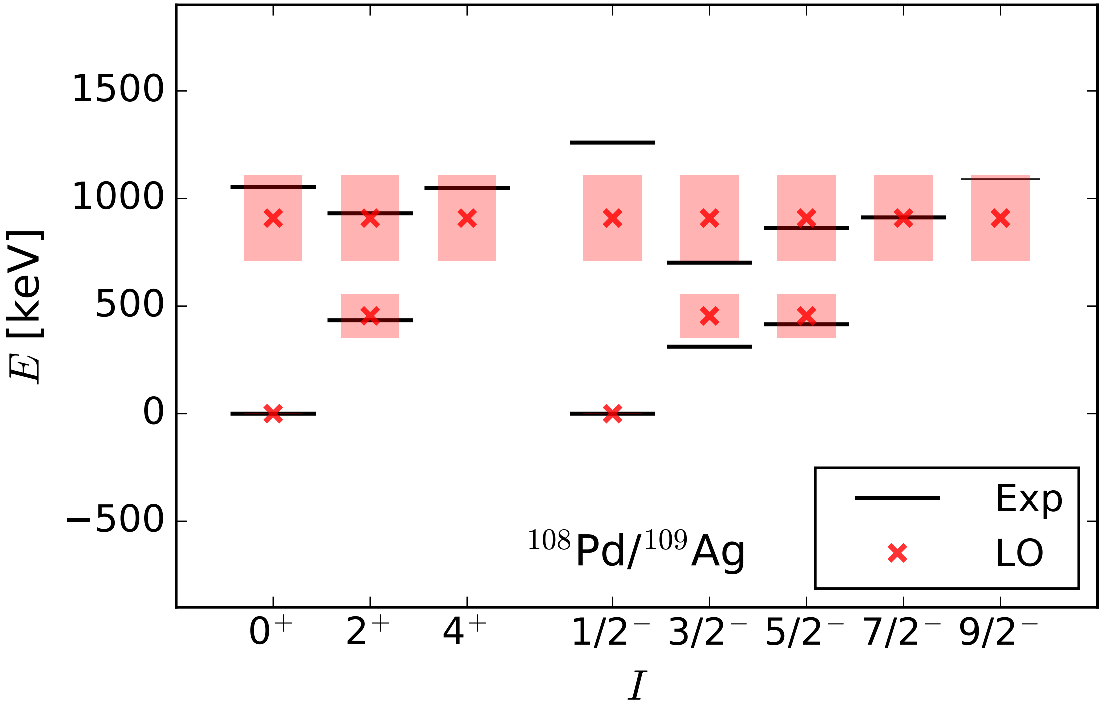




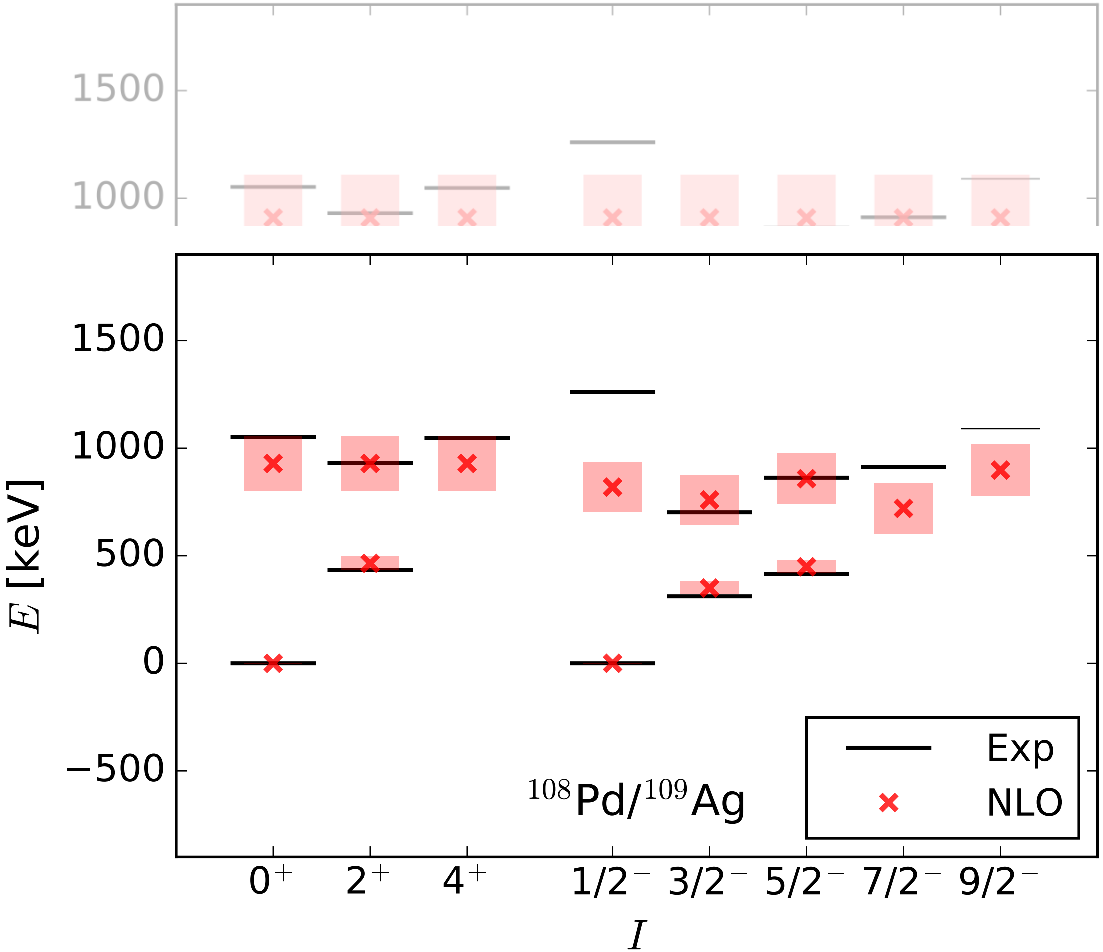
Cumulative distributions for fitted LO and NLO expansion coefficients for the energies are in agreement with the power counting

