Isomeric states in heaviest nuclei

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4. Summary

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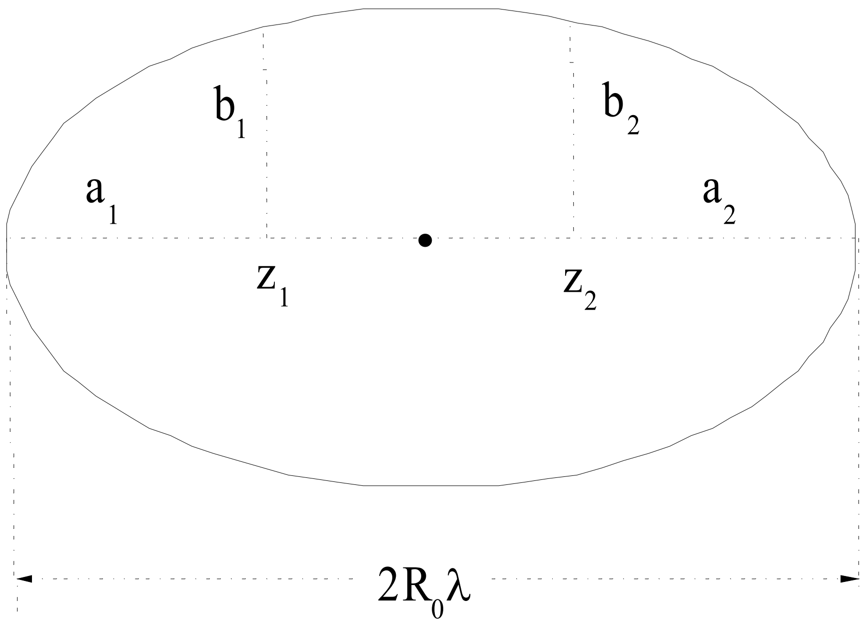
-Search of shells and subshells closure which crucially influence the evaporation residue cross sections

-Identification of heavy nuclei by α-decay needs the analysis of isomer states

-Population of isomer states in reactions

$\beta_i = a_i / b_i$

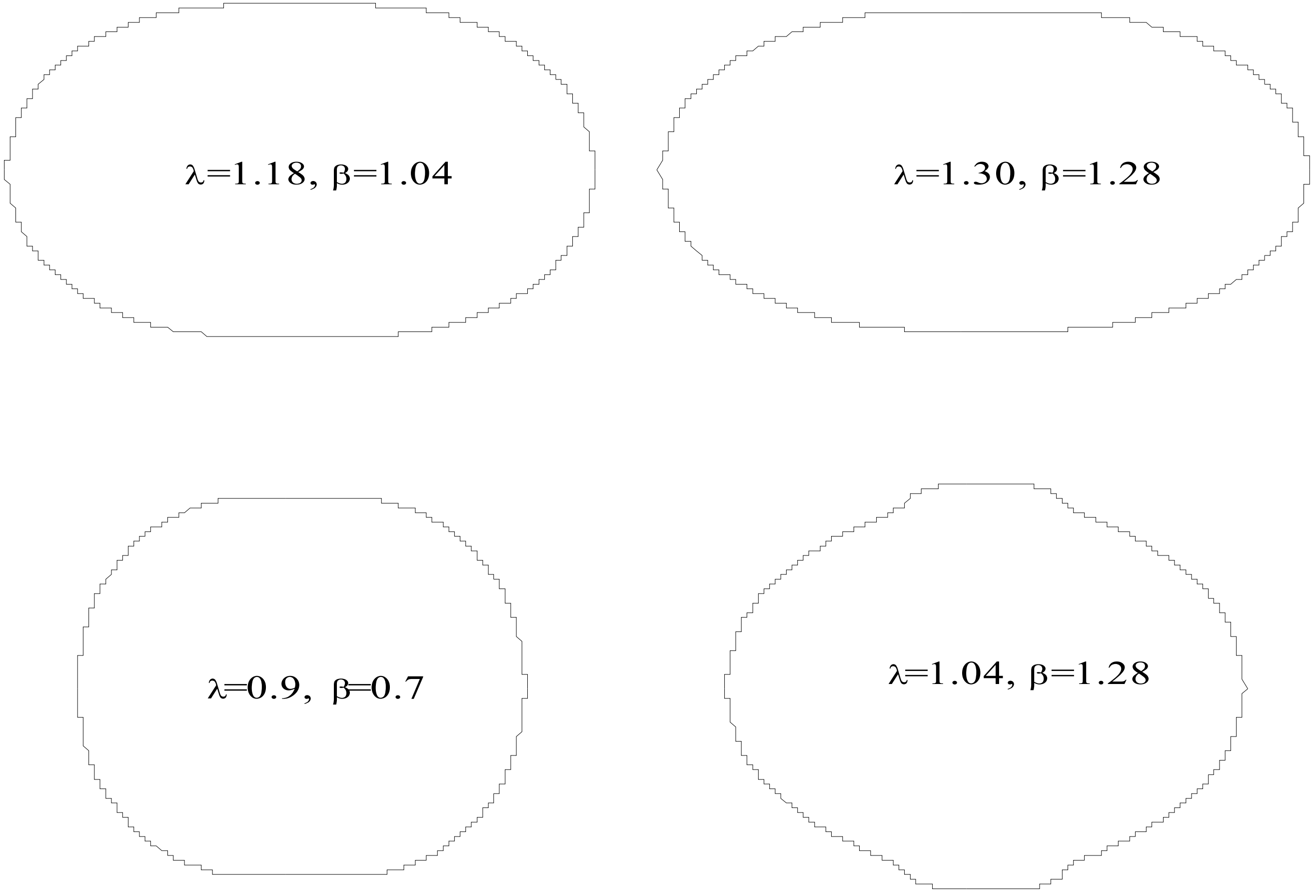


$\beta_1 = \beta_2$, even multipolarities; $\beta_1 \neq \beta_2$, odd and even multipolarities

R_0 is the radius of spherical nucleus

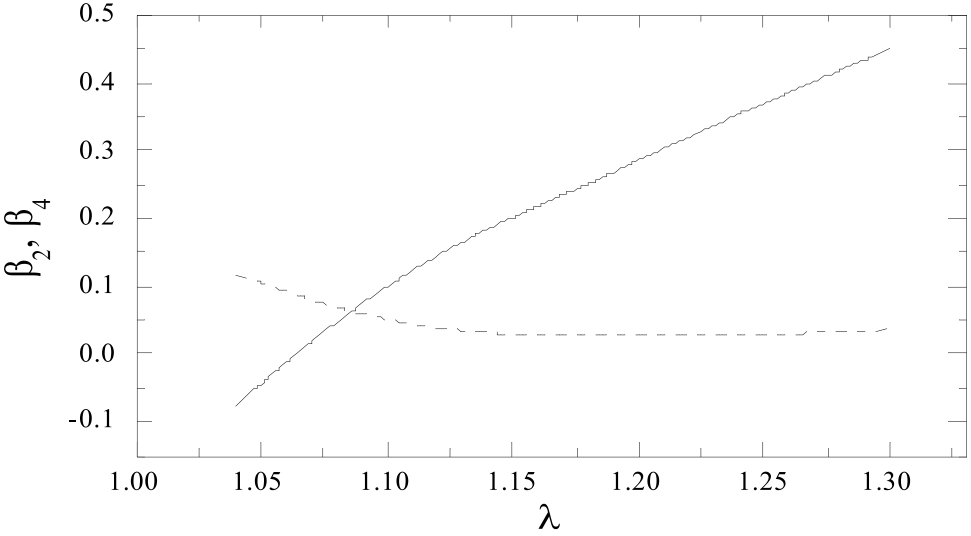
Parametrisation of nuclear shape with TCSM

^{248}Fm

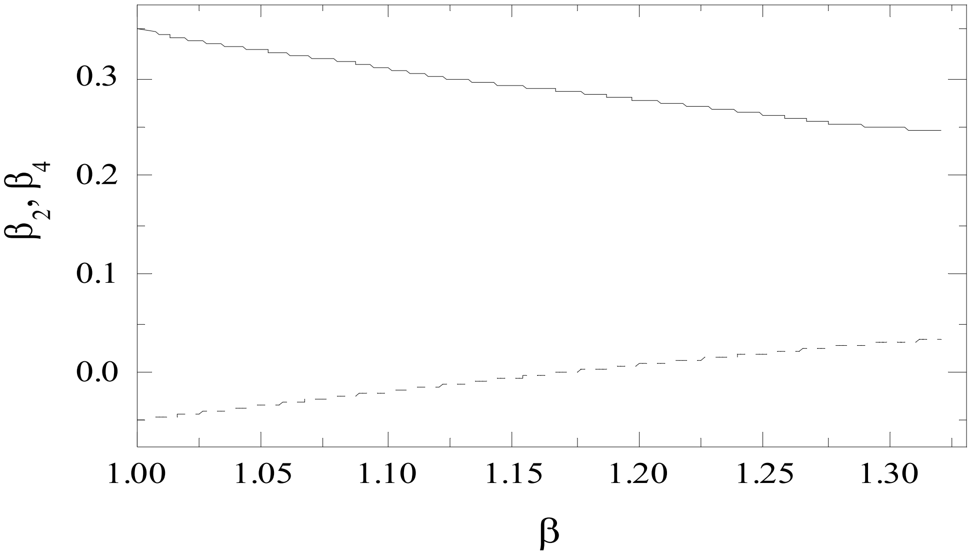


^{248}Fm

$\beta_2 - solid\_lines, \beta_4 - dashed\_lines$



β=1.28



λ=1.18

$$H = T + V(\rho, z) + V_{LS} + V_{L^2}$$

$$V(\rho, z) = \begin{cases} \frac{1}{2} m \omega_z^2 (z - z_1)^2 + \frac{1}{2} m \omega_\rho^2 \rho^2, z < z_1 \\ \frac{1}{2} m \omega_\rho^2 \rho^2, z_1 < z < z_2 \\ \frac{1}{2} m \omega_z^2 (z - z_2)^2 + \frac{1}{2} m \omega_\rho^2 \rho^2, z > z_2 \end{cases}$$

$$V_{LS} = -\frac{2\hbar \kappa_i}{m \omega_{0\mathrm{i}}} (\nabla V \times \vec{p}) \vec{s}$$

$$V_{L^2} = -\hbar \omega_{0\mathrm{i}} \kappa_i \mu_i \hat{l}^2 + \hbar \kappa_i \mu_i \omega_{0\mathrm{i}} N_1 (N_1 + 3)/2 \delta_{if}$$

$$\omega_{0\mathrm{i}} = 41\, MeV / A_i^{1/3}, A_i = a_i b_i^2 / 1.22^3, \omega_\rho / \omega_z = a_i / b_i, z_2 - z_1 = 2\mathrm{R}_0 \lambda - a_1 - a_2$$

Parameters

$$35 \le N - Z \le 64$$

for neutrons

$$\kappa_n = -0.076 + 0.0058(N-Z) - 6.53\times10^{-5}(N-Z)^2 + 0.002\,A^{1/3},$$

$$\mu_n = 1.598 - 0.0295(N-Z) + 3.036\times10^{-4}(N-Z)^2 - 0.095\,A^{1/3},$$

for protons

$$\kappa_p = 0.0383 + 0.00137(N-Z) - 1.22\times10^{-5}(N-Z)^2 - 0.003\,A^{1/3},$$

$$\mu_p = 0.335 + 0.01(N-Z) - 9.367\times10^{-5}(N-Z)^2 + 0.003\,A^{1/3},$$

The parts in front of the terms with $A^{1/3}$ vary: (0.05-0.053) for κ_n , (0.075-0.0768) for κ_p ,

(0.88-0.92) for μ_n , (0.58-0.61) for μ_p

Parameters were set so to describe spins & parities of g.-s. of known heavy nuclei

Potential energy

$$U(Z,A,\lambda,\beta)=U_{LDM}(Z,A,\lambda,\beta)+\delta U_{mic}(Z,A,\lambda,\beta)$$

Binding energy

$$B(Z,A)=U(Z,A,\lambda_{gs},\beta_{gs})-a_v\left(1-a_s\left(\frac{N-Z}{A}\right)^2\right)A$$

$$+W\left|\frac{N-Z}{A}\right|+\delta+c[(N-Z)-58]$$

$$a_s=1.778,\, W=30\,MeV,\, c=0.25\,MeV,$$

$$\delta=4.8/N^{1/3}\delta_{N,odd}+4.8/Z^{1/3}\delta_{Z,odd},$$

$$a_v=15.703\,MeV\ at\ N-Z<52;15.715\,MeV\ at\ 54\leqslant N-Z\leqslant 61,$$

Comparison with other calculations

^{248}Fm gs.:

λ=1.18, β=1.28 -> β_2=0.25, β_4=0.027

P.Möller et al. β_2=0.235, β_4=0.049

For ^{247,248,249}Fm, the microscopic corrections are

-3.85, -3.88, and -4.3 MeV.

P.Möller et al.: -3.52, -3.57, and -3.97 MeV

The values of Δ differ within 0.1 MeV.

Comparison with other calculations

^{270}Hs gs.:

$\lambda=1.14$, $\beta=1.06$ -> $\beta_2=0.25$, $\beta_4=-0.03$

P.Möller et al.: $\beta_2=0.231$, $\beta_4=-0.086$

For ^{268,269,270,271}Hs, the microscopic corrections are

-5.95, -6.38, -6.54, -6.64 MeV

P.Möller et al.: -5.94, -6.37, -5.95, -5.86 MeV

A.Kuzmina et al., Eur. Phys. J. A 47 (2011) 145

Phys. Rev. C 85 (2012) 014319; 017302

Comparison with other calculations

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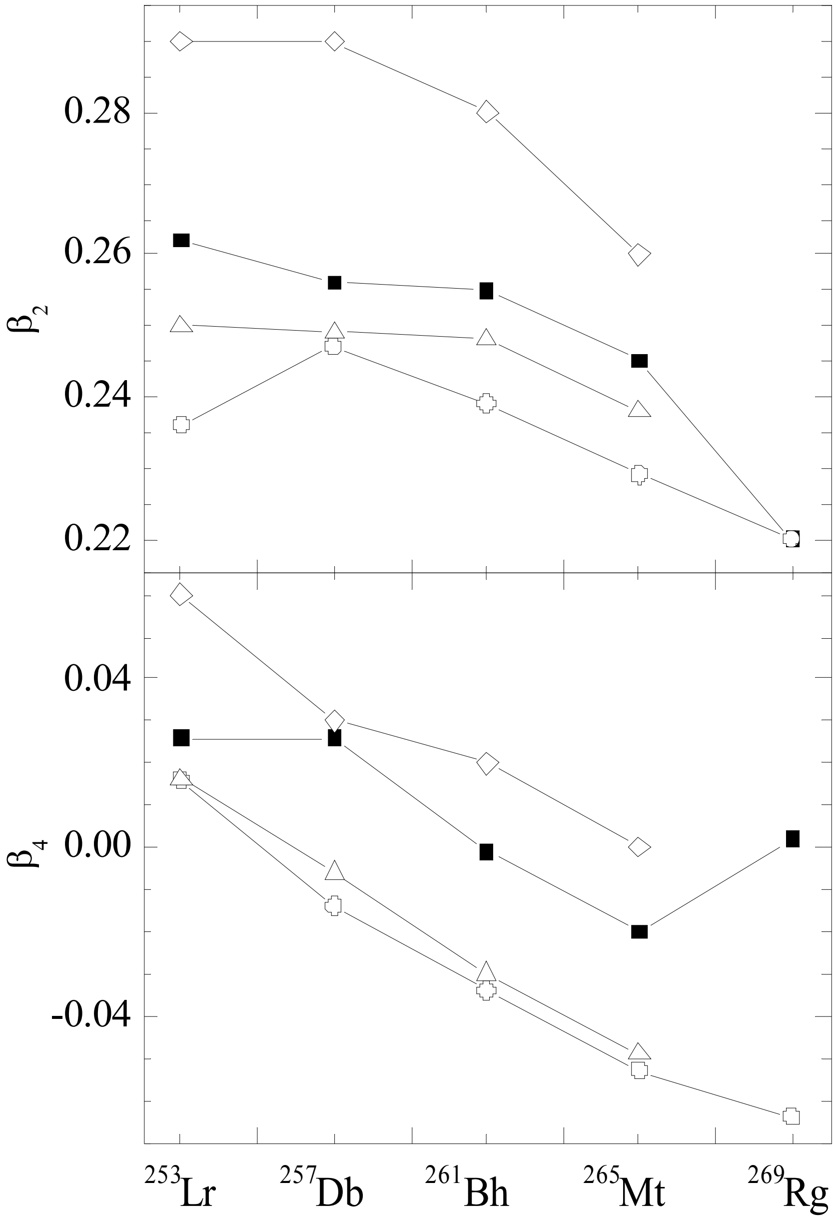


▪ TCSM

△ A. Sobiczewski et al.

○ P. Möller et al.

◇ S. Goriely et al.

Q_α energy

$$Q_\alpha(Z,A) = B(Z,A) + 28.296 - B(Z-2, A-4)$$

Alpha decay half-lives T_α (A. Sobiczewski et al.)

$$\log_{10} T_\alpha(Z,A) = 1.5372\, Z Q_\alpha^{-1/2} - 0.1607\, Z - 36.573$$

Strength parameters of paring interaction

$$G_{\substack{n\\p}} = \left(19.2 \mp 7.4\,\frac{N-Z}{A}\right) A^{-1}\,MeV$$

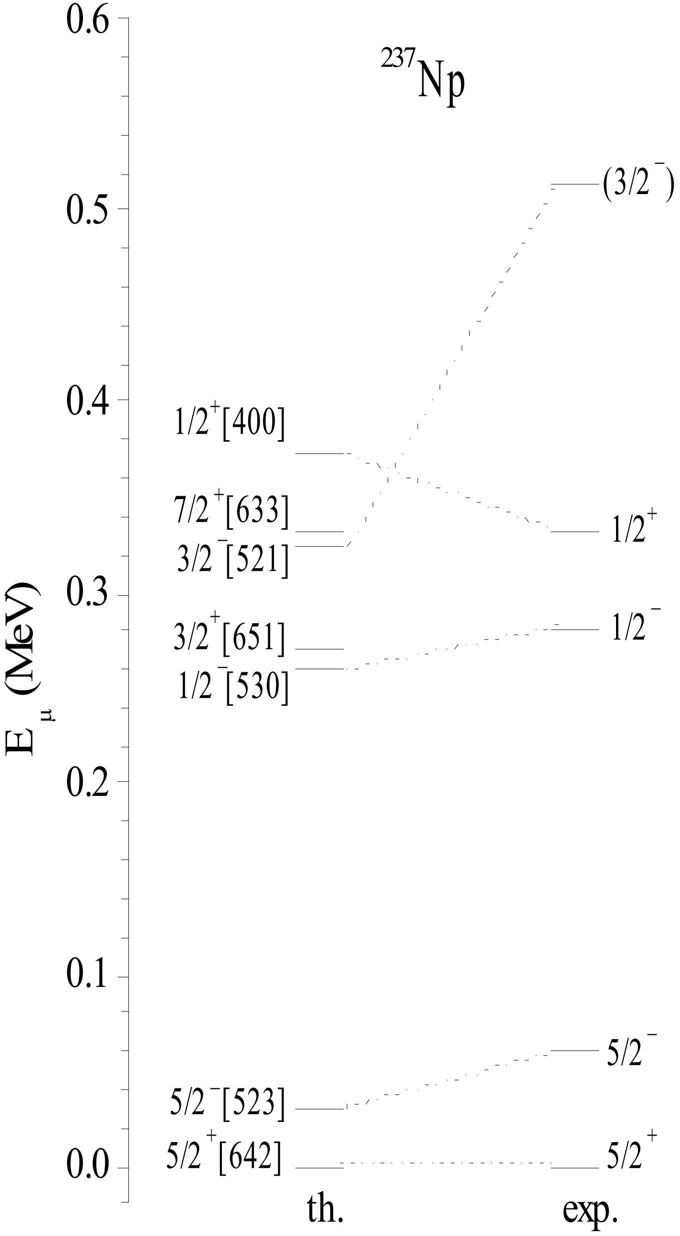
$$A \approx 250 \rightarrow G_n \approx 0.075\,MeV, G_p \approx 0.085\,MeV$$

