



Fig. 1: Known experimental values for heavy particle emission of the even- Z $T_z = +11$ nuclei.

Last updated 4/4/23

Table 1

Observed and predicted β -delayed particle emission from the even- Z , $T_z = +11$ nuclei. Unless otherwise stated, all Q -values are taken from [2021Wa16] or deduced from values therein.

Nuclide	J^π	$T_{1/2}$	Q_ε	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{146}Sm	0^+	$6.8(7)\times 10^7$ y	stable	—	—	[2012Ki16]
^{150}Gd	0^+	$1.78(8)\times 10^6$ y	stable	—	—	[1966Fr11]
^{154}Dy	0^+	$3.0(15)\times 10^6$ y	stable	—	—	[1985HoZM]
^{158}Er	0^+	2.24(10) h	0.880(40)	-3.168(26)	2.428(52)	[1982Vy06]
^{162}Yb	0^+	18.87(19) m	1.660(30)	-1.909(17)	3.941(31)	[1972Ch23]
^{166}Hf	0^+	6.77(30) m	2.160(40)	-0.853(39)	5.194(38)	[1974De09]
^{170}W	0^+	2.42(4) m	2.850(30)	0.137(31)	6.305(33)	[1990Me12]
^{174}Os	0^+	44(4) s*	3.678(30)	1.443(30)	7.717(30)	[1972Be89, 1971Bo06]
^{178}Pt	0^+	20.8(5) s**	4.257(21)	2.670(18)	9.251(30)	[2000Ko16, 1982Bo14, 1980Sc09, 1968De01, 1966Si08]
^{182}Hg	0^+	10.83(6) s	4.727(21)	3.516(17)	10.253(21)	[1993Wa03, 1993WaZO]
^{186}Pb	0^+	4.79(5) s	5.202(23)	4.214(18)	11.198(22)	[1980Sc09]
^{190}Po	0^+	2.45(5) ms	6.033(25)	5.992(19)	12.895(25)	[2001An07, 2000An14]
^{194}Rn	0^+	780(160) μ s	6.441(29)	6.761(22)	13.896(27)	[2006An36]

* Weighted average of 44(4) s [1972Be89] and 42(6) s [1971Bo06].

** Weighted average of 20(2) s [2000Ko16, 21(1) s [1982Bo14], 19(2) s [1980Sc09], 21.2(8) s [1968De01] and 21.3(15) s [1966Si08].

Table 2

Particle separation, Q -values, and measured values for direct particle emission of the even- Z , $T_z = +11$ 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
^{146}Sm	7.018(4)	11.826(3)	2.529(3)	100%*	[1987Me08, 2012Ki16, 1990Pe06, 1967Gu14, 1966Fr11, 1964Nu02, 1961Ma05, 1960Ka23, 1960Ma47, 1953Du21, 1952Lo20]
^{150}Gd	6.612(7)	11.006(6)	2.807(6)	100%*	[1962Si14, 1967Go32, 1966Fr11, 1965Og01, 1962Do13, 1960To05, 1953Ra02]
^{154}Dy	6.369(8)	10.265(7)	2.945(5)	100%*	[1967Go32, 1985HoZN, 1971Go08, 1965Ma51, 1962Ry03, 1961Ma18, 1960Ma47, 1958To27]
^{158}Er	5.760(34)	9.352(25)	2.665(26)		
^{162}Yb	5.211(32)	8.335(29)	3.058(29)		
^{166}Hf	4.706(39)	7.425(32)	3.537(32)		
^{170}W	4.289(31)	6.508(31)	4.143(31)		
^{174}Os	3.730(30)	5.476(30)	4.871(10)	$0.020^{+0.010}_{-0.004}\%$	[1971Bo06, 1971BoZK]
^{178}Pt	3.239(22)	4.444(15)	5.573(2)	7.5(3)%	[2000Ko16, 1980Sc09, 1992MeZW, 1982HeZM, 1979Ha10, 1973BoXL, 1970Ha18, 1968De01, 1966Si08]
^{182}Hg	2.995(22)	3.725(14)	5.996(5)	15.2(8)%	[1979Ha10, 1980Sc09, 1993Wa03, 1993WaZO, 1982HeZM, 1970Ha18, 1969Ha03, 1968De11]
^{186}Pb	2.212(23)	2.914(15)	6.471(5)	38(9)%	[1994Wa23, 1999An22, 2000Va34, 1998DaZQ, 1997An09, 1997Ba25, 1984To09, 1980Sc09, 1974JoZU, 1974Le02, 1972Ga27]
^{190}Po	1.787(25)	1.330(17)	7.693(7)	100%***	[2001An07, 2000An14, 2000AnZZ, 1999An22, 1997An09, 1998DaZQ, 1997Ba25, 1996Ba35, 1988QuZZ]
^{194}Rn	1.497(27)	0.787(20)	7.862(10)	100%***	[2006An36, 2007An19, 2006AnZT]

* Only decay mode energetically possible.