Order-by-order improvement



LO:
- One LEC
- Harmonic behavior

Order-by-order improvement



LO:
- One LEC
- Harmonic behavior

NLO:
- Two additional LECs
- Particle-core interactions

Order-by-order improvement

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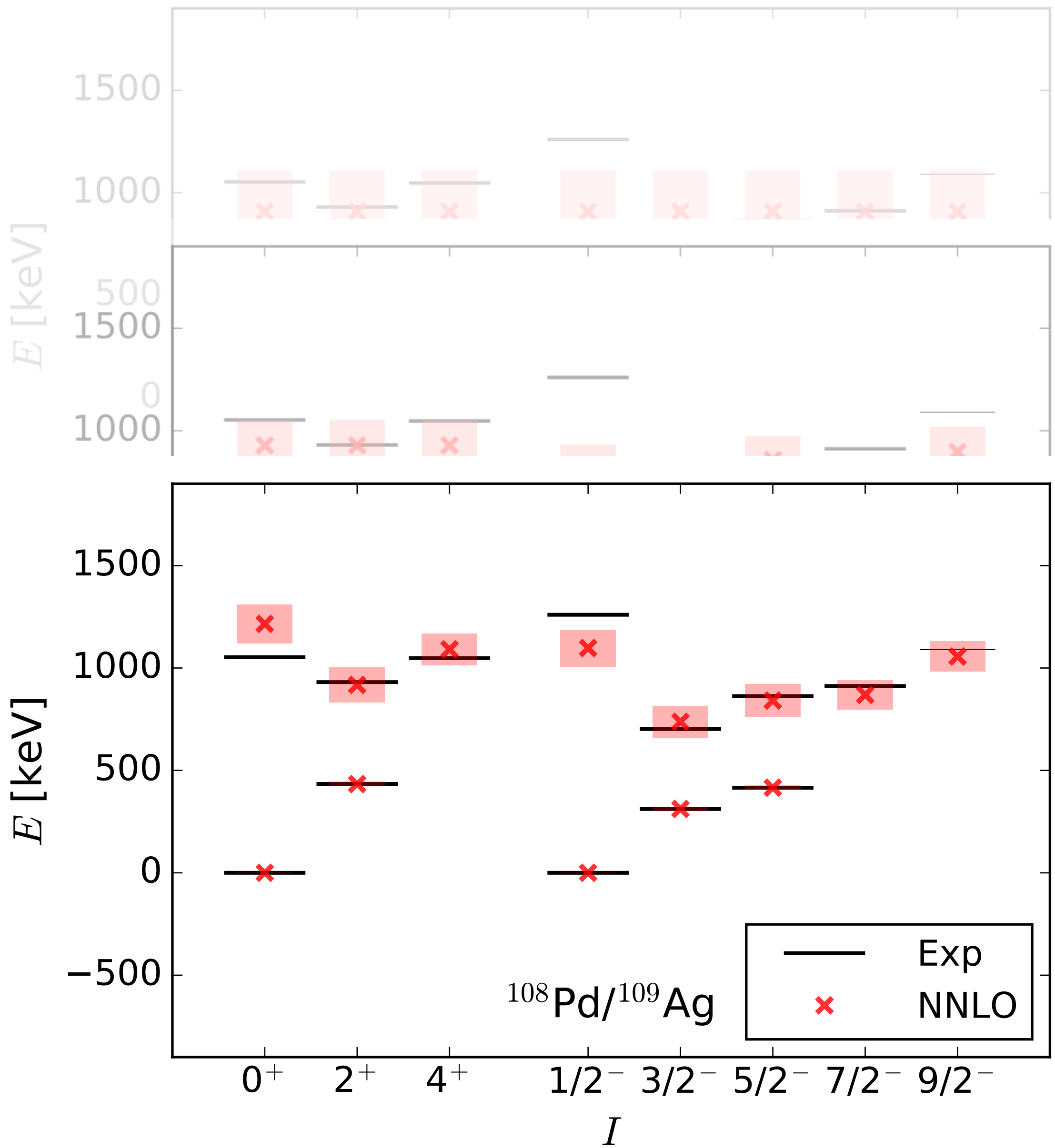


LO:

- One LEC
- Harmonic behavior

NLO:

- Two additional LECs
- Particle-core interactions

NNLO:

- Three additional LECs
- Anharmonic corrections

Accuracy and precision increases order by order at the expense of reduced predictive power