One-quasiparticle excitations

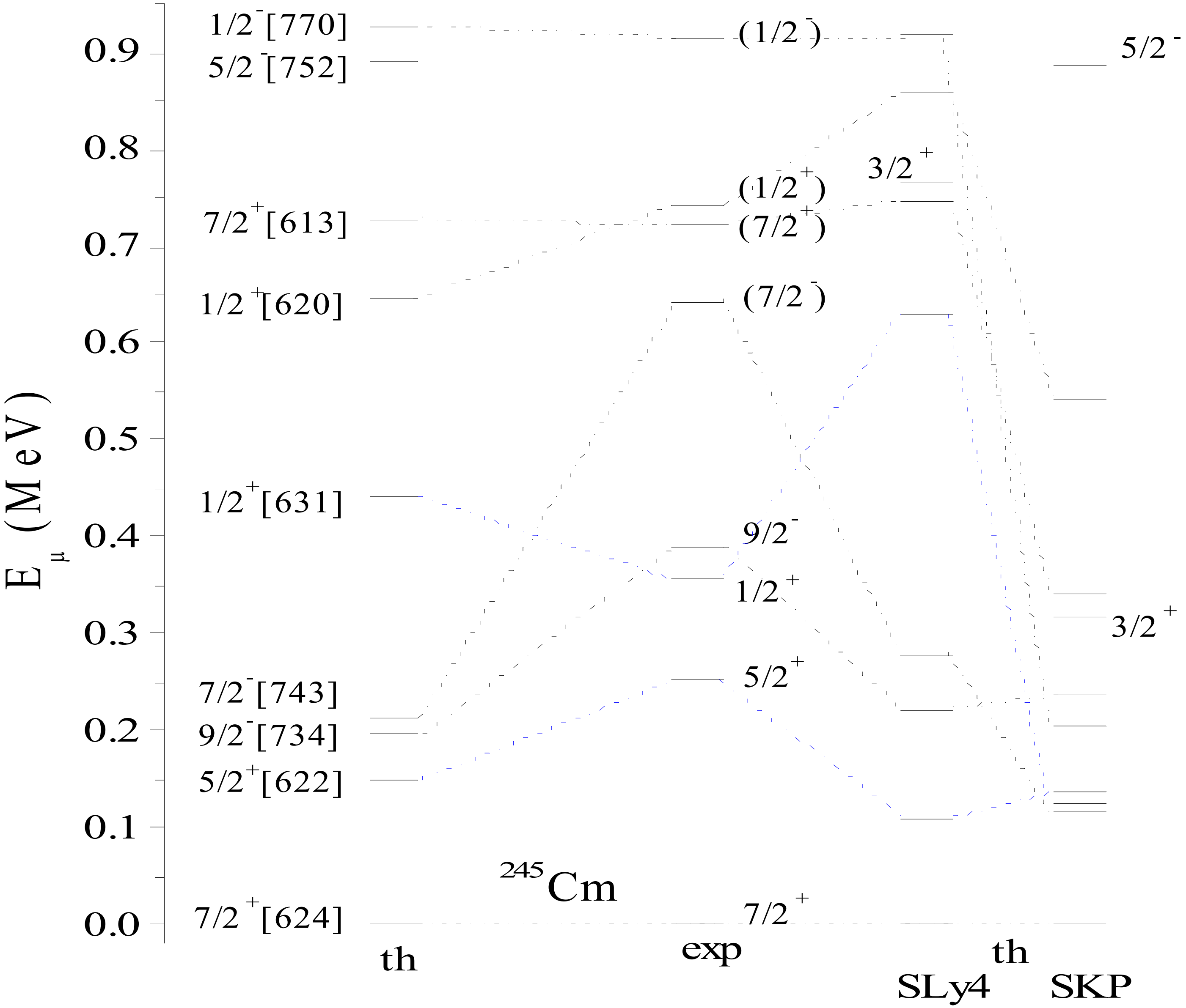
$$E_\mu = \sqrt{\left(e_\mu - e_F\right)^2 + \Delta^2} - \sqrt{\left(e_\mu{}' - e_F\right)^2 + \Delta^2}$$

Two-quasiparticle excitations

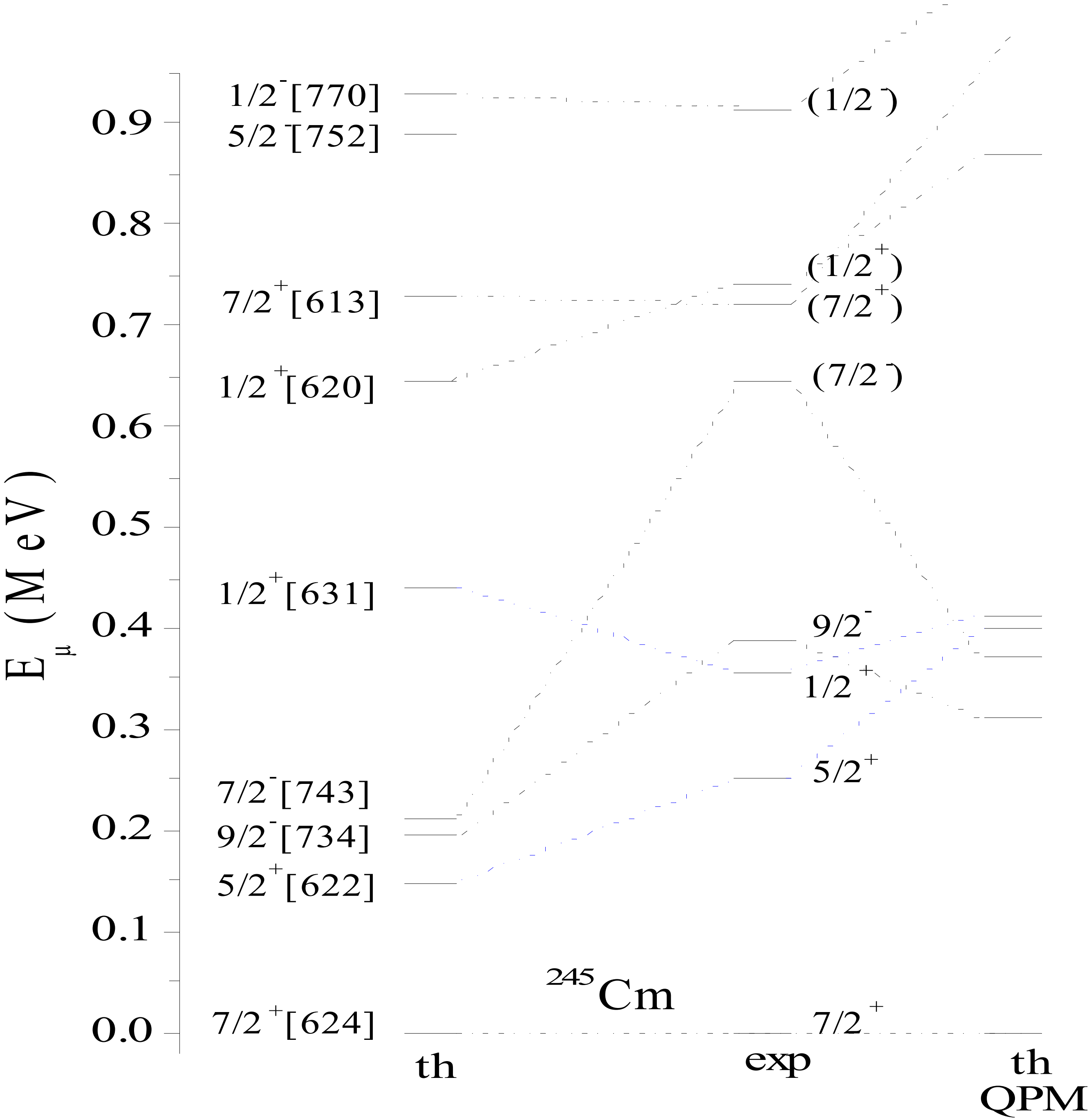
$$E_\mu = \sqrt{\left(e_\mu - e_F\right)^2 + \Delta^2} + \sqrt{\left(e_\mu{}' - e_F\right)^2 + \Delta^2}$$

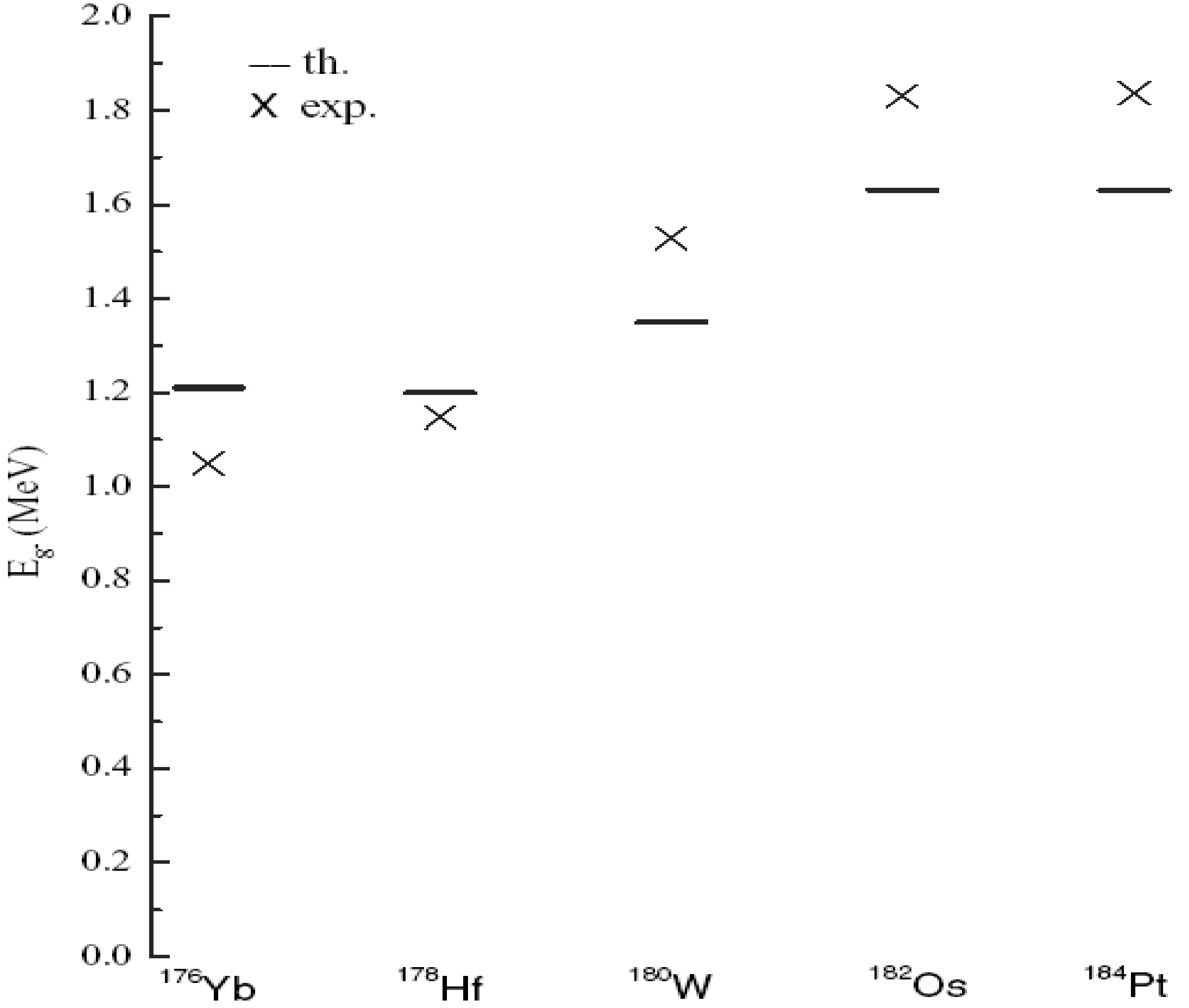


^{237}Np
E$_\mu$ (MeV)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
$1/2^+[400]$
$7/2^+[633]$
$3/2^-[521]$
$3/2^+[651]$
$1/2^-[530]$
$5/2^-[523]$
$5/2^+[642]$
$(3/2^-)$
$1/2^+$
$1/2^-$
$5/2^-$
$5/2^+$
th.
exp.

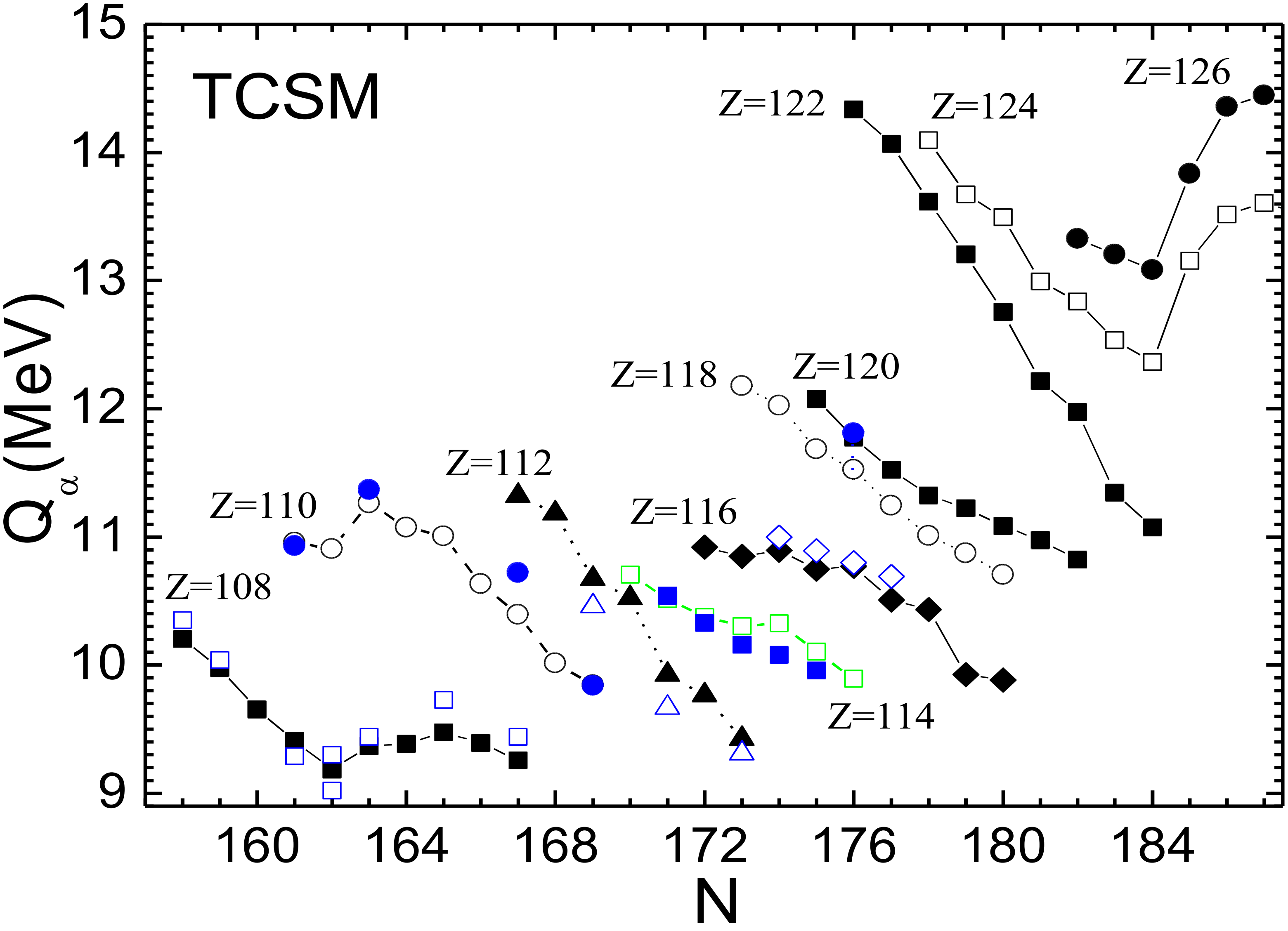


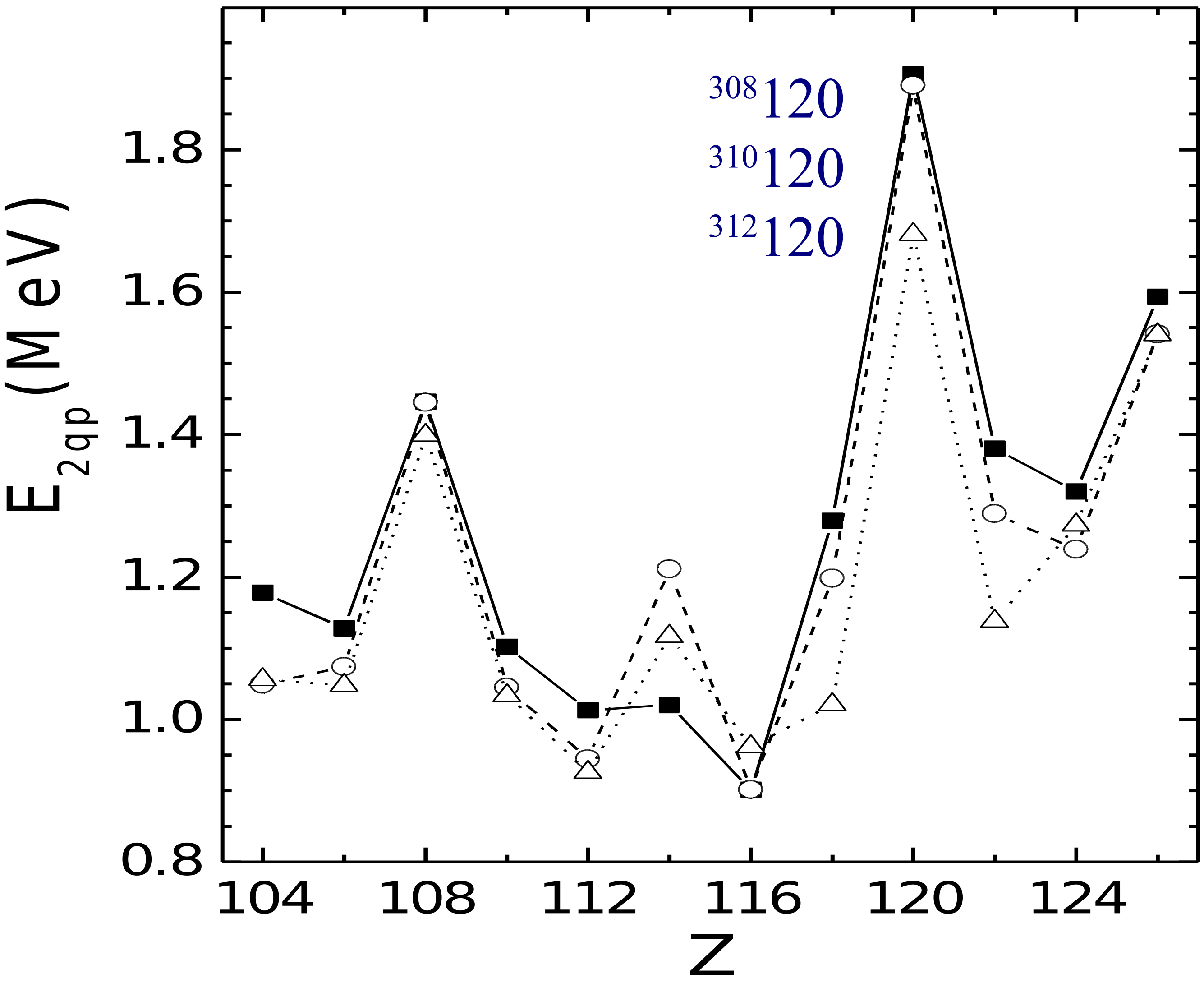
E_μ (MeV)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/2⁻[770]
5/2⁻[752]
7/2⁺[613]
1/2⁺[620]
1/2⁺[631]
7/2⁻[743]
9/2⁻[734]
5/2⁺[622]
7/2⁺[624]
(1/2⁻)
(1/2⁺)
(7/2⁺)
(7/2⁻)
9/2⁻
1/2⁺
5/2⁺
7/2⁺
3/2⁺
5/2⁻
3/2⁺
²⁴⁵Cm
th
exp
th
SLy4
SKP


