



Fig. 1: Known experimental values for heavy particle emission of the even-Z $T_z = +27/2$ nuclei.

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Table 1

Observed and predicted β -delayed particle emission from the even- Z , $T_z = +27/2$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{143}Ce , ^{147}Nd , ^{151}Sm , ^{155}Gd , ^{159}Dy , ^{163}Er , ^{167}Yb , ^{171}Hf , ^{175}W , ^{179}Os , ^{183}Pt and ^{187}Hg are taken from ENSDF

Nuclide	Ex	J^π	$T_{1/2}$	Q_ϵ	$Q_{\epsilon p}$	$Q_{\epsilon\alpha}$	Experimental
$^{143}\text{Ce}^*$		$3/2^-$	33.039(6) h	-3.435(8)	—	—	[1989Ab18]
$^{147}\text{Nd}^*$		$5/2^-$	11.03(3) d	-2.703(16)	—	—	[2019Br01]
$^{151}\text{Sm}^*$		$5/2^-$	90(6) y**	-1.190(4)	—	—	[1968Re04, 1965Fi02]
^{155}Gd		$3/2^-$	stable	stable	—	—	
^{159}Dy		$3/2^-$	144.4(2) d	0.365(1)	-5.766(1)	0.226(2)	[1959Ke28]
^{163}Er		$5/2^-$	75.1(4) m	1.211(5)	-4.275(5)	1.940(5)	[1963Pe16]
^{167}Yb		$5/2^-$	17.5(2) m***	1.953(4)	-2.955(4)	3.363(4)	[1964Wa04, 1960Wi15]
^{171}Hf		$7/2^+$	12.1(4) h	2.397(29)	-1.956(29)	4.687(29)	[1970Ch17]
^{175}W		$(1/2^-)$	35.2(6) m	2.780(40)	-1.077(28)	5.771(28)	[1984Sz07]
^{179}Os		$1/2^-$	6.3(3) m	3.564(29)	0.098(22)	6.964(32)	[1976Be62]
^{183}Pt		$1/2^-$	6.5(10) m	4.429(28)	1.547(26)	8.386(28)	[1963Gr08]
^{187}Hg		$3/2^-$	2.2(3) m	4.910(26)	2.457(25)	9.659(28)	[1970Ha18]
^{191}Pb		$(3/2^-)$	1.3(3) m	5.992(10)	3.790(17)	10.313(23)	[1974Le02]
^{195}Po		$(3/2^-)$	4.64(9) s	6.909(8)	5.802(18)	12.741(10)	[1993Wa04]
^{195m}Po	0.150(10)	$(13/2^+)$	1.92(2) s	7.059(13)	5.952(21)	12.891(14)	[2017Al34, 1993Wa04]
^{199}Rn		$(3/2^-)$	620(25) ms [@]	7.264(9)	6.624(19)	14.041(9)	[1984Ca32, 1999Ti03]
^{199m}Rn	0.223(12)	$(13/2^+)$	316(16) ms ^{@@}	7.487(15)	6.847(22)	14.264(15)	[1984Ca32, 1999Ti03]
^{203}Ra		$(3/2^-)$	31_{-9}^{+17} ms	7.725(12)	7.587(20)	15.000(11)	[2005Uu02]
^{203m}Ra	0.249(13)	$(13/2^+)$	24_{-4}^{+6} ms	7.975(18)	7.837(24)	15.250(17)	[2005Uu02]
^{207}Th			$9.7_{-4.4}^{+46.6}$ ms	8.164(65) ^{@@@}	8.459(31) ^{@@@}	16.013(26) ^{@@@}	[2022Ya15]

* 100% β^- emitter.

** Weighted average of 93(8) y [1968Re04] and 87(9) y [1965Fi02].

*** Weighted average of 17.7(2) m [1960Wi15] and 17.3(2) m [1964Wa04].

@ Weighted average of 620(25) ms [1984Ca32] and 570(30) ms [1999Ti03].

@@ Weighted average of 325(25) ms [1984Ca32] and 310(20) ms [1999Ti03].