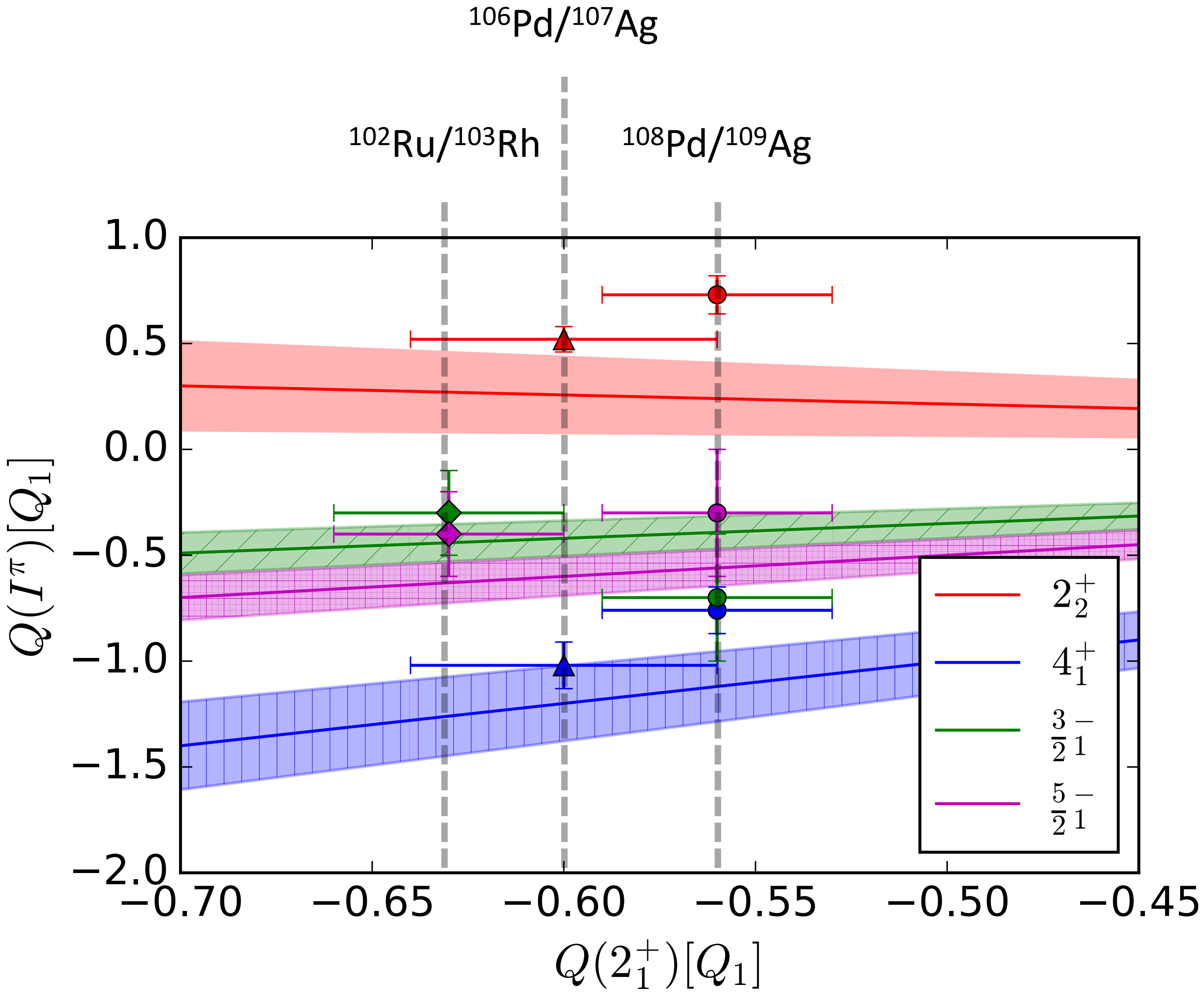
LO phonon-annihilating B(E2) values

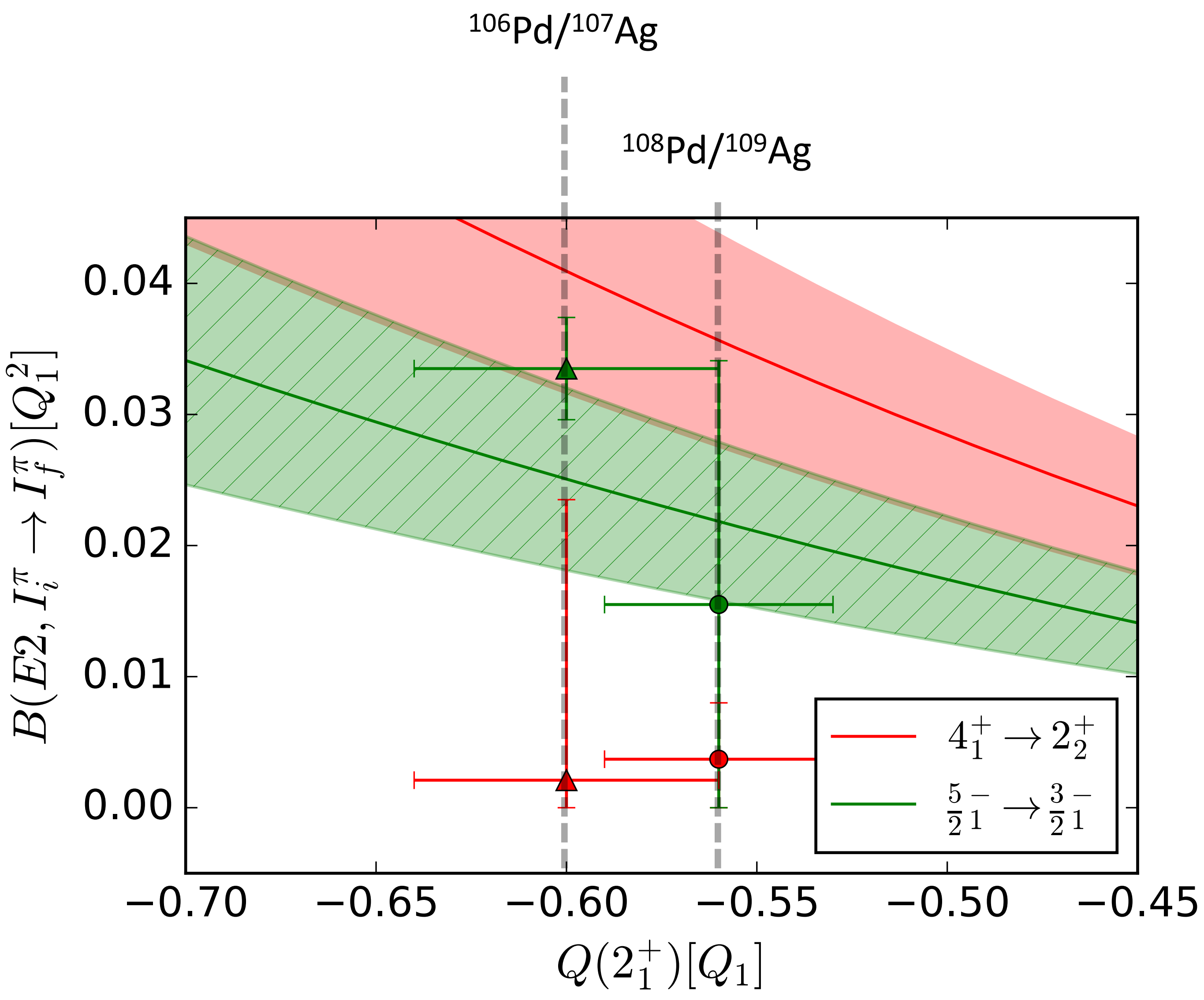
LO B(E2) values for phonon-annihilating transitions [W. u.]