E_μ (MeV)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1/2⁻[770]
5/2⁻[752]
7/2⁺[613]
1/2⁺[620]
1/2⁺[631]
7/2⁻[743]
9/2⁻[734]
5/2⁺[622]
7/2⁺[624]
(1/2⁻)
(1/2⁺)
(7/2⁺)
(7/2⁻)
9/2⁻
1/2⁺
5/2⁺
7/2⁺
²⁴⁵Cm
th
exp
th
QPM

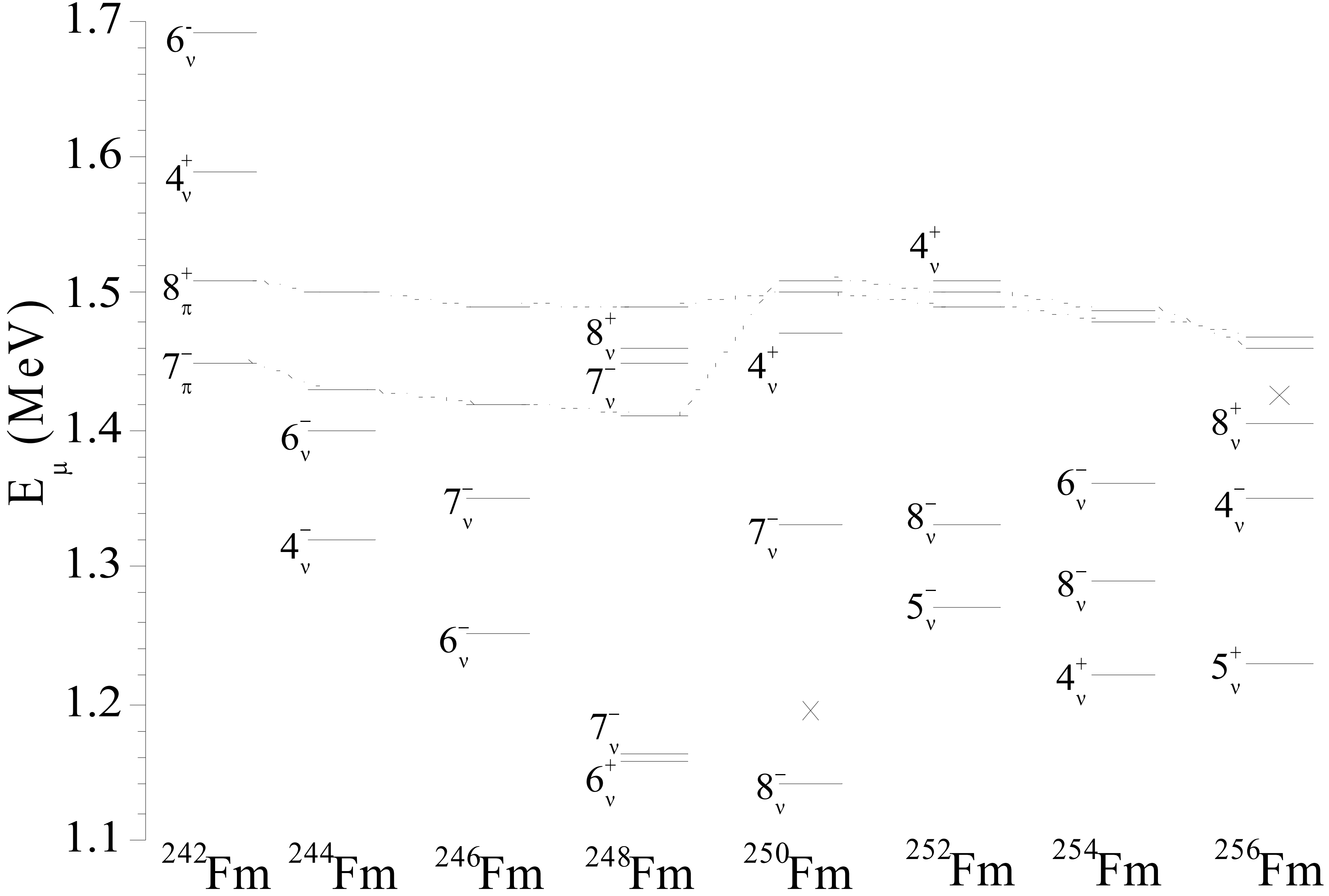


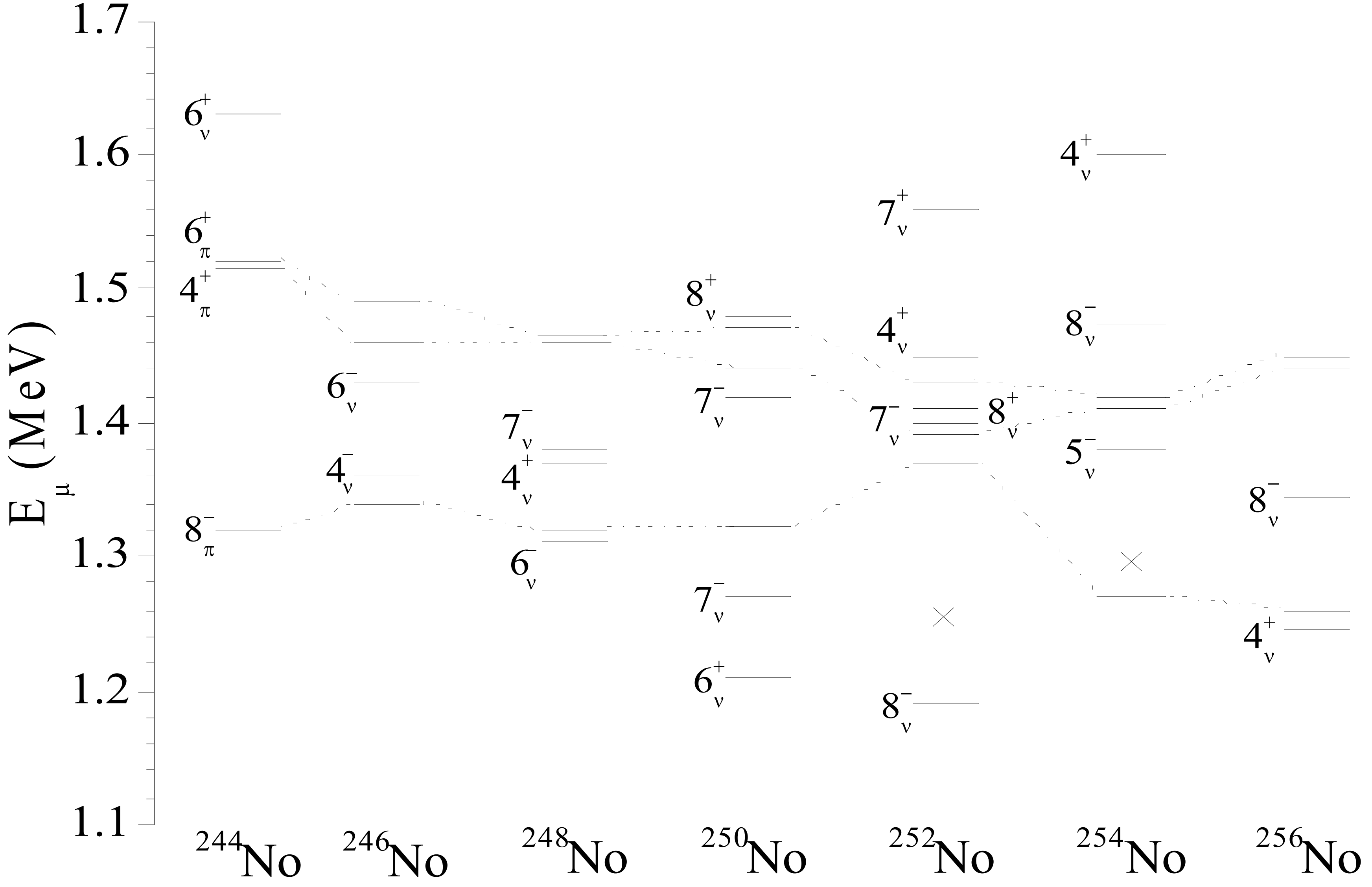
Calculated (th) and experimental (exp) energies E_{8^-} of two-quasiparticle states with $K^\pi = 8^-_\nu$ compared for the isotones from ^{176}Yb to ^{184}Pt.

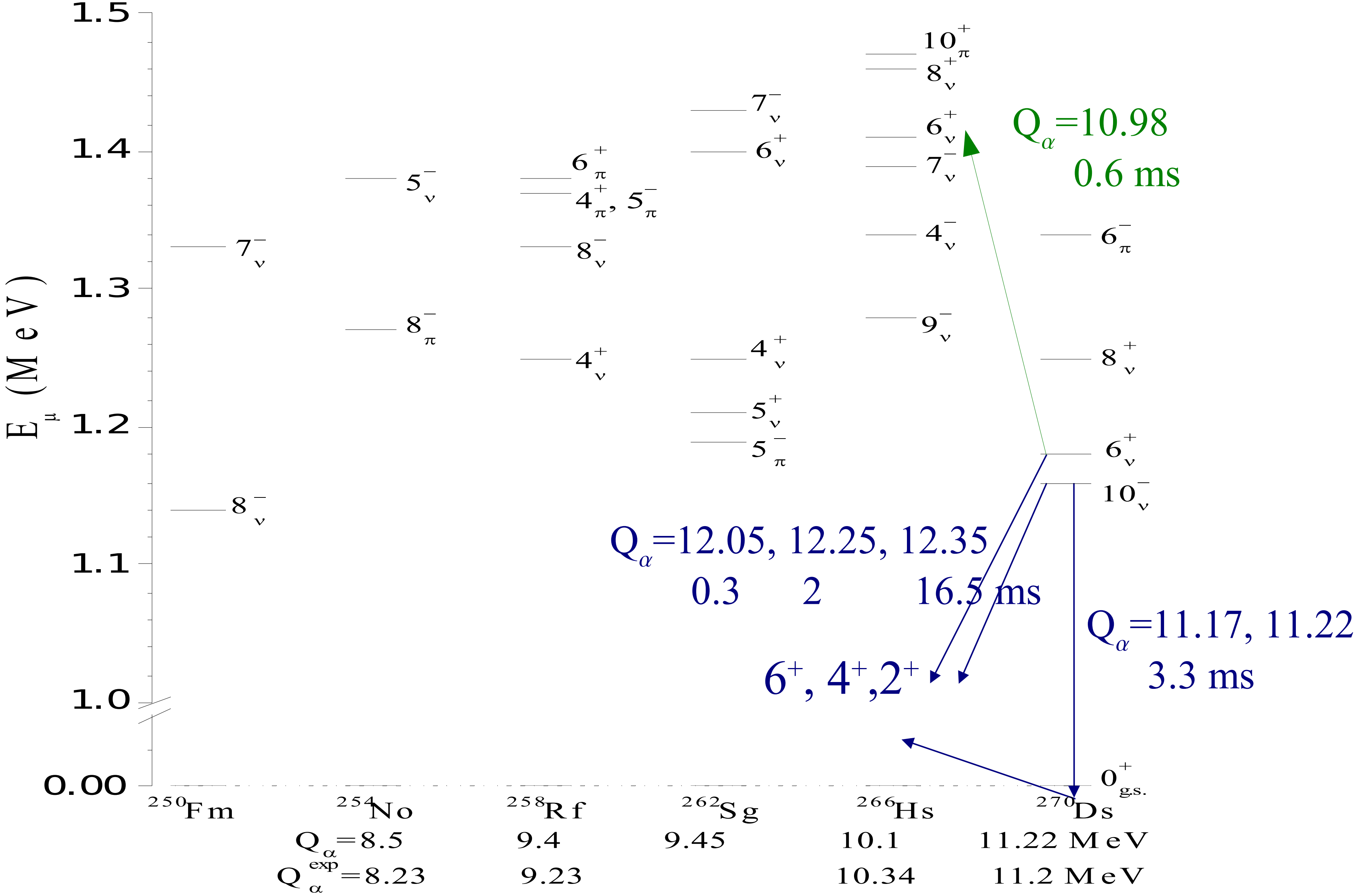

TCSM
Q_α (MeV)
N
Z=108
Z=110
Z=112
Z=114
Z=116
Z=118
Z=120
Z=122
Z=124
Z=126
9
10
11
12
13
14
15
160
164
168
172
176
180
184



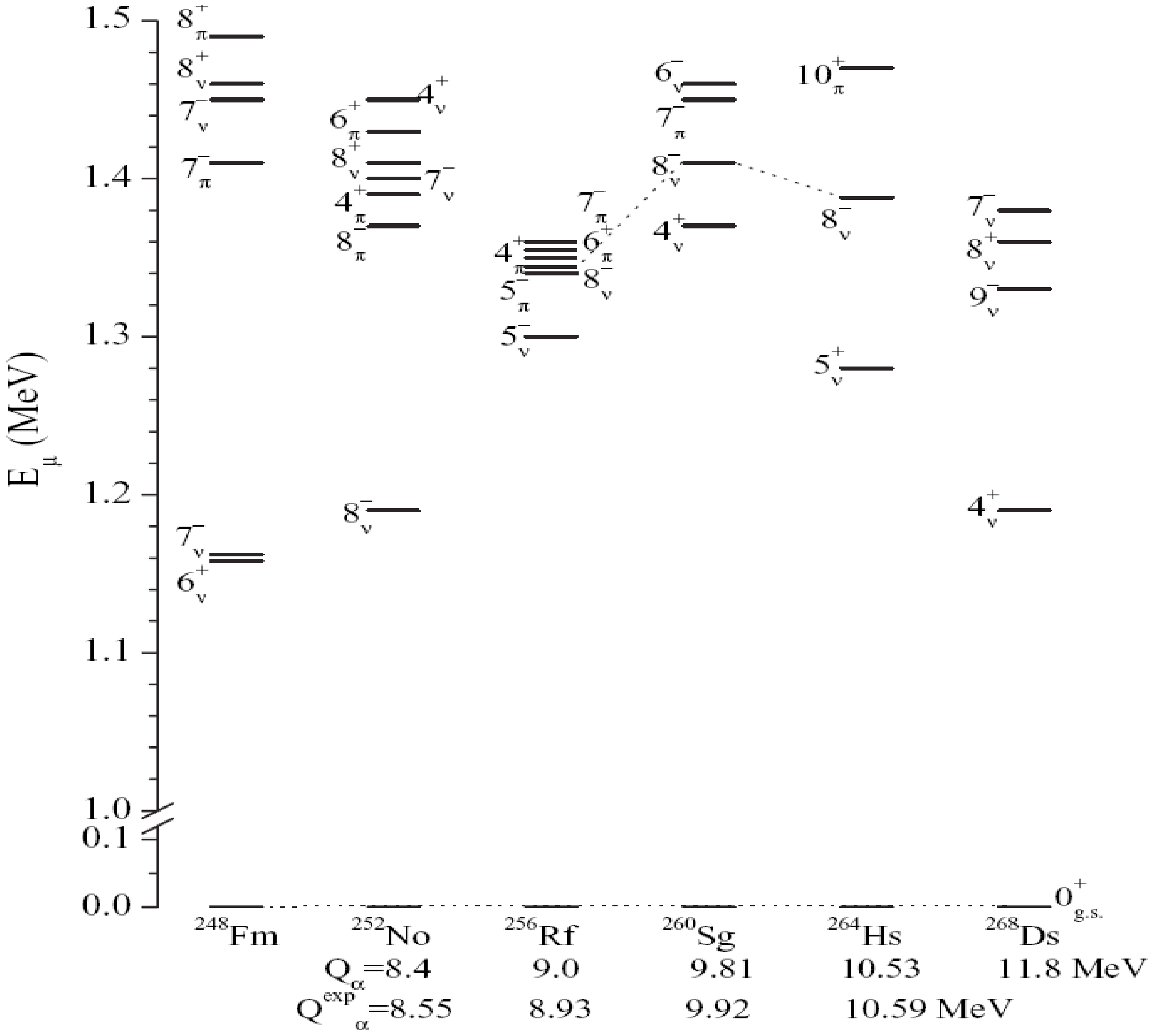
Energies of two-quasiproton states in alpha-decay chains containing indicated nuclei with Z=120


1.7
1.6
1.5
1.4
1.3
1.2
1.1
E_μ (MeV)
6^-_ν
4^+_ν
8^+_π
7^-_π
6^-_ν
4^-_ν
7^-_ν
6^-_ν
8^+_ν
7^-_ν
7^-_ν
6^+_ν
4^+_ν
7^-_ν
8^-_ν
4^+_ν
8^-_ν
5^-_ν
6^-_ν
8^-_ν
4^+_ν
8^+_ν
4^-_ν
5^+_ν
^{242}Fm
^{244}Fm
^{246}Fm
^{248}Fm
^{250}Fm
^{252}Fm
^{254}Fm
^{256}Fm


E_μ (MeV)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
244No
246No
248No
250No
252No
254No
256No
6+ν
6+π
4+π
8−π
6−ν
4−ν
7−ν
4+ν
6−ν
8+ν
7−ν
7−ν
6+ν
7+ν
4+ν
7−ν
8−ν
8+ν
4+ν
8−ν
5−ν
8−ν
4+ν


E_μ (MeV)
1.5
1.4
1.3
1.2
1.1
1.0
0.00
^{250}Fm
^{254}No
^{258}Rf
^{262}Sg
^{266}Hs
^{270}Ds
8^-_ν
7^-_ν
8^-_π
5^-_ν
4^+_ν
8^-_ν
4^+_π, 5^-_π
6^+_π
5^-_π
5^+_ν
4^+_ν
6^+_ν
7^-_ν
9^-_ν
4^-_ν
7^-_ν
6^+_ν
8^+_ν
10^+_π
$0^+_{g.s.}$
10^-_ν
6^+_ν
8^+_ν
6^-_π
Q_α=10.98
0.6 ms
Q_α=12.05, 12.25, 12.35
0.3 2 16.5 ms
Q_α=11.17, 11.22
3.3 ms
6^+, 4^+,2^+
Q_α=8.5 9.4 9.45 10.1 11.22 MeV
Q_α^{exp}=8.23 9.23 10.34 11.2 MeV

Nucleus	Decay mode	Q_α (MeV)	T_α	$T_{1/2}^{\rm exp.}$
^{270}Ds	$0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	11.22	0.17 ms	0.1 ms, %$\alpha \approx 100$
	$0^+_{\rm g.s.} \xrightarrow{\alpha} 2^+_{\rm g.s.}$	11.17	3.3 ms	
	$10^-_\nu, 6^+_\nu \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	11.22		
	$10^-_\nu \xrightarrow{\alpha} 10^-_{K=1^-} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	11.3	10 ms	
	$6^+_\nu \xrightarrow{\alpha} 6^+_{\rm g.s.} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	12.05	0.3 ms	
	$6^+_\nu \xrightarrow{\alpha} 4^+_{\rm g.s.} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	12.25	2 ms	
	$6^+_\nu \xrightarrow{\alpha} 2^+_{\rm g.s.} \xrightarrow{\gamma} 0^+_{\rm g.s.}$	12.35	16.5 ms	
	$6^+_\nu \xrightarrow{\alpha} 6^+_\nu$	10.98	0.6 ms	
^{266}Hs	$0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	10.1	37 ms	2.3 ms, %$\alpha \approx 100$
	$9^-_\nu, 4^-_\nu \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	10.1		
	$9^-_\nu \xrightarrow{\alpha} 9^-_{K=1^-} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	10.33	530 ms	
	$4^-_\nu \xrightarrow{\alpha} 4^-_{K=1^-} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	10.7	67 ms	
^{262}Sg	$0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	9.45	250 ms	6.9 ms, %SF $\geqslant 78$
	$5^-_\pi, 5^+_\nu \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.} \xrightarrow{\rm SF}$			
	$5^-_\pi, 5^+_\nu \xrightarrow{\rm SF}$			
^{258}Rf	$0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	9.4	72 ms	14.7 ms, %$\alpha \approx 31 \pm 11$,
	$4^+_\nu, 8^-_\nu \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.} \xrightarrow{{\rm SF},\alpha}$			$T_\alpha^{\rm exp.} = 47^{+24}_{-12}$ ms
	$4^+_\nu, 8^-_\nu \xrightarrow{\rm SF}$			
	$4^+_\nu \xrightarrow{\alpha} 4^+_{\rm g.s.} \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.}$	10.51	11 ms	
^{254}No	$0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$	8.45	9.4 s	51 s, %$\alpha \approx 90$
	$8^-_\pi \xrightarrow{\gamma' {\rm s}} 0^+_{\rm g.s.} \xrightarrow{\alpha} 0^+_{\rm g.s.}$			