@@@ Deduced from our mass excess (19314(25) keV) for ^{207}Th and daughter mass excesses from [2021Wa16].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the even-Z, $T_z = +27/2$ nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	S_{2p}	Q_α	BR_α	Experimental
^{143}Ce	8.871(6)	16.452(6)	0.883(2)		
^{147}Nd	8.762(34)	15.658(34)	1.035(2)		
^{151}Sm	8.268(20)	14.779(2)	1.145(1)		
^{155}Gd	7.621(1)	14.088(1)	0.081(1)		
^{159}Dy	6.985(1)	12.921(1)	0.478(1)		
^{163}Er	6.416(6)	11.690(5)	1.575(5)		
^{167}Yb	5.992(12)	10.646(4)	2.153(6)		
^{171}Hf	5.414(33)	9.634(29)	2.734(29)		
^{175}W	5.181(40)	8.799(40)	3.374(40)		
^{179}Os	4.656(32)	7.896(32)	4.188(32)		
^{183}Pt	4.010(25)	6.801(29)	4.822(9)	$9.6(5)\times 10^{-3}\%$	[1995Bi01, 1993BiZY, 1966Si08, 1963Gr08]
^{187}Hg	3.693(25)	6.008(20)	5.145(20)*	$>3.7\times 10^{-3}\%$	[1970Ha18, 1969NaZT, 1969NaZU]
^{191}Pb	3.214(10)	5.243(32)	5.402(14)	0.051(5)%	[2010Co13, 1974Ho26, 1974Le02, 1974JoZU]
^{195}Po	2.383(8)	3.465(12)	6.750(3)	94(4)%	[2010Co13, 2017Al34, 2005Uu01, 2002Va13, 1993Wa04, 1982LeZN, 1967Si09, 1967Tr04, 1967Tr06]
^{195m}Po	2.233(13)	3.315(16)	6.900(10)	93(7)%	[2010Co13, 2017Al34, 1993Wa04, 2005Uu01, 2002Va13, 1982LeZN, 1967Si09, 1967Tr04, 1967Tr06]
^{199}Rn	2.140(9)	2.745(12)	7.132(4)	$\approx 100\%^{**}$	[2005Uu02, 2014Ka23, 1999Ta03, 1993Wa04, 1984Ca32, 1982Hi14, 1982HiZR, 1981En02, 1980Di07]
^{199m}Rn	1.917(15)	2.522(17)	7.355(13)	$\approx 100\%^{**}$	[2005Uu02, 2014Ka23, 1999Ta03, 1993Wa04, 1984Ca32, 1982Hi14, 1982HiZR, 1980Di07]
^{203}Ra	1.789(11)	1.869(14)	7.736(6)	$\approx 100\%^{**}$	[2014Ka23, 2005Uu02, 1996Le02]
^{203m}Ra	1.539(17)	1.8619(14)	7.986(19)	$\approx 100\%^{**}$	[2014Ka23, 2005Uu02, 1996Le02]
^{207}Th	1.455(74) [Ⓞ]	1.068(34) [Ⓞ]	8.328(21)***	$\approx 100\%^{**}$	[2022Ya15]

* Deduced from α energy, 5.230(14) in [2021Wa16].

** Not measured, based on short half-life.

*** Deduced from α energy, assuming it feeds the ground state of ^{203}Ra , giving a mass excess for ^{207}Th of 19314(25) keV.

Ⓞ Deduced from our mass excess (19314(25) keV) for ^{207}Th and daughter mass excesses from [2021Wa16].

Table 3

direct α emission from $^{183}\text{Pt}^*$, $J_f^\pi = 1/2^-$, $T_{1/2} = 6.5(10)$ m**, $BR_\alpha = 9.6(5)\times 10^{-3}\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{179}\text{Os})$	coincident γ -rays	R_0 (fm)	HF
4.819(10)	4.714(10)	$9.6(5)\times 10^{-3}\%$	$1/2^-$	0.0	—	1.548(17)	$1.5^{+0.7}_{-0.5}$

* All values from [1995Bi01], except where noted.

** [1963Gr08].

Table 4

direct α emission from $^{187}\text{Hg}^*$, $J_f^\pi = 3/2^-$, $T_{1/2} = 2.2(3)$ m, $BR_\alpha = >3.7\times 10^{-3}\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{183}\text{Pt})$	coincident γ -rays	R_0 (fm)	HF
4.976(20)	4.870(20)	32(5)%	$>1.2\times 10^{-3}\%$		0.169(28)		1.490(16)	<1.3
5.145(20)	5.035(20)	100%	$>2.5\times 10^{-3}\%$	$1/2^-$	0.0	—	1.490(16)	<3.5

* All values from [1970Ha18].

Table 5
direct α emission from $^{191}\text{Pb}^*$, $J_i^\pi = (3/2^-)$, $T_{1/2} = 1.3(3)$ m, $BR_\alpha = 0.051(5)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{187}\text{Hg})$	coincident γ -rays	R_0 (fm)	HF
5.403(20)	5.290(20)	0.051(5)%**	$3/2^-$	0.0	—	1.4964(71)	$1.4^{+1.4}_{-0.7}$

* All values from [1974Le02], except where noted.
** [2010Co13].