Nucleus	$I_i^\pi \rightarrow I_f^\pi$	$B(E2)_{\mathrm{exp}}$	$B(E2)_{\mathrm{EFT}}$
^{108}Pd	$2_1^+ \rightarrow 0_1^+$	49(1)	34(11)
	$0_2^+ \rightarrow 2_1^+$	52(5)	69(23)
	$2_2^+ \rightarrow 2_1^+$	71(5)	69(23)
	$4_1^+ \rightarrow 2_1^+$	73(8)	69(23)
^{109}Ag	$\frac{3}{2}_1^- \rightarrow \frac{1}{2}_1^-$	40(40)	34(11)
	$\frac{5}{2}_1^- \rightarrow \frac{1}{2}_1^-$	41(6)	34(11)
	$\frac{1}{2}_2^- \rightarrow \frac{3}{2}_1^-$		27(23)
	$\frac{1}{2}_2^- \rightarrow \frac{5}{2}_1^-$		41(23)
	$\frac{3}{2}_2^- \rightarrow \frac{3}{2}_1^-$	49(24)	47(23)
	$\frac{3}{2}_2^- \rightarrow \frac{5}{2}_1^-$		20(23)
	$\frac{5}{2}_2^- \rightarrow \frac{3}{2}_1^-$	8(4)	14(23)
	$\frac{5}{2}_2^- \rightarrow \frac{5}{2}_1^-$	10(7)	54(23)
	$\frac{7}{2}_1^- \rightarrow \frac{3}{2}_1^-$		61(23)
	$\frac{7}{2}_1^- \rightarrow \frac{5}{2}_1^-$		7(23)
	$\frac{9}{2}_1^- \rightarrow \frac{5}{2}_1^-$		68(23)

LEC fitted to even-even and odd-mass nuclei E2 transitions strengths

LO relations between even-even and odd-mass E2 observables





^{106}Pd/^{107}Ag
^{108}Pd/^{109}Ag
0.04
0.03
0.02
0.01
0.00
$B(E2, I_i^\pi \to I_f^\pi)[Q_1^2]$
−0.70
−0.65
−0.60
−0.55
−0.50
−0.45
$Q(2_1^+)[Q_1]$
$4_1^+ \to 2_2^+$
$\frac{5}{2}{}_1^- \to \frac{3}{2}{}_1^-$

M1 operator

Most general operator of rank one

$$\hat{\mu} = \mu_d \hat{\mathbf{J}} + \mu_a \hat{\mathbf{j}} + \left[\left(d^\dagger + \tilde{d} \right) \otimes \left(\mu_{d1} \hat{\mathbf{J}} + \mu_{a1} \hat{\mathbf{j}} \right) \right]^{(1)}$$

LO term:
- Two LECs
- Phonon-conserving transition strengths
- Static M1 moments

NLO term:
- Two LECs
- Phonon-annihilating transition strengths

LO M1 static moments and phonon-conserving B(M1) values

LO M1 static moment in [μ_N]

Nucleus	I_i^π	$\mu_{\rm exp}(I_i^\pi)$	$\mu_{\rm EFT}(I_i^\pi)$
^{106}Pd	2_1^+	$0.79(2)^*$	$0.79(5)$
	2_2^+	$0.71(10)$	$0.79(10)$
	4_1^+	$1.8(4)$	$1.58(8)$
^{107}Ag	$\frac{1}{2}_1^-$	-0.11^*	-0.11
	$\frac{3}{2}_1^-$	$0.98(9)$	$0.78(5)$
	$\frac{5}{2}_1^-$	$1.02(9)$	$0.68(4)$
	$\frac{7}{2}_1^-$		$1.6(1)$
	$\frac{9}{2}_1^-$		$1.5(1)$
^{108}Pd	2_1^+	$0.71(2)^*$	$0.71(4)$
	2_2^+		$0.71(9)$
	4_1^+		$1.42(7)$
^{109}Ag	$\frac{1}{2}_1^-$	-0.13^*	-0.13
	$\frac{3}{2}_1^-$	$1.10(10)$	$0.72(5)$
	$\frac{5}{2}_1^-$	$0.85(8)$	$0.58(4)$
	$\frac{7}{2}_1^-$		$1.5(1)$
	$\frac{9}{2}_1^-$		$1.3(1)$

LO B(M1) values for phonon-conserving transitions in [W. u.]