E_μ (MeV)
1.5
1.4
1.3
1.2
1.1
1.0
0.1
0.0
8+π
8+ν
7−ν
7−π
7−ν
6+ν
6+π
8+ν
4+π
8−π
4+ν
7−ν
8−ν
4+π
5−π
5−ν
7−π
6+π
8−ν
6−ν
7−π
8−ν
4+ν
10+π
8−ν
5+ν
7−ν
8+ν
9−ν
4+ν
0+g.s.
248Fm
252No
256Rf
260Sg
264Hs
268Ds
Qα=8.4
9.0
9.81
10.53
11.8 MeV
Qαexp=8.55
8.93
9.92
10.59 MeV

Nucleus	Decay mode	Q_α (MeV)	T_α	$T_{1/2}^{\mathrm{exp.}}$
^{268}Ds	$0^+_{\mathrm{g.s.}} \xrightarrow{\alpha} 0^+_{\mathrm{g.s.}}$	11.8	9.4 μs	
	$4^+_{\nu} \xrightarrow{\alpha} 4^+_{\mathrm{g.s.}}$	12.86	8 μs	
	$9^-_{\nu} \xrightarrow{\alpha} 9^-_{\mathrm{g.s.}} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}}$	12.07	0.26 ms	
	$8^+_{\nu} \xrightarrow{\alpha} 8^+_{\mathrm{g.s.}} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}}$	12.71	15 μs	
^{264}Hs	$0^+_{\mathrm{g.s.}} \xrightarrow{\alpha} 0^+_{\mathrm{g.s.}}$	10.53	1.7 ms	≈ 0.8 ms, %$\alpha \approx 50$, %SF ≈ 50
	$8^-_{\nu} \xrightarrow{\alpha} 8^-_{\nu}$	10.508	1.9 ms	
	$5^+_{\nu} \xrightarrow{\alpha} 4^-_{K=1^-} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}}$	11.04	55 ms	
	$8^-_{\nu} \xrightarrow{\alpha} 8^-_{K=1^-} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}}$	10.87	27 ms	
^{260}Sg	$0^+_{\mathrm{g.s.}} \xrightarrow{\alpha} 0^+_{\mathrm{g.s.}}$	9.81	26 ms	3.6 ms, %$\alpha \approx 50$, %SF ≈ 50
	$8^-_{\nu} \xrightarrow{\alpha} 8^-_{\nu}$	9.92	13.4 ms	
	$4^+_{\nu} \xrightarrow{\alpha} 4^+_{\mathrm{g.s.}} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}}$	11.04	2.7 ms	
^{256}Rf	$0^+_{\mathrm{g.s.}} \xrightarrow{\alpha} 0^+_{\mathrm{g.s.}}$	9	1 s	6.4 ms, %$\alpha \approx 0.32$, %SF ≈ 99.68
	$8^-_{\nu} \xrightarrow{\alpha} 8^-_{\nu}$	9.12	0.45 s	
^{252}No	$0^+_{\mathrm{g.s.}} \xrightarrow{\alpha} 0^+_{\mathrm{g.s.}}$	8.4	13.6	2.4 s, %$\alpha > 66.7$, %SF $= 32.2$
	$8^-_{\pi} \xrightarrow{\gamma' \mathrm{s}} 0^+_{\mathrm{g.s.}} \xrightarrow{\alpha}$	8.4		

The nuclei ^{248,252}Fm, ^{256}No, and ^{262}Sg produced in the reactions ^{20}Ne + ^{232}Th, ^{12}C + ^{248}Cm, ^{22}Ne+^{238}U, and ^{18}O+^{249}Cf seem to be good candidates for studying the low-lying *K* isomers.

^{64}Ni+^{207}Pb$\rightarrow$^{270}Ds+1n

ground state: $E_{CN}^{*} \approx 14$ MeV

2qp isomer state: $E_{CN}^{*} \approx 14 - E_{\mu} \approx 12.8$ MeV

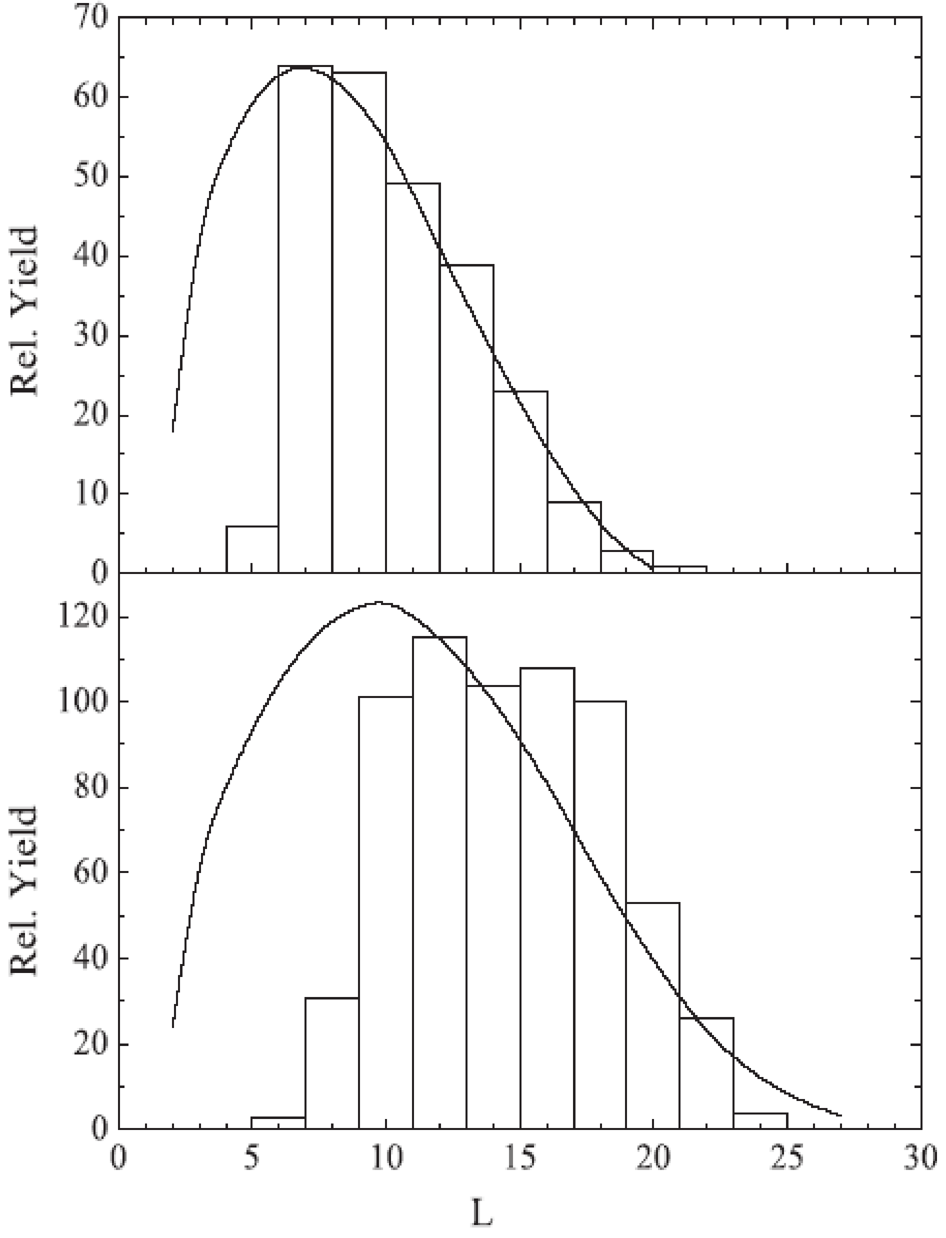
W_{sur}(isomer)/W_{sur}(gs)≈ 2

For $E_{\mu} \approx 1.2$ MeV, the population of isomer state is $\approx \exp(-(E_{\mu}-E_{rot})/T) \approx 0.32$.

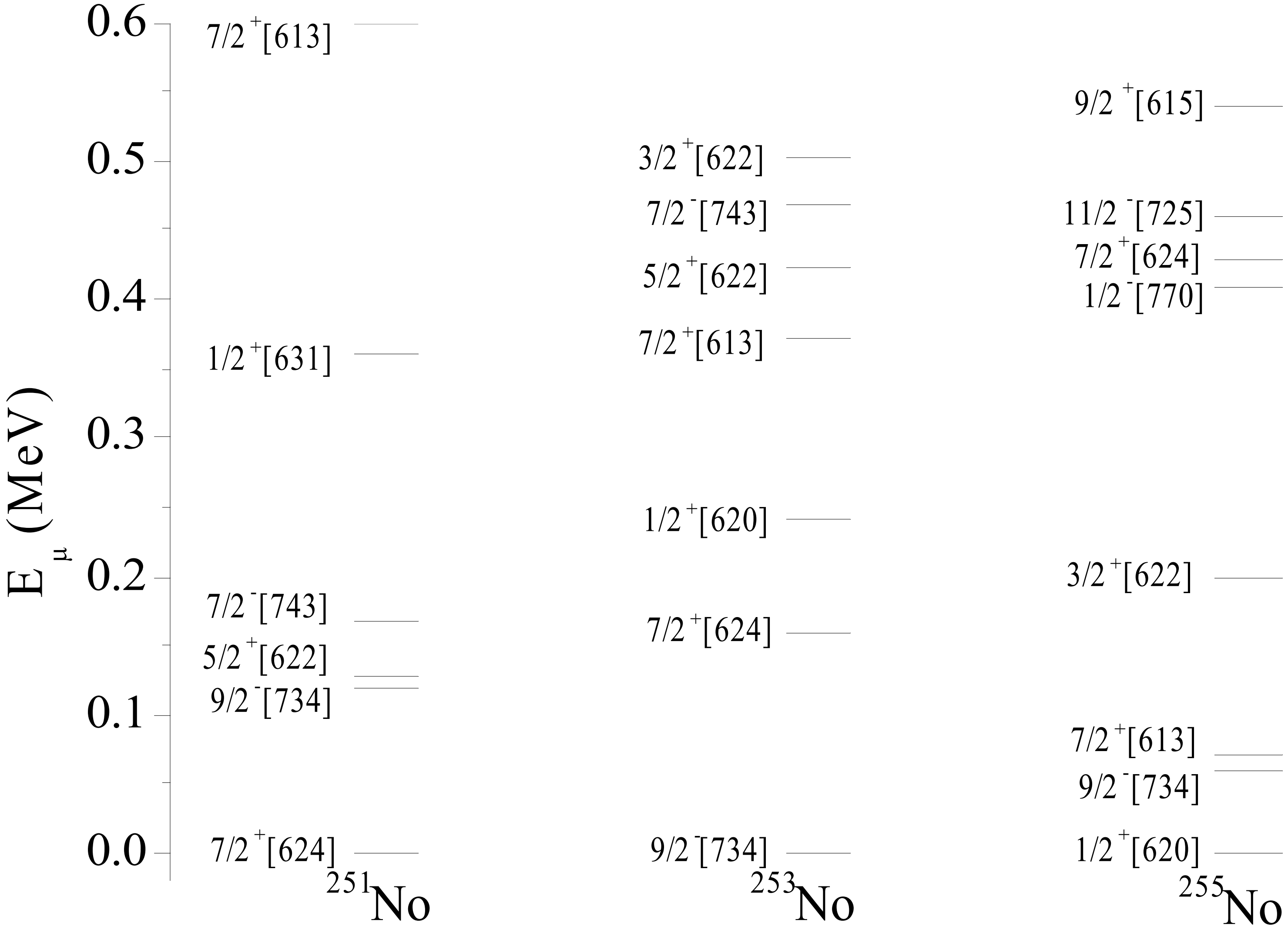
σ_{ER}(gs)/σ_{ER}(isomer)$\approx 0.68:0.64$

exp.: $\approx 1:1$

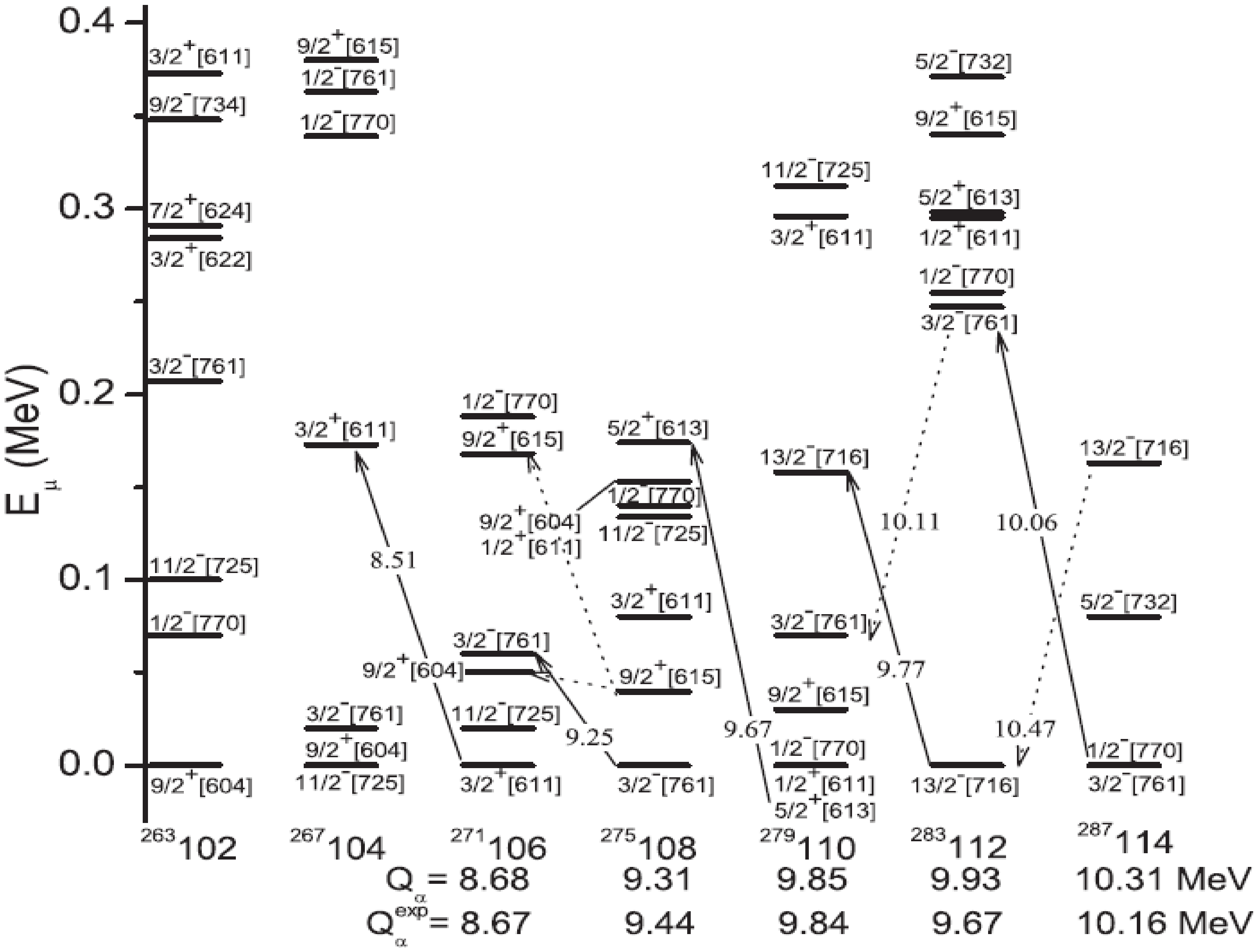
PRC 81, 024320 (2010)



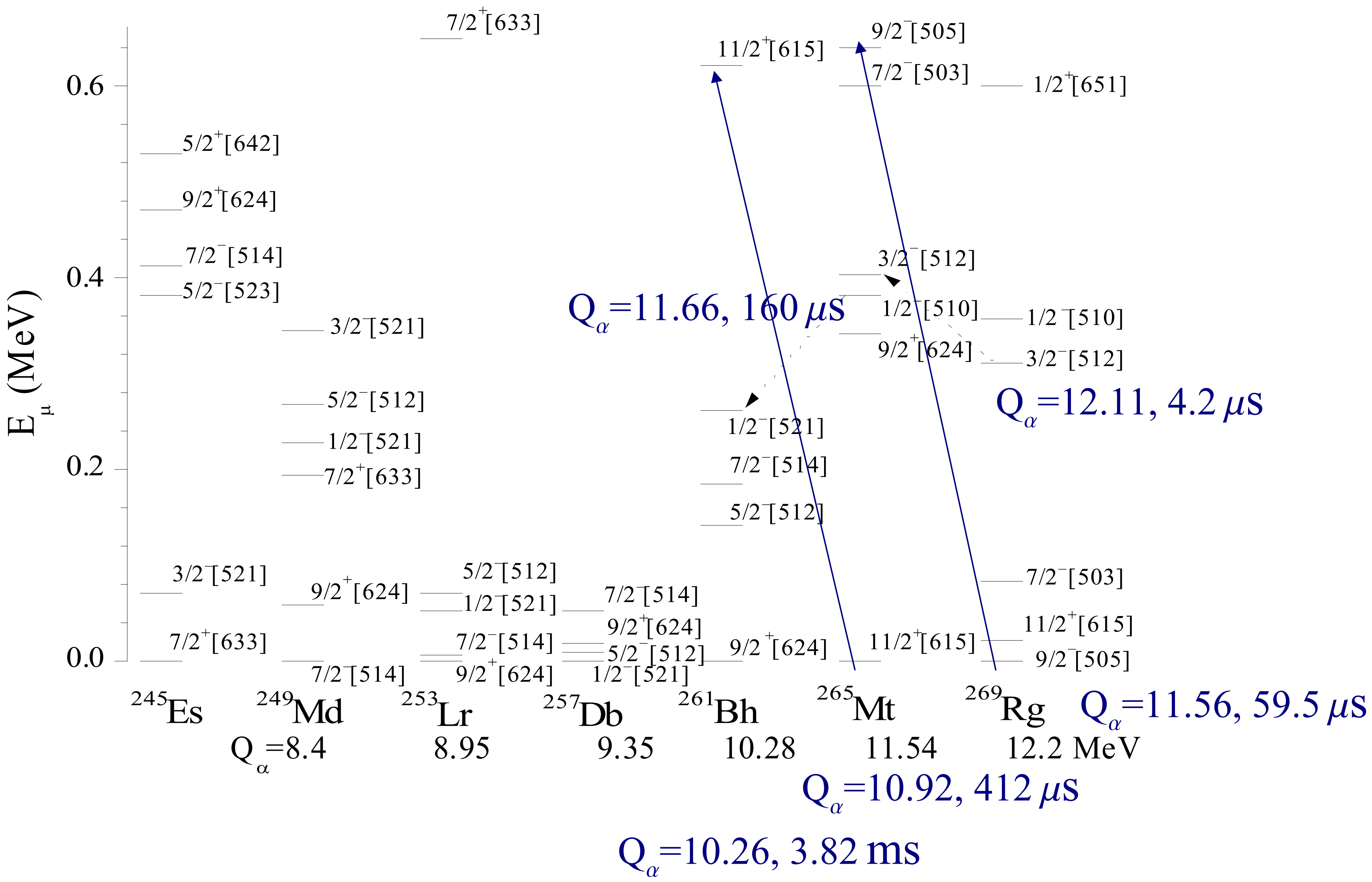
The entry spin distribution of ^{254}No, produced in the reaction ^{208}Pb(^{48}Ca,2*n*)^{254}No at beam energies 215 MeV (upper part) and 219 MeV (lower part). The experimental data from Phys. Rev. Lett. 84, 3542 (2000) are presented by squares.