Table 6
direct α emission from $^{195}\text{Po}^*$, $J_i^\pi = (3/2^-)$, $T_{1/2} = 4.64(9)$ s**, $BR_\alpha = 94(4)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{191}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
6.110(10)	5.985(10)	0.036(3)%	0.034(3)%	$(3/2^-)$	0.642	0.2148, 0.427	1.5120(34)	11.5(14)
6.153(5)	6.027 5(5)	0.34(3)%	0.32(3)%	$(3/2^-)$	0.5972	0.2148, 0.383, 0.5972	1.5120(34)	1.91(24)
6.533(10)	6.399(10)	0.054(12)%	0.051(12)%	$(5/2^-)$	0.20148	0.2148	1.5120(34)	450^{+150}_{-100}
6.744(5)	6.606(5)	100.00(2)%	94(4)%	$(3/2^-)$	0.0	—	1.5120(34)	1.64(16)

* All values from [2010Co13], except where noted.
** [1993Wa04].

Table 7
direct α emission from $^{195m}\text{Po}^*$, Ex. = 150(10) keV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 1.92(2)$ s***, $BR_\alpha = 93(7)\%$ ***.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{191}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
6.174(5)	6.047(5)	0.17(1)%	0.16(2)%	$(13/2^+)$	0.725(12)	0.6697	1.5120(34)	1.99(24)
6.839(5)	6.699(5)	100.00(1)%	93(7)%	$(13/2^+)$	0.55(12)	—	1.5120(34)	1.54(17)

* All values from [2010Co13], except where noted.
** [2017Al34].
*** [1993Wa04].

Table 8
direct α emission from $^{199}\text{Rn}^*$, $J_i^\pi = (3/2^-)$, $T_{1/2} = 620(25)$ ms**, $BR_\alpha = \approx 100\%$ ***.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{195}\text{Po})$	coincident γ -rays	R_0 (fm)	HF
7.132(6)	6.989(6)	$\approx 100\%$	$(3/2^-)$	0.0	—	1.5330(60)	≈ 1.4

* All values from [2005Uu02], except where noted.
** Weighted average of 620(25) ms [1984Ca32] and 570(30) ms [1999Ti03].
*** Not measured, based on short half-life.

Table 9
direct α emission from $^{199m}\text{Rn}^*$, Ex. = 223(12) keV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 316(16)$ ms**, $BR_\alpha = \approx 100\%$ ***.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{195}\text{Po})$	coincident γ -rays	R_0 (fm)	HF
7.205(6)	7.060(6)	$\approx 100\%$	$(13/2^+)$	0.150(10)	—	1.5330(60)	≈ 1.3

* All values from [2005Uu02], except where noted.
** Weighted average of 325(25) ms [1984Ca32] and 310(20) ms [1999Ti03].
*** Not measured, based on short half-life.

Table 10direct α emission from ^{203}Ra , $J_f^\pi = (3/2^-)$, $T_{1/2} = 31_{-9}^{+17}$ ms*, $BR_\alpha = \approx 100\%^{***}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{199}\text{Rn})$	coincident γ -rays	R_0 (fm)	HF
7.736(8)	7.584(8)**	$\approx 100\%$	(3/2 ⁻)	0.0	—	1.549(15)	1.9(12)

* [2005Uu02].

** Weighted average of 7.575(10) MeV [2014Ka23] and 7.589(8) MeV [2005Uu02].

*** Not measured, based on short half-life.

Table 11direct α emission from ^{203m}Ra , Ex. = 250(13) keV, $J_f^\pi = (13/2^+)$, $T_{1/2} = 24_{-4}^{+6}$ ms*, $BR_\alpha = \approx 100\%^{***}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{199}\text{Rn})$	coincident γ -rays	R_0 (fm)	HF
7.763(6)	7.610(6)**	$\approx 100\%$	(13/2 ⁺)	0.223(12)		1.5330(60)	1.8(8)

* [2005Uu02].

** Weighted average of 7.575(10) MeV [2014Ka23] and 7.589(8) MeV [2005Uu02].

*** Not measured, based on short half-life.

Table 12direct α emission from $^{207}\text{Th}^*$, $T_{1/2} = 9.7_{-4.4}^{+46.6}$ ms, $BR_\alpha = \approx 100\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{203}\text{Ra})$	coincident γ -rays	R_0 (fm)	HF
8.328(21)	8.167(21)	$\approx 100\%$		0.0***	—		

* All values from [2022Ya15].

** Not measured, based on short half-life.

*** Transition assumed to feed the ground state.

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