Nucleus	$I_i^\pi \to I_f^\pi$	$B(M1)_{\rm exp}$	$B(M1)_{\rm EFT}$
^{107}Ag	$\frac{5}{2}_1^- \to \frac{3}{2}_1^-$	$0.033(4)$	$0.036(2)$
	$\frac{5}{2}_2^- \to \frac{3}{2}_2^-$		$0.036(4)$
	$\frac{9}{2}_1^- \to \frac{7}{2}_1^-$		$0.040(2)$
^{109}Ag	$\frac{5}{2}_1^- \to \frac{3}{2}_1^-$	$0.043(7)$	$0.036(2)$
	$\frac{5}{2}_2^- \to \frac{3}{2}_2^-$		$0.036(3)$
	$\frac{9}{2}_1^- \to \frac{7}{2}_1^-$		$0.040(2)$

LECs fitted to static M1 moments

LO phonon-annihilating B(M1) values

LO B(M1) values for phonon-conserving transitions in odd-mass nuclei [W. u.]

Nucleus	$I_i^\pi \rightarrow I_f^\pi$	$B(M1)_{\text{exp}}$	$B(M1)_{\text{EFT}}$
^{103}Rh	$\frac{3}{2}_1^- \rightarrow \frac{1}{2}_1^-$	0.12(1)	0.10(2)
	$\frac{1}{2}_2^- \rightarrow \frac{3}{2}_1^-$		0.08(8)
	$\frac{3}{2}_2^- \rightarrow \frac{3}{2}_1^-$		0.10(4)
	$\frac{3}{2}_2^- \rightarrow \frac{5}{2}_1^-$		0.03(4)
	$\frac{5}{2}_2^- \rightarrow \frac{3}{2}_1^-$	0.014(2)	0.018(28)
	$\frac{5}{2}_2^- \rightarrow \frac{5}{2}_1^-$	0.020(3)	0.023(28)
	$\frac{7}{2}_1^- \rightarrow \frac{5}{2}_1^-$		0.17(2)
^{109}Ag	$\frac{3}{2}_1^- \rightarrow \frac{1}{2}_1^-$	0.117(15)	0.122(27)
	$\frac{1}{2}_2^- \rightarrow \frac{3}{2}_1^-$		0.10(11)
	$\frac{3}{2}_2^- \rightarrow \frac{3}{2}_1^-$	0.16(7)	0.07(5)
	$\frac{3}{2}_2^- \rightarrow \frac{5}{2}_1^-$		0.05(5)
	$\frac{5}{2}_2^- \rightarrow \frac{3}{2}_1^-$	0.036(16)	0.033(36)
	$\frac{5}{2}_2^- \rightarrow \frac{5}{2}_1^-$	0.10(4)	0.07(4)
	$\frac{7}{2}_1^- \rightarrow \frac{5}{2}_1^-$		0.22(3)

LECs fitted to even-even and odd-mass nuclei M1 transitions strengths

Low-lying positive-parity odd-odd states are constructed as

$$|IM; j_p; j_n\rangle = \sum_{\mu\nu} C^{IM}_{j_n\mu j_p\nu} n^\dagger_\mu p^\dagger_\nu |0\rangle,$$