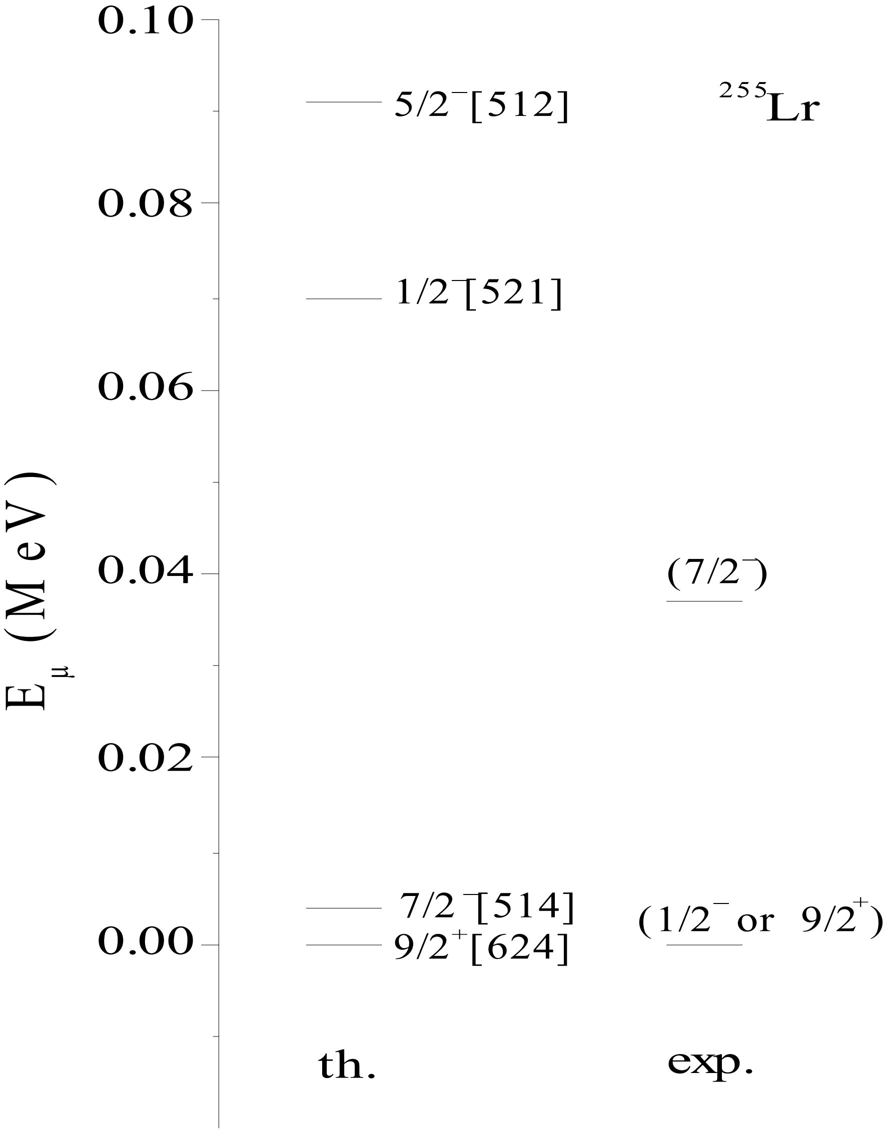


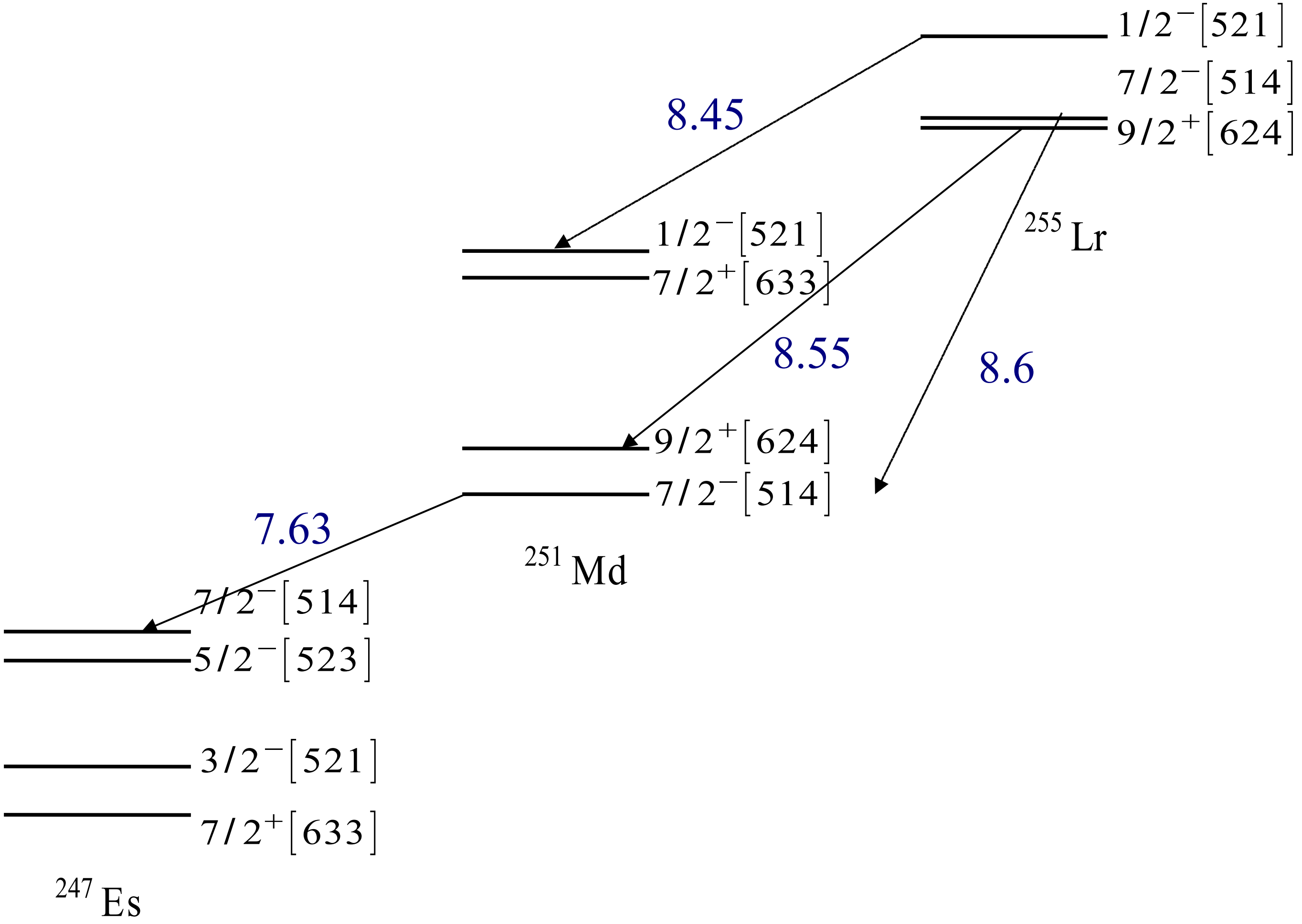
E_μ (MeV)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
7/2+[613]
1/2+[631]
7/2-[743]
5/2+[622]
9/2-[734]
7/2+[624]
251No
3/2+[622]
7/2-[743]
5/2+[622]
7/2+[613]
1/2+[620]
7/2+[624]
9/2-[734]
253No
9/2+[615]
11/2-[725]
7/2+[624]
1/2-[770]
3/2+[622]
7/2+[613]
9/2-[734]
1/2+[620]
255No



E_μ (MeV)
0.4
0.3
0.2
0.1
0.0
3/2+[611]
9/2-[734]
7/2+[624]
3/2+[622]
3/2-[761]
11/2-[725]
1/2-[770]
9/2+[604]
9/2+[615]
1/2-[761]
1/2-[770]
3/2+[611]
3/2-[761]
9/2+[604]
11/2-[725]
1/2-[770]
9/2+[615]
9/2+[604]
1/2+[611]
3/2-[761]
9/2+[604]
11/2-[725]
3/2+[611]
5/2+[613]
1/2-[770]
11/2-[725]
3/2+[611]
9/2+[615]
3/2-[761]
11/2-[725]
3/2+[611]
13/2-[716]
3/2-[761]
9/2+[615]
1/2-[770]
1/2+[611]
5/2+[613]
5/2-[732]
9/2+[615]
5/2+[613]
1/2+[611]
1/2-[770]
3/2-[761]
13/2-[716]
13/2-[716]
5/2-[732]
1/2-[770]
3/2-[761]
8.51
9.25
9.67
9.77
10.11
10.06
10.47
$^{263}102$
$^{267}104$
$^{271}106$
$^{275}108$
$^{279}110$
$^{283}112$
$^{287}114$
Q_α = 8.68 9.31 9.85 9.93 10.31 MeV
Q_α^{exp} = 8.67 9.44 9.84 9.67 10.16 MeV

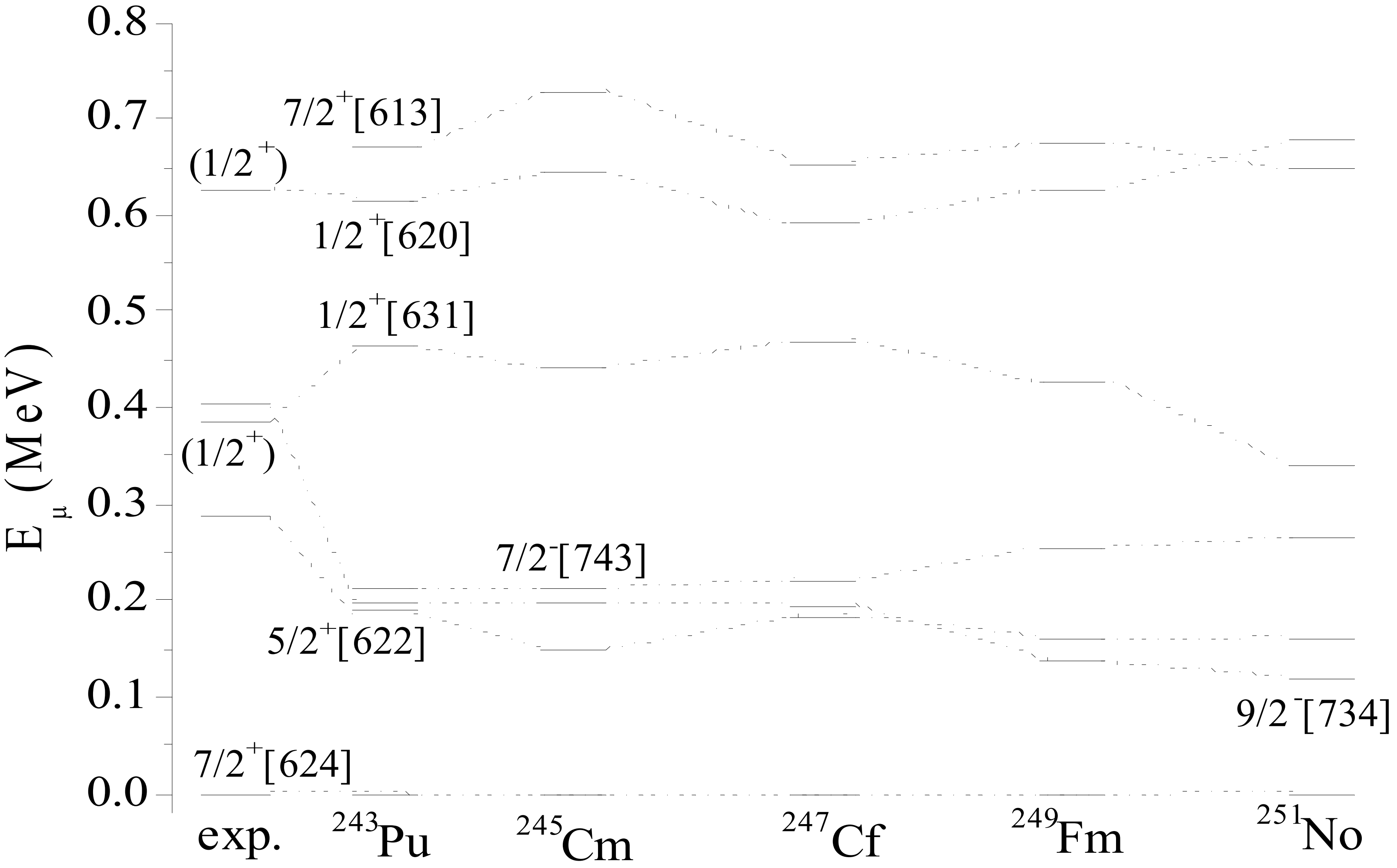

E_μ (MeV)
0.0
0.2
0.4
0.6
5/2+[642]
9/2+[624]
7/2−[514]
5/2−[523]
3/2−[521]
7/2+[633]
3/2−[521]
5/2−[512]
1/2−[521]
7/2+[633]
9/2+[624]
7/2−[514]
7/2+[633]
5/2−[512]
1/2−[521]
7/2−[514]
9/2+[624]
7/2−[514]
9/2+[624]
5/2−[512]
1/2−[521]
11/2+[615]
1/2−[521]
7/2−[514]
5/2−[512]
9/2+[624]
9/2−[505]
7/2−[503]
3/2−[512]
1/2−[510]
9/2+[624]
11/2+[615]
1/2+[651]
1/2−[510]
3/2−[512]
7/2−[503]
11/2+[615]
9/2−[505]
Q_α=11.66, 160 μs
Q_α=12.11, 4.2 μs
Q_α=11.56, 59.5 μs
Q_α=10.92, 412 μs
Q_α=10.26, 3.82 ms
^{245}Es
^{249}Md
^{253}Lr
^{257}Db
^{261}Bh
^{265}Mt
^{269}Rg
Q_α=8.4
8.95
9.35
10.28
11.54
12.2 MeV


0.10
0.08
0.06
0.04
0.02
0.00
E_μ (MeV)
5/2⁻[512]
1/2⁻[521]
7/2⁻[514]
9/2⁺[624]
²⁵⁵Lr
(7/2⁻)
(1/2⁻ or 9/2⁺)
th.
exp.


1/2⁻[521]
7/2⁻[514]
9/2⁺[624]
255 Lr
8.45
8.55
8.6
1/2⁻[521]
7/2⁺[633]
9/2⁺[624]
7/2⁻[514]
251 Md
7.63
7/2⁻[514]
5/2⁻[523]
3/2⁻[521]
7/2⁺[633]
247 Es

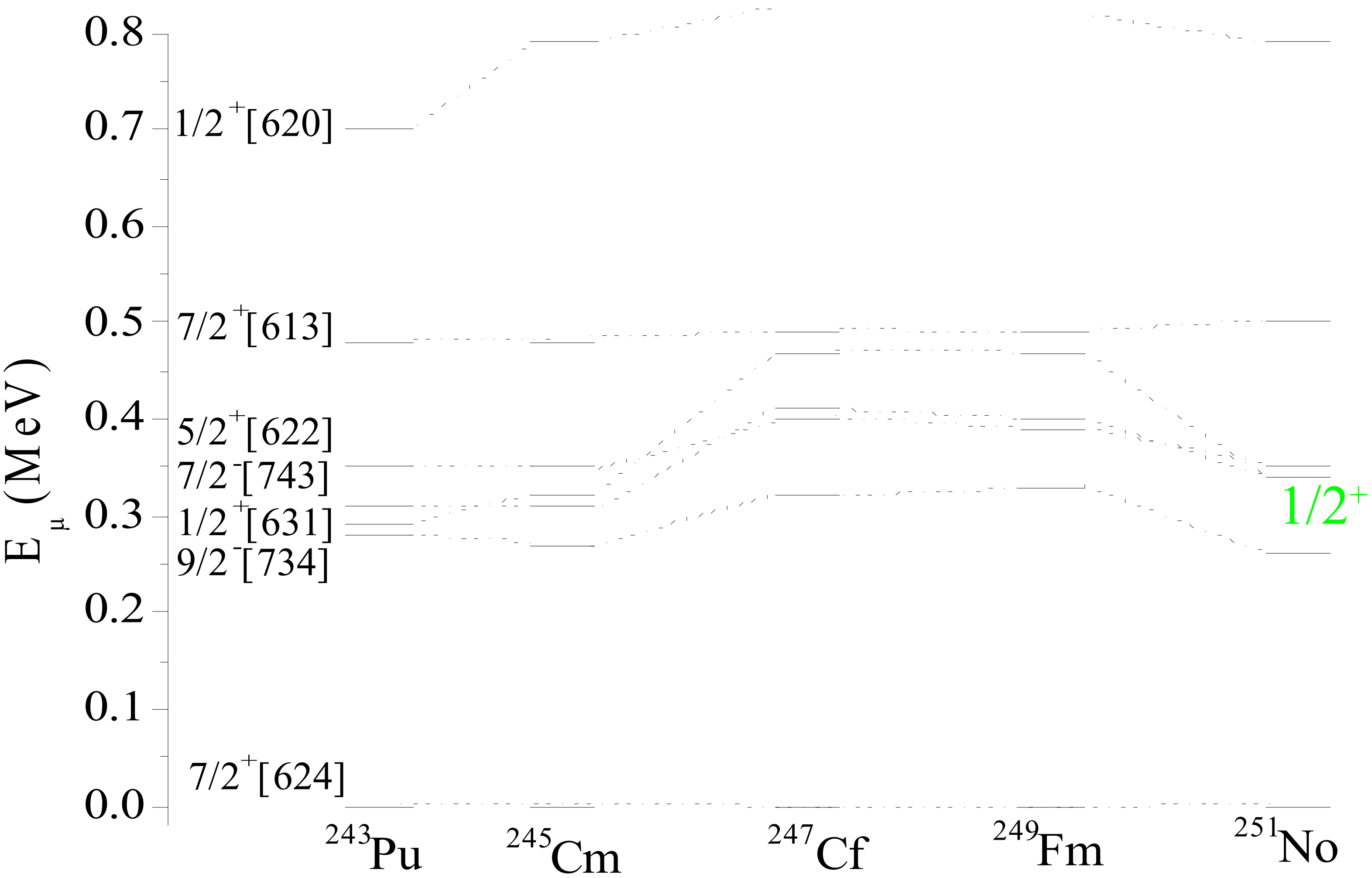
N=149 isotones

TCSM



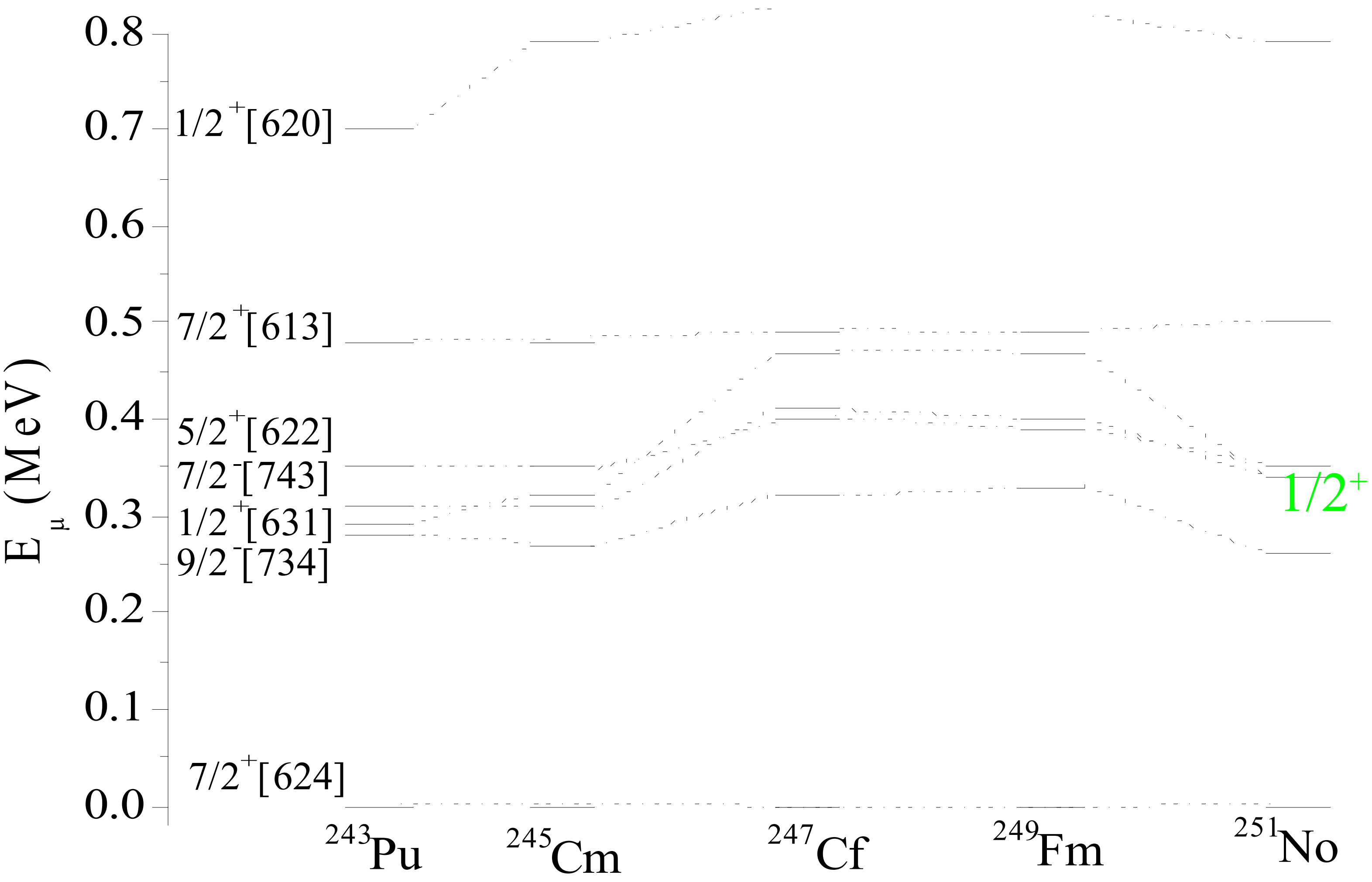
N=149 isotones

QPM



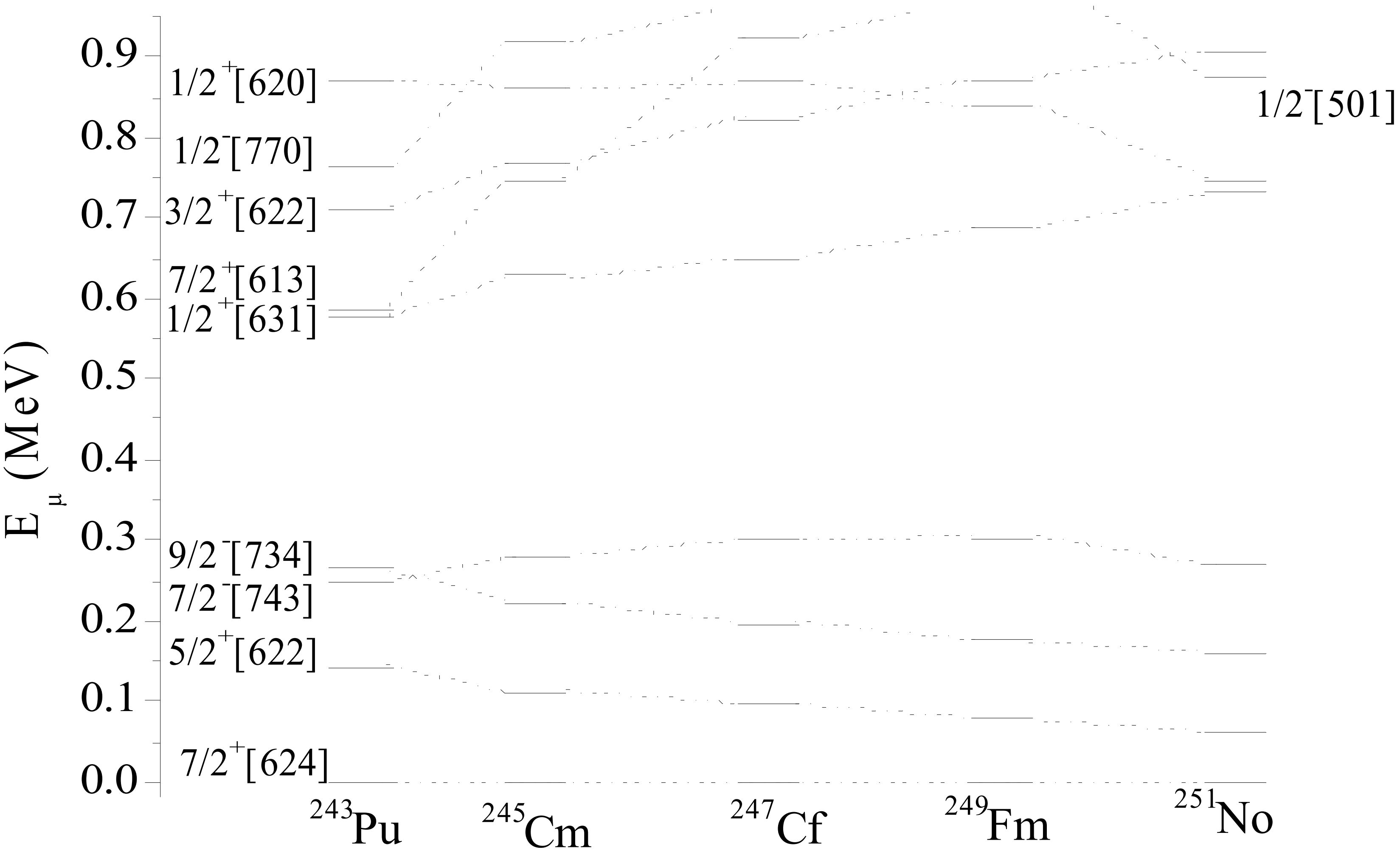
N=149 isotones

QPM

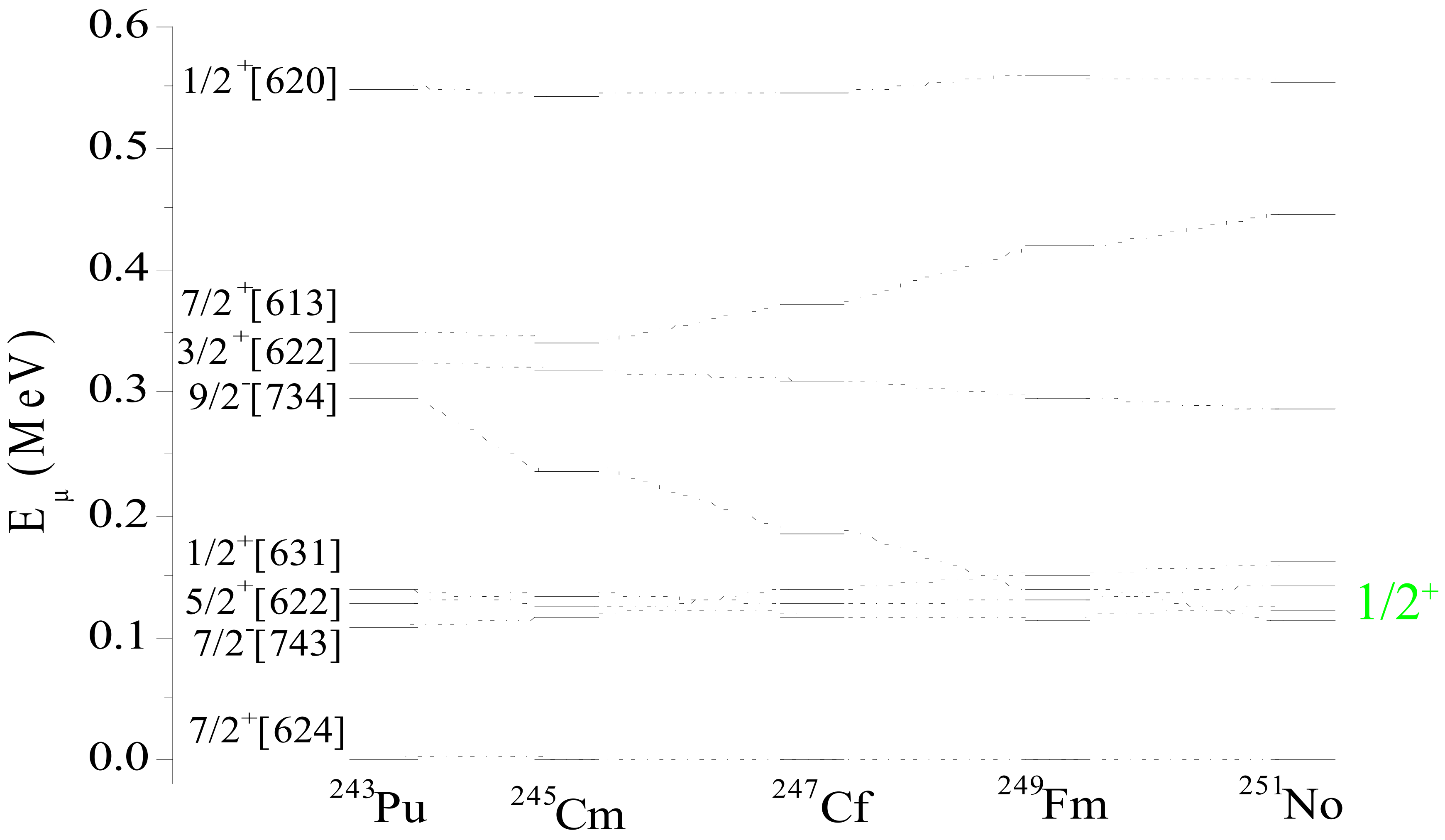


N=149 isotones

SLy4



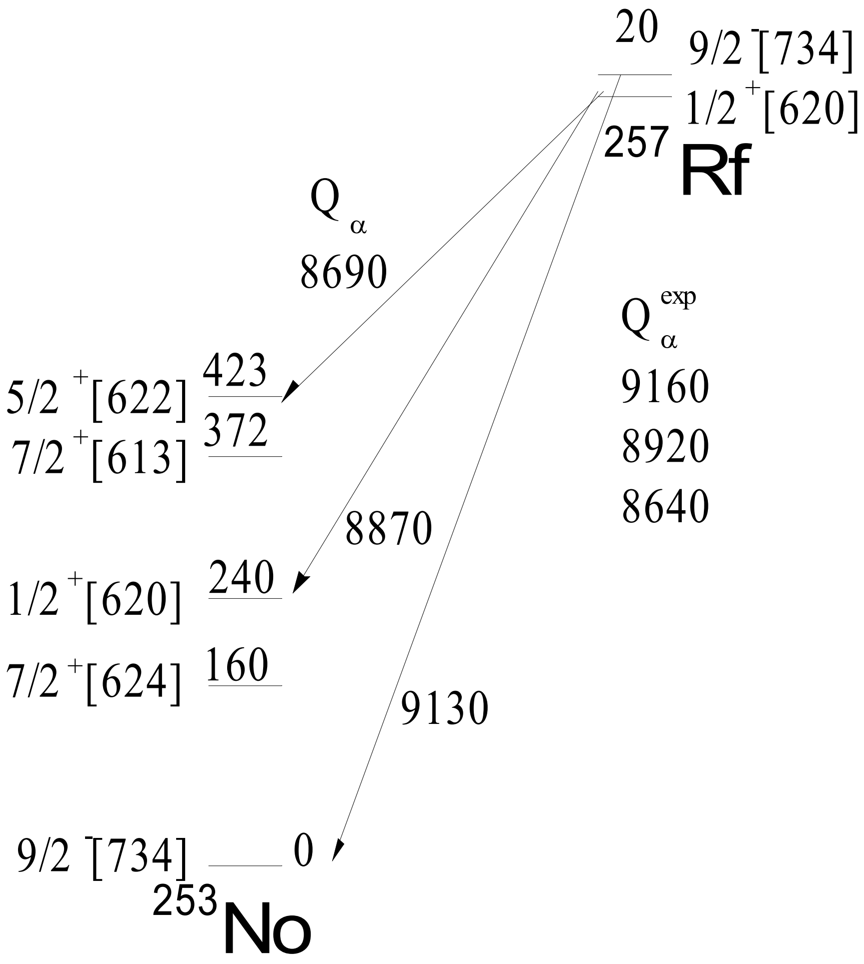
N=149 isotones SkP



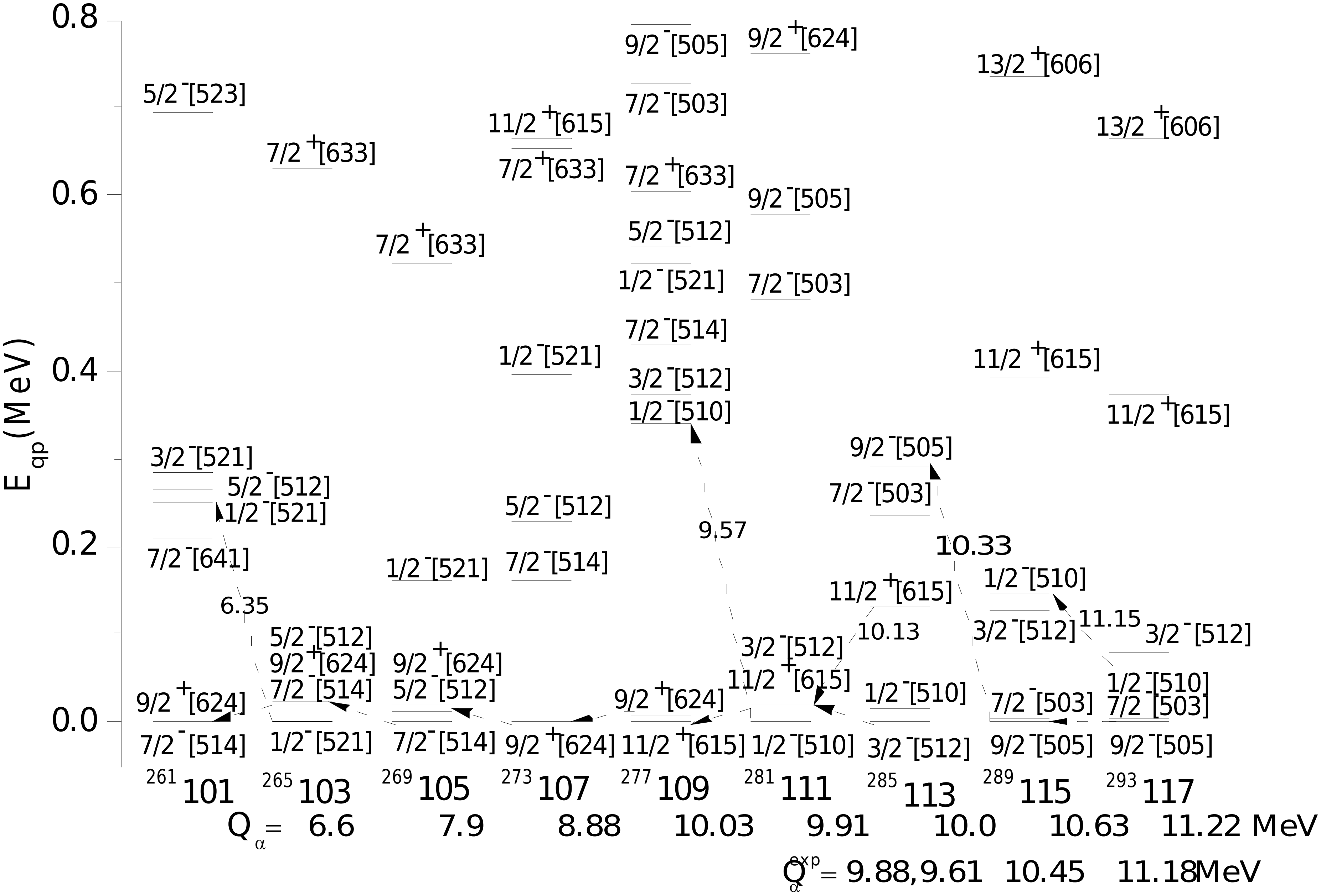
The smooth change of energies of almost all one-quasiparticle states in the isotone chain.

The deformation parameters of the N=149 nuclei treated are almost the same. Although different methods of calculations give various deformations of the ground state. For example, in the case of ^{251}No β_2=0.234 and β_4=0.057 are resulted from the TCSM, β_2=0.296 and β_4=0.01 from the HB with Sly4 parameterization.

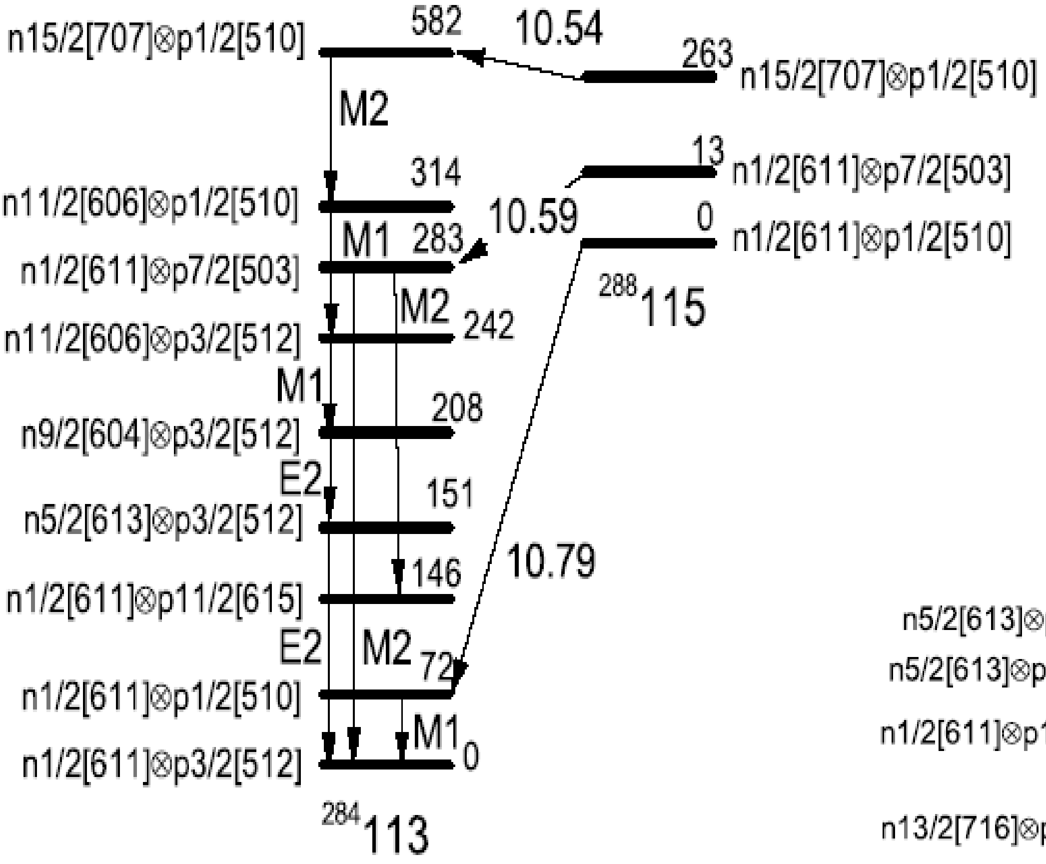
Long-living isomer in ^{251}No: $1/2^+[631]$, about 1 s



Using the one-quasiparticle spectra calculated with the TCSM for ^{257}Rf and ^{253}No, the possible α decay scheme of ^{257}Rf is suggested. The calculated Q_{α} values are consistent with the experimental values listed.