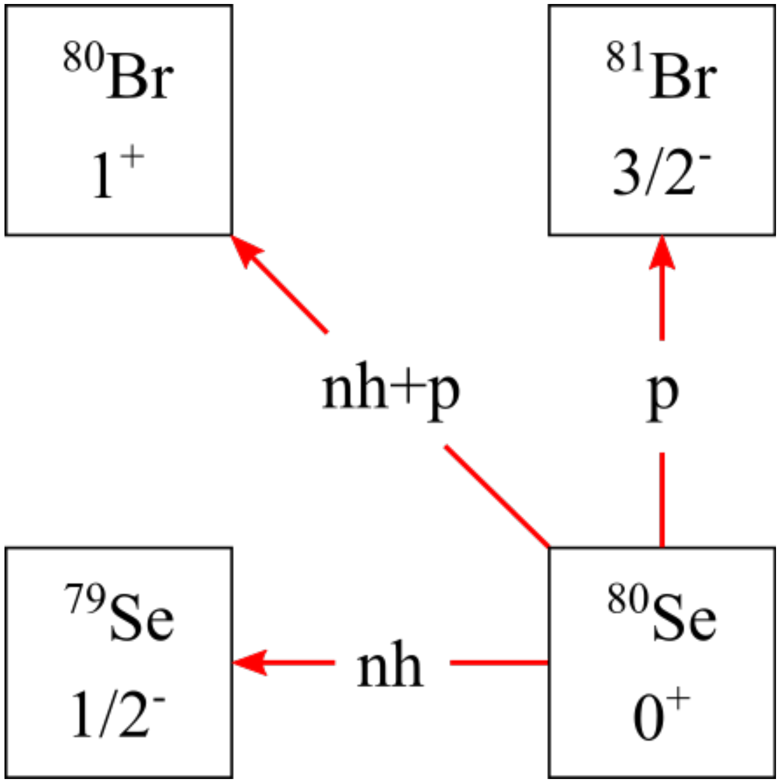
where

$$|j_n - j_p| \leq I \leq j_n + j_p$$

and

$$\pi_n \pi_p = 1$$

Odd-odd nucleus as a core + nh + p



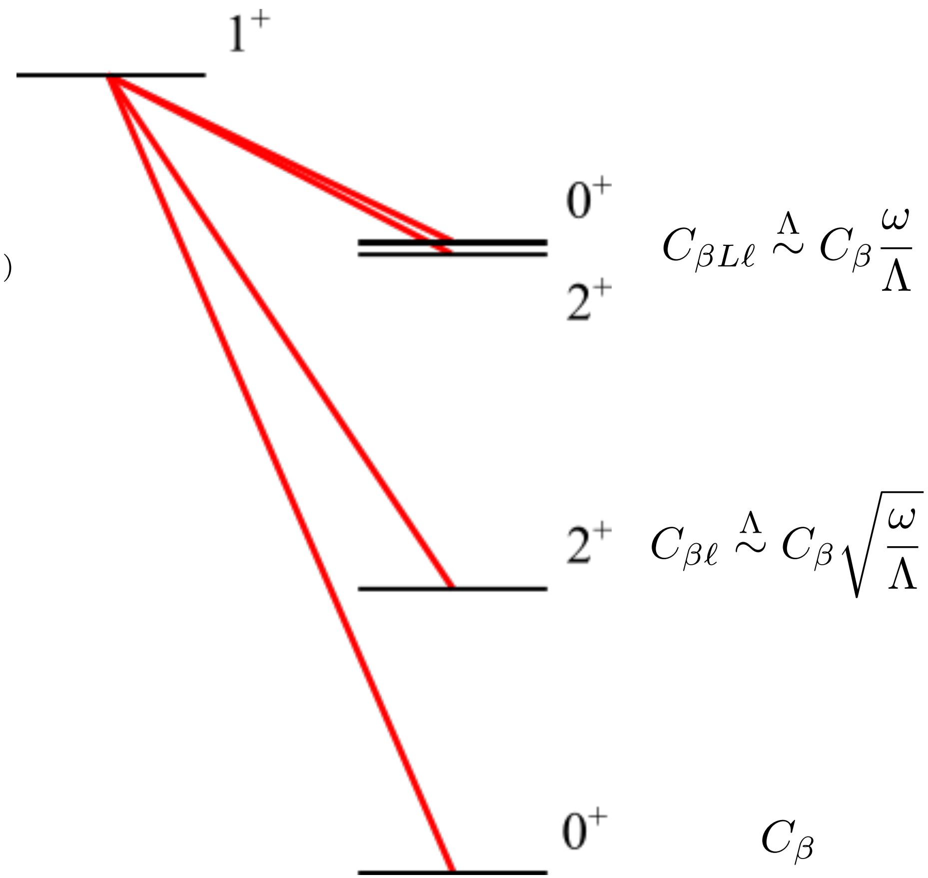
β operator for Gamow-Teller transitions

From the power counting

$$\frac{C_{\beta\ell}}{C_\beta} \overset{\mathrm{EFT}}{\sim} 0.58(^{+42}_{-25}) \quad \text{and} \quad \frac{C_{\beta L\ell}}{C_\beta} \overset{\mathrm{EFT}}{\sim} 0.33(^{+25}_{-14})$$

Most general operator of rank one that couples odd-odd and even-even states

$$\hat{O}_\beta = C_\beta \, (\tilde{p} \otimes \tilde{n})^{(1)} + \sum_\ell C_{\beta\ell} \left[\left(d^\dagger + \tilde{d} \right) \otimes (\tilde{p} \otimes \tilde{n})^{(\ell)} \right]^{(1)} + \sum_{L\ell} C_{\beta L\ell} \left[\left(d^\dagger \otimes d^\dagger + \tilde{d} \otimes \tilde{d} \right)^{(L)} \otimes (\tilde{p} \otimes \tilde{n})^{(\ell)} \right]^{(1)}$$



LO term:
- Couples states with $\Delta\mathcal{N} = 0$

NLO term:
- Couples states with $\Delta\mathcal{N} = 1$

NNLO term:
- Couples states with $\Delta\mathcal{N} = 2$

The matrix elements of the β operator between low-lying odd-odd states and even-even ground, one- and two-phonon states are

$$\langle 0||\hat{O}_\beta||I_i;j_n;j_p\rangle = \begin{cases} -C_\beta\sqrt{3}(-1)^{j_p-j_n+I_i} & I_i=1 \\ 0 & \text{otherwise} \end{cases},$$

$$\langle 2;\mathcal{N}=1||\hat{O}_\beta||I_i;j_n;j_p\rangle = \begin{cases} C_{\beta I_i}\sqrt{3}(-1)^{j_p-j_n+I_i} & |I_i-1|\leq 2\leq I_i+1 \\ 0 & \text{otherwise} \end{cases}$$

$$\langle I_f;\mathcal{N}=2||\hat{O}_\beta||I_i;j_n;j_p\rangle = \begin{cases} C_{\beta I_f I_i}\sqrt{6}(-1)^{j_p-j_n+I_i} & |I_i-1|\leq I_f\leq I_i+1 \\ 0 & \text{otherwise} \end{cases}$$

From Fermi's golden rule

$$(ft)_{if} = \kappa\frac{2I_i+1}{g_A^2\left|\langle f||\hat{O}_\beta||i\rangle\right|^2} \quad \text{or} \quad \frac{\left|\langle f'||\hat{O}_\beta||i\rangle\right|}{\left|\langle f||\hat{O}_\beta||i\rangle\right|} = \sqrt{10^{\log(ft)_{if}-\log(ft)_{if'}}}$$

For β decays from low-lying 1^+ odd-odd states

$$\sqrt{10^{\log(ft)_{\rm gs\,gs}-\log(ft)_{\rm gs\,1ph}}} = \frac{C_{\beta 1}}{C_\beta} \overset{\rm EFT}{\sim} 0.58^{+42}_{-25} \quad \text{and} \quad \sqrt{10^{\log(ft)_{\rm gs\,gs}-\log(ft)_{\rm gs\,2ph}}} = \frac{\sqrt{2}C_{\beta I_f 1}}{C_\beta} \overset{\rm EFT}{\sim} 0.47^{+35}_{-20}$$