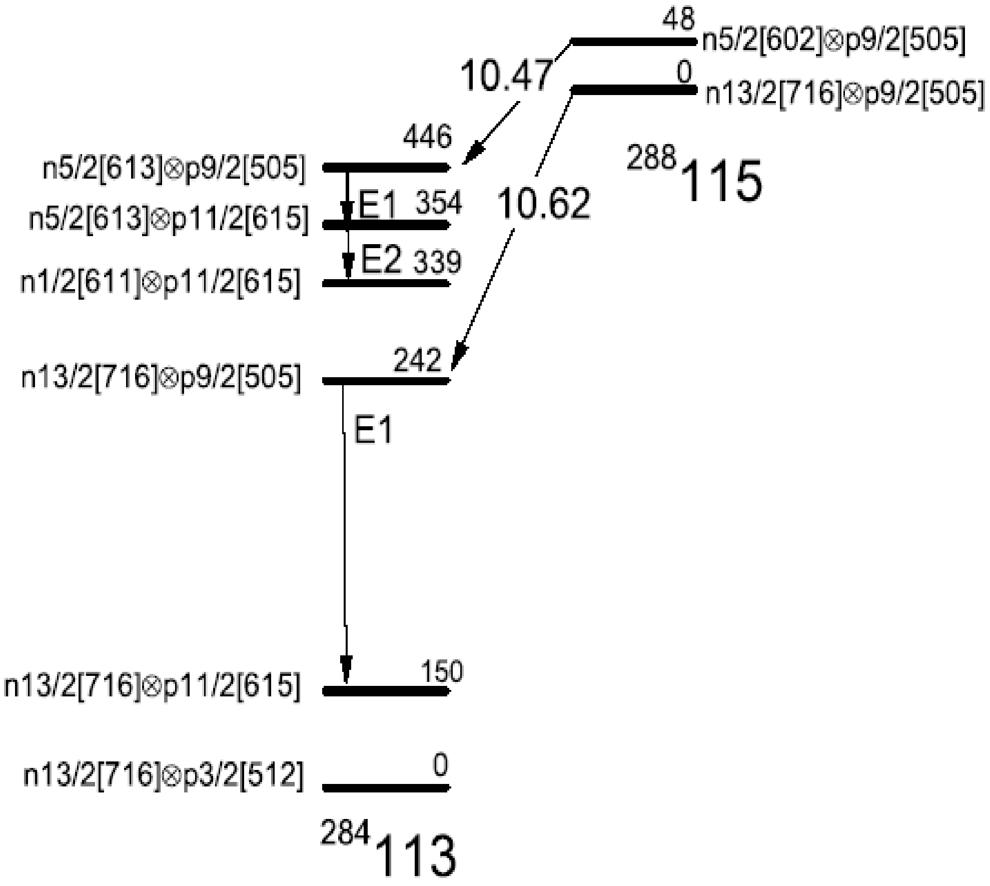


0.8
0.6
0.4
0.2
0.0
E_qp (MeV)
5/2⁻[523]
3/2⁻[521]
5/2⁻[512]
1/2⁻[521]
7/2⁻[641]
6.35
9/2⁺[624]
7/2⁻[514]
7/2⁺[633]
5/2⁻[512]
9/2⁺[624]
7/2⁻[514]
1/2⁻[521]
7/2⁺[633]
1/2⁻[521]
9/2⁺[624]
5/2⁻[512]
7/2⁻[514]
11/2⁺[615]
7/2⁺[633]
1/2⁻[521]
5/2⁻[512]
7/2⁻[514]
9/2⁺[624]
9/2⁻[505]
7/2⁻[503]
7/2⁺[633]
5/2⁻[512]
1/2⁻[521]
7/2⁻[514]
3/2⁻[512]
1/2⁻[510]
9.57
9/2⁺[624]
11/2⁺[615]
9/2⁺[624]
9/2⁻[505]
7/2⁻[503]
3/2⁻[512]
11/2⁺[615]
1/2⁻[510]
9/2⁻[505]
7/2⁻[503]
10.33
11/2⁺[615]
10.13
1/2⁻[510]
3/2⁻[512]
13/2⁺[606]
11/2⁺[615]
1/2⁻[510]
3/2⁻[512]
7/2⁻[503]
9/2⁻[505]
11.15
13/2⁺[606]
11/2⁺[615]
3/2⁻[512]
1/2⁻[510]
7/2⁻[503]
9/2⁻[505]
²⁶¹101
²⁶⁵103
²⁶⁹105
²⁷³107
²⁷⁷109
²⁸¹111
²⁸⁵113
²⁸⁹115
²⁹³117
Q_α = 6.6 7.9 8.88 10.03 9.91 10.0 10.63 11.22 MeV
Q_α^exp = 9.88,9.61 10.45 11.18MeV

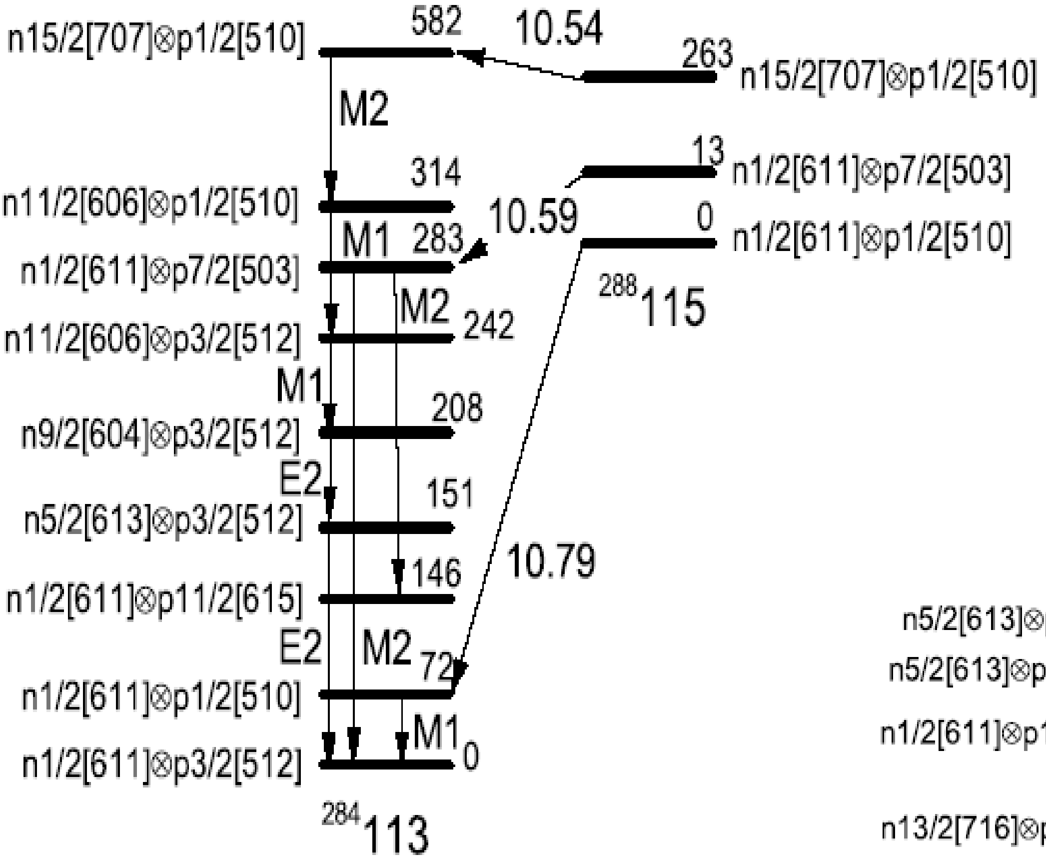


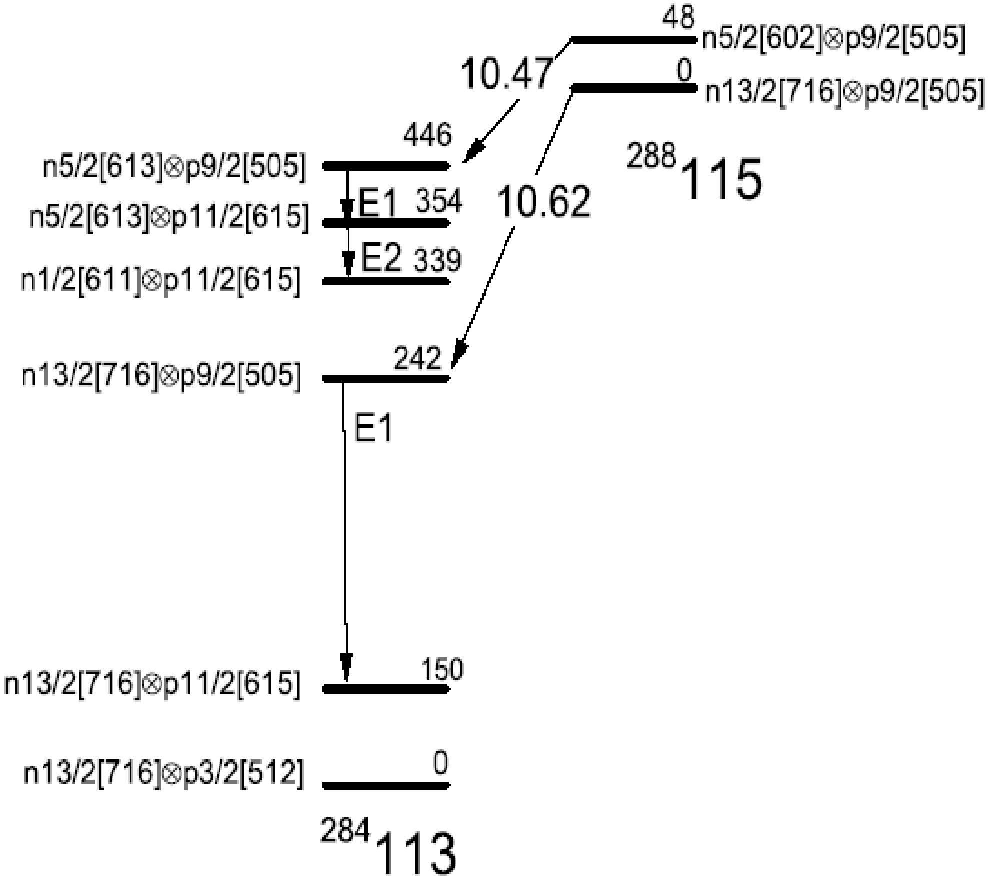
TCSM calculations

SHF calculations (SV-bas)



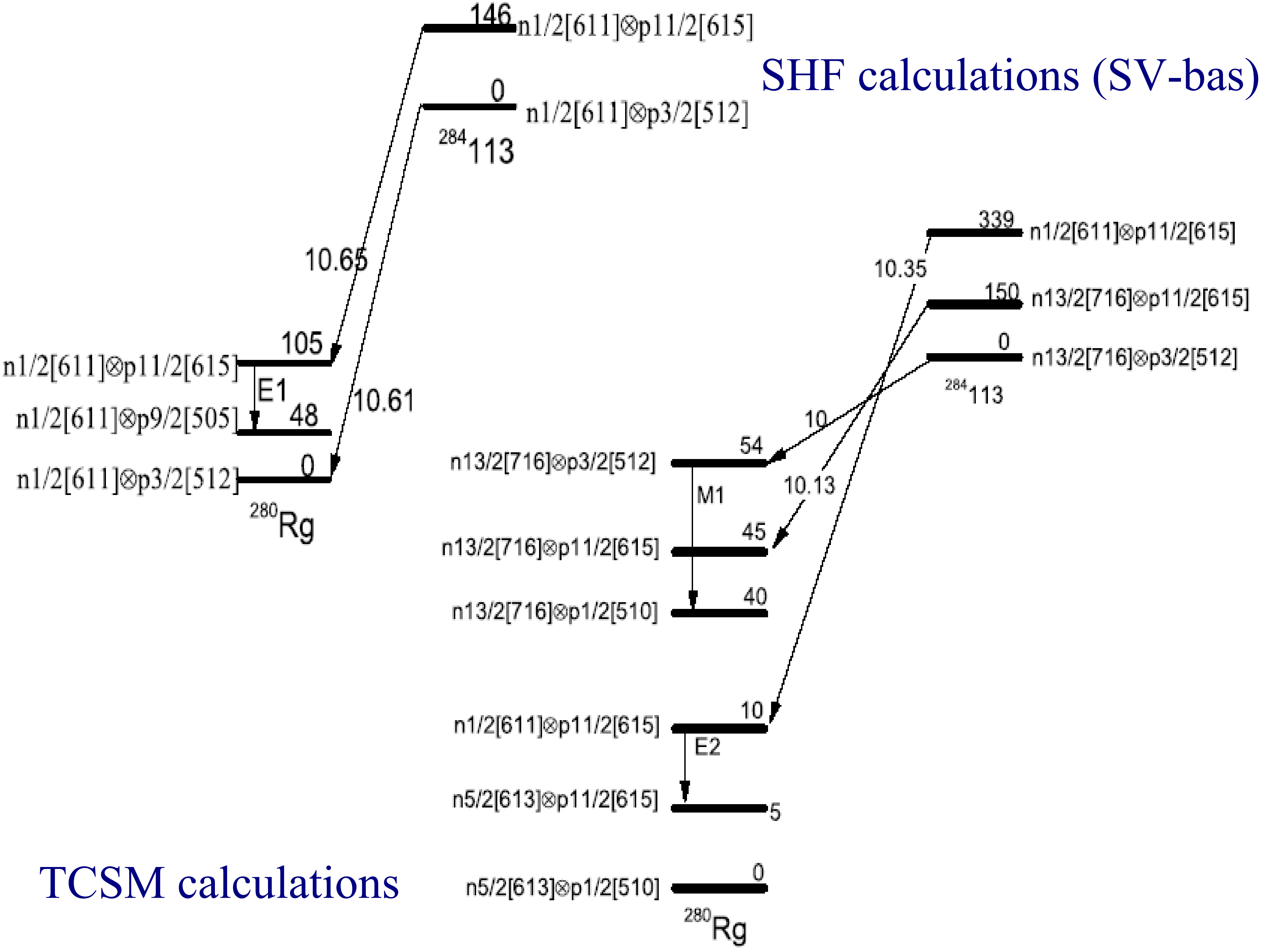
SHF calculations (SV-bas)





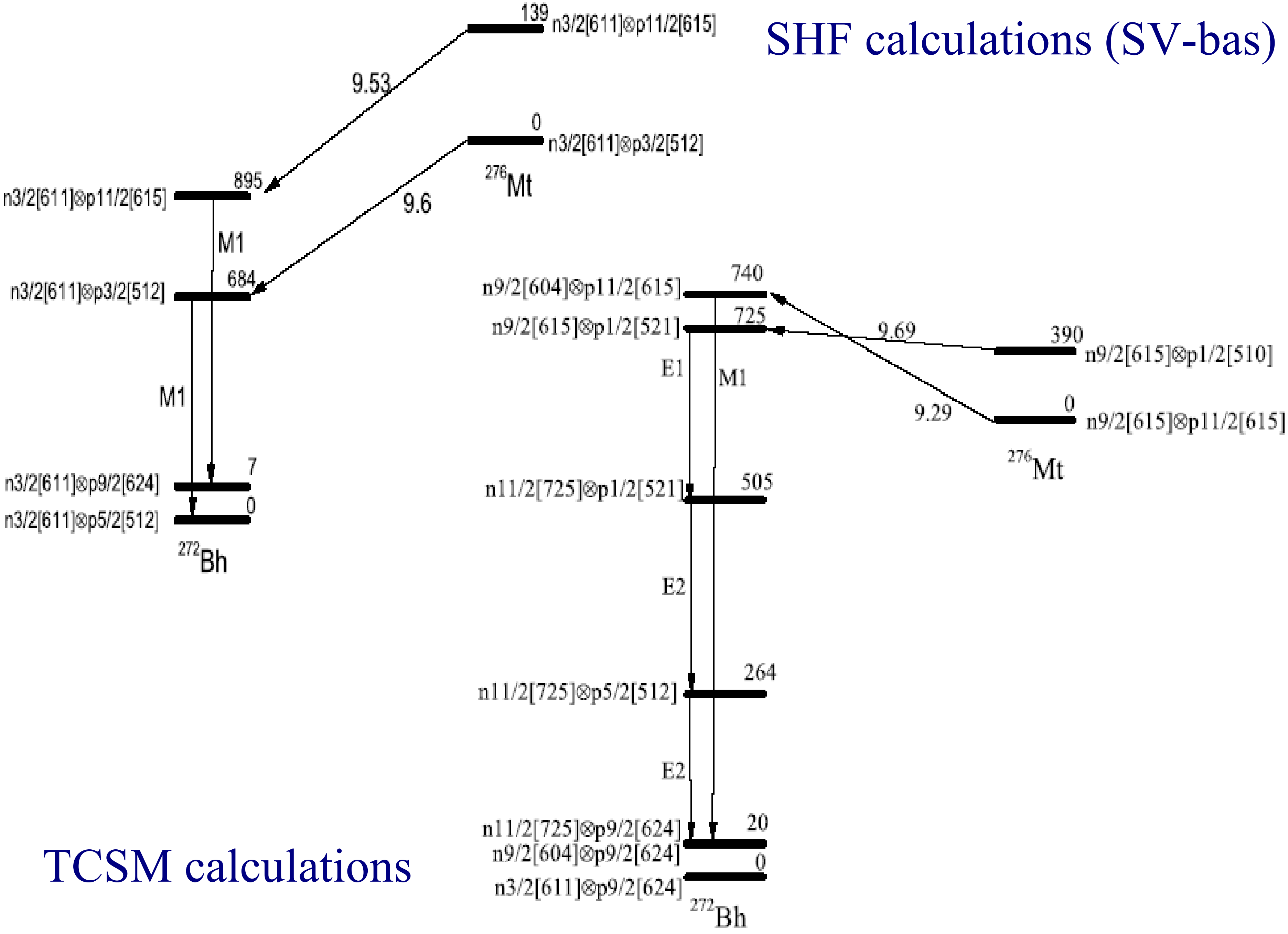
TCSM calculations

SHF calculations (SV-bas)



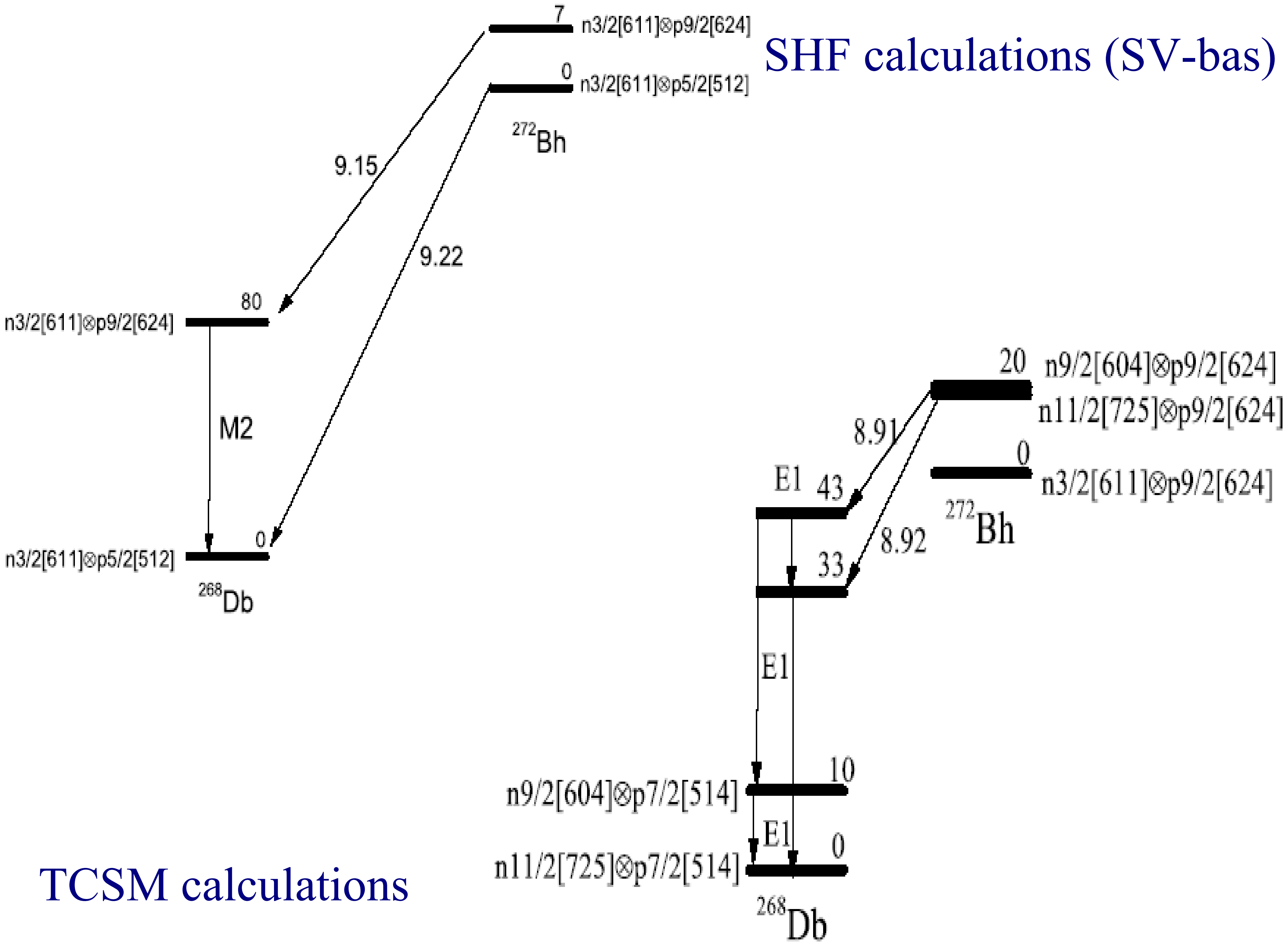
TCSM calculations

SHF calculations (SV-bas)