Relative sizes of β-decay matrix elements

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LO matrix elements for β decays to excited states relative to the matrix element for the β decay to the ground state

Parent $\to$ Daughter	$\log(ft)_{\mathrm{gs}}$	$\log(ft)_{2_1^+}$	$\log(ft)_{0_2^+}$	$\log(ft)_{2_2^+}$	$\lvert\langle 2_1^+\lVert\hat{O}_\beta\rVert 1_1^+\rangle\rvert$		$\lvert\langle 0_2^+\lVert\hat{O}_\beta\rVert 1_1^+\rangle\rvert$		$\lvert\langle 2_2^+\lVert\hat{O}_\beta\rVert 1_1^+\rangle\rvert$	
$^{62}\mathrm{Cu} \overset{\varepsilon}{\to} {}^{62}\mathrm{Ni}$	5.16	7.03	6.00	5.98	0.12	$0.58(^{+42}_{-25})$	0.38	$0.47(^{+35}_{-20})$	0.39	$0.47(^{+35}_{-20})$
$^{64}\mathrm{Cu} \overset{\varepsilon}{\to} {}^{64}\mathrm{Ni}$	4.97	5.50			0.54	$0.58(^{+42}_{-25})$				
$^{66}\mathrm{Cu} \overset{\beta^-}{\to} {}^{66}\mathrm{Zn}$	5.33	5.43	6.01	5.82	0.79	$0.58(^{+42}_{-25})$	0.46	$0.47(^{+35}_{-20})$	0.57	$0.47(^{+35}_{-20})$
$^{68}\mathrm{Cu} \overset{\beta^-}{\to} {}^{68}\mathrm{Zn}$	5.76	5.16	6.30	5.80	1.97	$0.58(^{+42}_{-25})$	0.54	$0.47(^{+35}_{-20})$	0.95	$0.47(^{+35}_{-20})$
$^{68}\mathrm{Ga} \overset{\varepsilon}{\to} {}^{68}\mathrm{Zn}$	5.19	5.49	6.90	5.88	0.71	$0.58(^{+42}_{-25})$	0.14	$0.47(^{+35}_{-20})$	0.45	$0.47(^{+35}_{-20})$
$^{70}\mathrm{Ga} \overset{\beta^-}{\to} {}^{70}\mathrm{Ge}$	5.09	5.89	5.43		0.40	$0.58(^{+42}_{-25})$	0.68	$0.47(^{+35}_{-20})$		$0.47(^{+35}_{-20})$
$^{80}\mathrm{As} \overset{\beta^-}{\to} {}^{80}\mathrm{Se}$	5.70	5.70	7.20	6.70	1.00	$0.58(^{+42}_{-25})$	0.18	$0.47(^{+35}_{-20})$	0.32	$0.47(^{+35}_{-20})$
$^{82}\mathrm{As} \overset{\beta^-}{\to} {}^{82}\mathrm{Se}$	6.19	6.91	7.44	7.00	0.44	$0.58(^{+42}_{-25})$	0.24	$0.47(^{+35}_{-20})$	0.39	$0.47(^{+35}_{-20})$
$^{78}\mathrm{Br} \overset{\beta^-}{\to} {}^{78}\mathrm{Kr}$		> 5.80				$0.58(^{+42}_{-25})$				
$^{78}\mathrm{Br} \overset{\varepsilon}{\to} {}^{78}\mathrm{Se}$	4.75	5.07	6.50	6.60	0.69	$0.58(^{+42}_{-25})$	0.13	$0.47(^{+35}_{-20})$	0.12	$0.47(^{+35}_{-20})$
$^{80}\mathrm{Br} \overset{\beta^-}{\to} {}^{80}\mathrm{Kr}$	5.48	5.98	6.34	6.27	0.56	$0.58(^{+42}_{-25})$	0.37	$0.47(^{+35}_{-20})$	0.40	$0.47(^{+35}_{-20})$
$^{80}\mathrm{Br} \overset{\varepsilon}{\to} {}^{80}\mathrm{Se}$	4.67	4.94	5.30	5.70	0.73	$0.58(^{+42}_{-25})$	0.48	$0.47(^{+35}_{-20})$	0.30	$0.47(^{+35}_{-20})$
$^{80}\mathrm{Rb} \overset{\varepsilon}{\to} {}^{80}\mathrm{Kr}$	4.93	5.19	5.88	5.87	0.74	$0.58(^{+42}_{-25})$	0.33	$0.47(^{+35}_{-20})$	0.34	$0.47(^{+35}_{-20})$
$^{82}\mathrm{Rb} \overset{\varepsilon}{\to} {}^{82}\mathrm{Kr}$	4.58	4.86	6.72	6.29	0.72	$0.58(^{+42}_{-25})$	0.08	$0.47(^{+35}_{-20})$	0.14	$0.47(^{+35}_{-20})$

Within the PPQ model*

$$|\Psi_{IM}\rangle = \sum_{\mu\nu} C^{IM}_{j_n\mu j_p\nu} \alpha^\dagger_{j_n\mu} \alpha^\dagger_{j_p\nu} |\Psi_0\rangle$$

and

$$\hat{G}^{(-)}_{\beta\mu} = \frac{\langle j_p||\boldsymbol{\sigma}||j_n\rangle}{\sqrt{3}} \sum_{mn} C^{1\mu}_{j_p m j_n n} \Big\{ U_{j_p} U_{j_n} (-1)^{j_n+n} \alpha^\dagger_{j_p m} \alpha_{j_n -n} + V_{j_p} U_{j_n} (-1)^{j_p - m + j_n + n} \alpha_{j_p -m} \alpha_{j_n -n} + U_{j_p} V_{j_n} \alpha^\dagger_{j_p m} \alpha^\dagger_{j_n n} + V_{j_p} V_{j_n} (-1)^{j_p - m} \alpha_{j_p -m} \alpha^\dagger_{j_n n} \Big\}$$