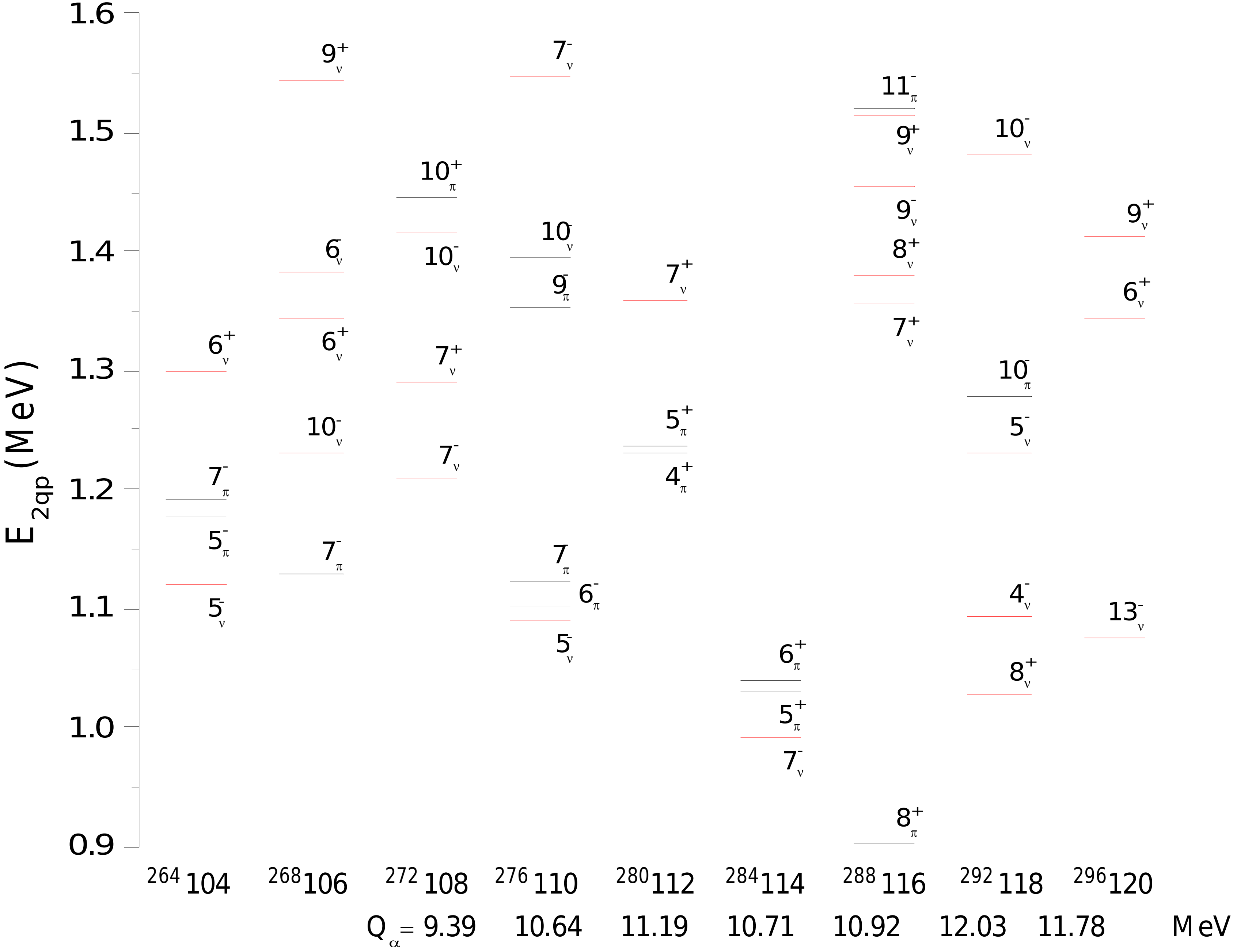


TCSM calculations

SHF calculations (SV-bas)

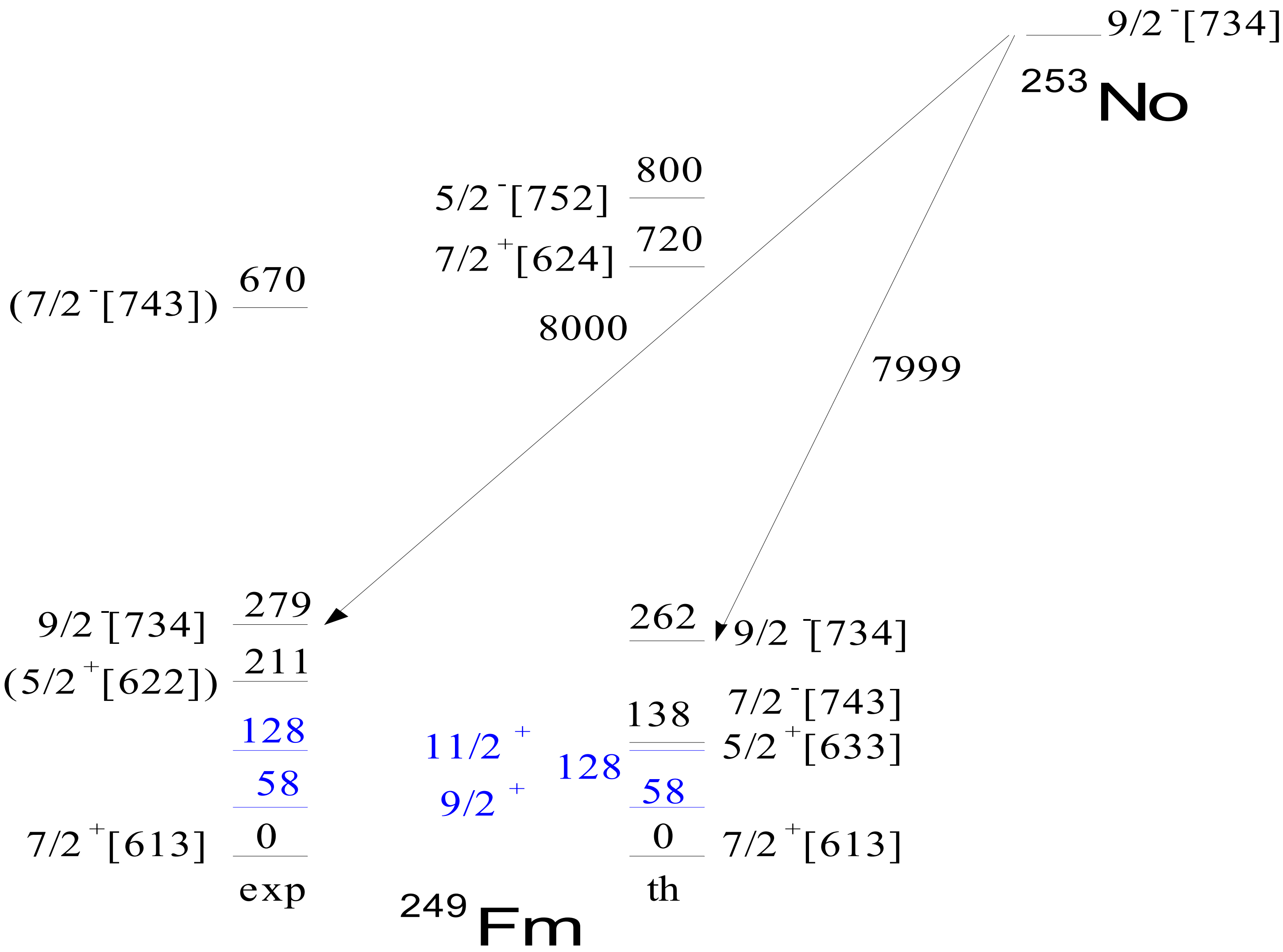


TCSM calculations


E2qp (MeV)
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
6+ ν
7- π
5- π
5- ν
9+ ν
6- ν
6+ ν
10- ν
7- π
10+ π
10- ν
7+ ν
7- ν
7- ν
10- ν
9- π
7- π
6- π
5- ν
7+ ν
5+ π
4+ π
6+ π
5+ π
7- ν
11- π
9+ ν
9- ν
8+ ν
7+ ν
8+ π
10- ν
10- π
5- ν
4- ν
8+ ν
9+ ν
6+ ν
13- ν
264 104
268 106
272 108
276 110
280 112
284 114
288 116
292 118
296 120
Qα = 9.39
10.64
11.19
10.71
10.92
12.03
11.78
MeV

Summary

- The used simple shape parametrization is suitable to describe some properties of heavy nuclei.
- Description and prediction of one- and two-quasiparticle isomeric states.
- Alpha-decay chain through the isomeric states.
- Isotonic and isotopic trends
- Lifetime of isomeric state
- Fission from isomers
- More experimental data


9/2⁻[734]
253 No
5/2⁻[752]
800
7/2⁺[624]
720
(7/2⁻[743])
670
8000
7999
9/2⁻[734]
279
(5/2⁺[622])
211
128
58
7/2⁺[613]
0
exp
262
9/2⁻[734]
138
7/2⁻[743]
11/2⁺
128
5/2⁺[633]
9/2⁺
58
0
7/2⁺[613]
th
249 Fm

Parameters

$$35 \leq N-Z \leq 56$$

$$for neutrons$$

$$\kappa_n = -0.076 + 0.0058\left(N-Z\right) - 6.53\times10^{-5}\left(N-Z\right)^2 + 0.002\,A^{1/3},$$

$$\mu_n = 1.598 - 0.0295\left(N-Z\right) + 3.036\times10^{-4}\left(N-Z\right)^2 - 0.095\,A^{1/3},$$

$$for protons$$

$$\kappa_p = 0.0383 + 0.00137\left(N-Z\right) - 1.22\times10^{-5}\left(N-Z\right)^2 - 0.003\,A^{1/3},$$

$$\mu_p = 0.335 + 0.01\left(N-Z\right) - 9.367\times10^{-5}\left(N-Z\right)^2 + 0.003\,A^{1/3},$$

The parts in front of the terms with $A^{1/3}$ vary: (0.05-0.053) for κ_n , (0.075-0.0768) for κ_p , (0.88-0.92) for μ_n , (0.58-0.61) for μ_p

Strength parameters of paring interaction

$$G_{\substack{n\\p}} = \left(19.2 \mp 7.4\,\frac{N-Z}{A}\right) A^{-1}\,MeV$$

$$A \approx 250 \rightarrow G_n \approx 0.075\,MeV, G_p \approx 0.085\,MeV$$

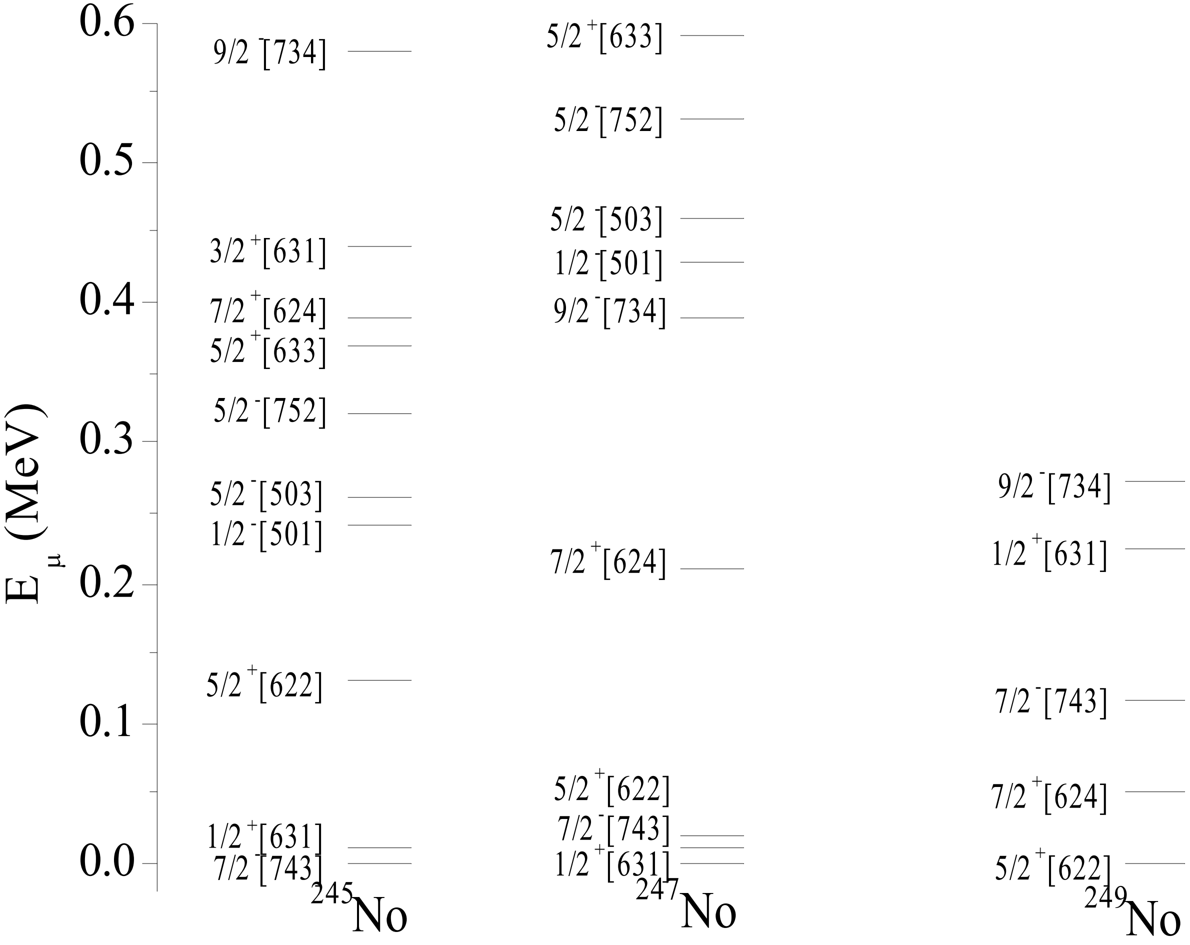
One-quasiparticle excitations

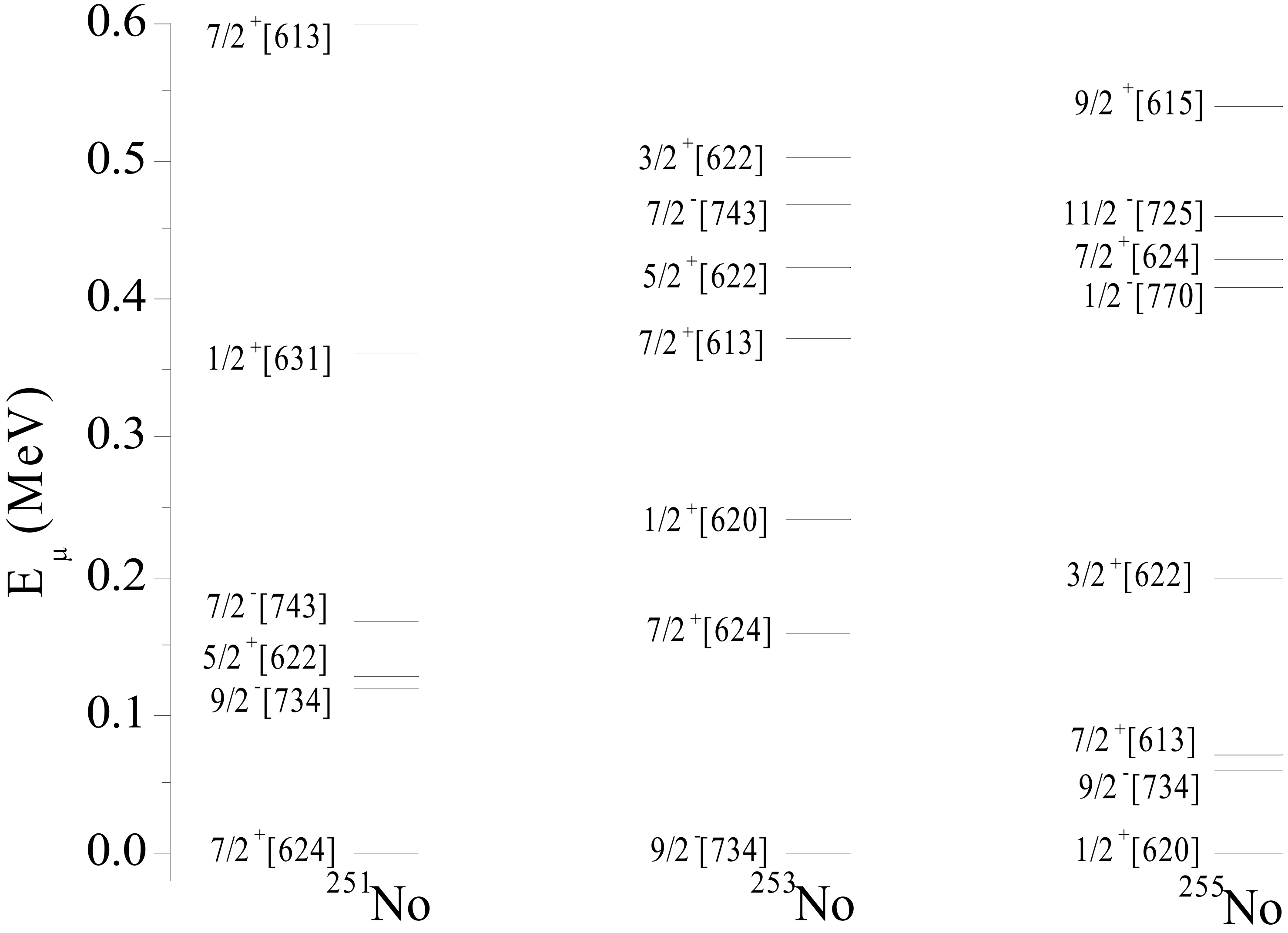
$$E_\mu = \sqrt{\left(e_\mu - e_F\right)^2 + \varDelta^2} - \sqrt{\left(e_\mu{}' - e_F\right)^2 + \varDelta^2}$$

Two-quasiparticle excitations

$$E_\mu = \sqrt{\left(e_\mu - e_F\right)^2 + \varDelta^2} + \sqrt{\left(e_\mu{}' - e_F\right)^2 + \varDelta^2}$$

$$\varDelta \geq 0.35\,MeV \rightarrow BCSapproximation$$


E_μ (MeV)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/2$^-$[734]
3/2$^+$[631]
7/2$^+$[624]
5/2$^+$[633]
5/2$^-$[752]
5/2$^-$[503]
1/2$^-$[501]
5/2$^+$[622]
1/2$^+$[631]
7/2$^-$[743]
^{245}No
5/2$^+$[633]
5/2$^-$[752]
5/2$^-$[503]
1/2$^-$[501]
9/2$^-$[734]
7/2$^+$[624]
5/2$^+$[622]
7/2$^-$[743]
1/2$^+$[631]
^{247}No
9/2$^-$[734]
1/2$^+$[631]
7/2$^-$[743]
7/2$^+$[624]
5/2$^+$[622]
^{249}No



E_μ (MeV)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
7/2$^+$[613]
1/2$^+$[631]
7/2$^-$[743]
5/2$^+$[622]
9/2$^-$[734]
7/2$^+$[624]
^{251}No
3/2$^+$[622]
7/2$^-$[743]
5/2$^+$[622]
7/2$^+$[613]
1/2$^+$[620]
7/2$^+$[624]
9/2$^-$[734]
^{253}No
9/2$^+$[615]
11/2$^-$[725]
7/2$^+$[624]
1/2$^-$[770]
3/2$^+$[622]
7/2$^+$[613]
9/2$^-$[734]
1/2$^+$[620]
^{255}No