We identify

$$\frac{\langle j_p||\boldsymbol{\sigma}||j_n\rangle}{\sqrt{3}} V_{j_p} U_{j_n} \left(\tilde{\alpha}_{j_p} \otimes \tilde{\alpha}_{j_n}\right)^{(1)} \quad \Leftrightarrow \quad C_\beta \left(\tilde{p} \otimes \tilde{n}\right)^{(1)}$$

and

$$\langle \Psi_0 || \hat{G}^{(-)}_\beta || \Psi_{IM} \rangle \quad \Leftrightarrow \quad \langle 0 || \hat{O}_\beta || I_i; j_n; j_p \rangle$$

*Kisslinger, Sorensen; Rev. Mod. Phys. **35** (1963) 853
*Futami, Sakai; Nucl. Phys. A **92**, 91 (1967)

Uncertainty estimates for log(ft)$_{gs\,gs}$ values

Uncertainties of the matrix element for the β decay to the ground state

$$\Delta\langle 0||\hat{O}_\beta||I;j_p;j_n\rangle \overset{\text{EFT}}{\sim} \langle 0||\hat{O}_\beta||I;j_p;j_n\rangle \frac{\omega}{\Lambda}$$

The Taylor expansion of

$$\log(ft)_{if} = \log\left(\kappa \frac{2I_i+1}{g_A^2 \left|\langle f||\hat{O}_\beta||i\rangle\right|^2}\right)$$

yields for the uncertainty

$$\Delta \log(ft)_{if} \overset{\text{EFT}}{\sim} \frac{2}{\ln 10}\frac{\omega}{\Lambda}$$

PPQ model lof(ft)$_{gs\ gs}$ values with EFT uncertainties

Parent → Daughter	$\log(ft)_{\text{exp}}$	$\log(ft)_{\text{PPQ}}$	g_A	$\lvert C_\beta \rvert$
$^{62}\text{Cu} \xrightarrow{\varepsilon} {}^{62}\text{Ni}$	5.16	5.80(29)	0.462	0.214(71)
$^{66}\text{Cu} \xrightarrow{\beta^-} {}^{66}\text{Zn}$	5.33	5.40(29)	0.462	0.339(113)
$^{70}\text{Ga} \xrightarrow{\beta^-} {}^{70}\text{Ge}$	5.09	5.20(29)	0.462	0.427(142)
$^{78}\text{Br} \xrightarrow{\varepsilon} {}^{78}\text{Se}$	4.75	5.00(29)	0.462	0.537(179)
$^{80}\text{Br} \xrightarrow{\beta^-} {}^{80}\text{Kr}$	5.48	5.70(29)	0.462	0.240(80)
$^{80}\text{Br} \xrightarrow{\varepsilon} {}^{80}\text{Se}$	4.67	4.90(29)	0.462	0.603(201)
$^{80}\text{Rb} \xrightarrow{\varepsilon} {}^{80}\text{Kr}$	4.93	5.20(29)	0.462	0.427(142)
$^{82}\text{Rb} \xrightarrow{\varepsilon} {}^{82}\text{Kr}$	4.58	5.10(29)	0.462	0.479(159)
$^{104}\text{Rh} \xrightarrow{\beta^-} {}^{104}\text{Pd}$	4.55	4.40(29)	0.291	1.698(566)
$^{106}\text{Rh} \xrightarrow{\beta^-} {}^{106}\text{Pd}$	5.17	4.50(29)	0.291	1.514(504)
$^{106}\text{Ag} \xrightarrow{\varepsilon} {}^{106}\text{Pd}$	4.92	5.00(29)	0.291	0.851(284)
$^{108}\text{Ag} \xrightarrow{\beta^-} {}^{108}\text{Cd}$	4.52	4.40(29)	0.291	1.698(566)
$^{108}\text{Ag} \xrightarrow{\varepsilon} {}^{108}\text{Pd}$	4.70	4.90(29)	0.291	0.955(318)
$^{110}\text{Ag} \xrightarrow{\beta^-} {}^{110}\text{Cd}$	4.66	4.50(29)	0.291	1.514(504)
$^{112}\text{In} \xrightarrow{\varepsilon} {}^{112}\text{Cd}$	4.64	5.00(29)	0.291	0.851(284)
$^{114}\text{In} \xrightarrow{\beta^-} {}^{114}\text{Sn}$	4.47	4.60(29)	0.291	1.349(450)
$^{128}\text{I} \xrightarrow{\beta^-} {}^{128}\text{Xe}$	6.06	5.70(29)	0.248	0.447(149)
$^{128}\text{I} \xrightarrow{\varepsilon} {}^{128}\text{Te}$	5.05	4.80(29)	0.248	1.259(420)

Summary

The EFT approach employed to describe spherical nuclei consistently describes the spectra, E2 and M1 properties of these systems at low energies

The systematic construction of the Hamiltonian and transition operators allows for the estimation of uncertainties

Assuming a simple form for low-lying odd-odd nuclei, a description of β decays from the later is attempted. The sizes of the matrix elements for decays to excited states relative to the matrix element for the decay to the ground state scale as expected

An identification of the matrix elements for the decay to the ground state calculated within a PPQ model to those calculated within the EFT, allows for the "calculation" of the relevant LEC. This increases the EFT's predictive power and provides the model with uncertainty estimates

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Thanks