** [1958To27] also report a 3.350(50) MeV α attributed to an isomeric state of ^{154}Dy . A later study [1971Go08] with far more statistics did not observe this.

*** based on short half-life.

Table 3

direct α emission from ^{146}Sm , $J^\pi = 0^+$, $T_{1/2} = 6.8(7)\times 10^7$ y*, $BR_\alpha = 100\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}$ (^{142}Nd)	coincident γ -rays	R_0 (fm)	HF
2.524(4)	2.455(4)***	100%	0^+	0.0	—	1.5930(74)	1.0

* [2012Ki16].

** Only decay mode energetically possible.

*** [1987Me08].

Table 4
direct α emission from ^{150}Gd , $J^\pi = 0^+$, $T_{1/2} = 1.78(8) \times 10^6$ y*, $BR_\alpha = 100\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{142}\text{Nd})$	coincident γ -rays	R_0 (fm)	HF
2.805(10)	2.730(10)***	100%	0^+	0.0	—	1.5748(86)	1.0

* [1966Fr11].

** Only decay mode energetically possible.

*** [1962Si14].

Table 5
direct α emission from ^{154}Dy , $J^\pi = 0^+$, $T_{1/2} = 3.0(15) \times 10^6$ y*, $BR_\alpha = 100\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{142}\text{Nd})$	coincident γ -rays	R_0 (fm)	HF
2.947(5)	2.870(5)***	100%	0^+	0.0	—	1.541(36)	1.0

* [1985HoZM].

** Only decay mode energetically possible.

*** 2.872(5) MeV in [1967Go32], adjusted to 2.870(5) MeV in [1999Ry01].

Table 6
direct α emission from $^{174}\text{Os}^*$, $J^\pi = 0^+$, $T_{1/2} = 44(4)$ s**, $BR_\alpha = 0.020_{-4}^{+10}\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{170}\text{W})$	coincident γ -rays	R_0 (fm)	HF
4.872(10)	4.760(10)	100%	0^+	0.0	—	1.540(34)	1.0

* All values from [1971Bo06], except where noted.

** Weighted average of 44(4) s [1972Be89] and 42(6) s [1971Bo06].

Table 7
direct α emission from $^{178}\text{Pt}^*$, $J^\pi = 0^+$, $T_{1/2} = 20.8(5)$ s**, $BR_\alpha = 7.5(3)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{174}\text{Os})$	coincident γ -rays	R_0 (fm)	HF
5.411(8)	5.289(8)	3.6(4)	0.26(3)%	2^+	0.1586(1)***	0.1586(1)***	1.5708(31)	$5.0_{-0.7}^{+0.9}$
5.572(4)	5.447(4)	100(3)	7.2(9)%	0^+	0.0	—	1.5708(31)	1.0

* All values from [2000Ko16], except where noted.

** Weighted average of 20(2) s [2000Ko16], 21(1) s [1982Bo14], 19(2) s [1980Sc09], 21.2(8) s [1968De01] and 21.3(15) s [1966Si08].

*** [1999Br24].

Table 8
direct α emission from ^{182}Hg , $J^\pi = 0^+$, $T_{1/2} = 10.83(6)$ s*, $BR_\alpha = 15.2(8)\%^{**}$.

E_α (c.m.)	E_α (lab)	I_α (rel)***	I_α (abs)	J_f^π	$E_{daughter}(^{178}\text{Pt})$	coincident γ -rays	R_0 (fm)	HF
5.578(10)	5.455(10) [@]	0.09(3)%	0.014(3)%	0^+	0.4210(6)	0.1703(1), 0.2506, 0.421	1.5176(41)	13_{-4}^{+7}
5.828(5)	5.700(5) [@]	0.58(16)%	0.09(2)%	2^+	0.1703(1)	0.1703(1)	1.5176(41)	28_{-7}^{+15}
5.999(5)	5.867(5) [@]	100(22)%	15(3)%	0^+	0.0	—	1.5176(41)	1.0

* [1993Wa03].

** [1980Sc09].

*** From α intensity ratios in [1979Ha10].

@ [1979Ha10].

Table 9direct α emission from $^{186}\text{Pb}^*$, $J^\pi = 0^+$, $T_{1/2}=4.79(5)$ s^{**}, $BR_\alpha = 38(9)\%$ ^{***}.

E_α (c.m.)	E_α (lab)	I_α (rel) ^{***}	I_α (abs)	J_f^π	$E_{daughter}(^{182}\text{Hg})$	coincident γ -rays	R_0 (fm)	HF
6.146(13)	6.014(13)	<0.20%	<0.076(18)%	(0 ⁺)	0.328	—	1.486(10)	>25
6.470(6)	6.331(6)	<100%	<38(9)%	0 ⁺	0.0	—	1.486(10)	1.0

* All values from [1994Wa23], except where noted.

** [1980Sc09].

*** [1999An22].

Table 10direct α emission from $^{190}\text{Po}^*$, $J^\pi = 0^+$, $T_{1/2}=2.45(5)$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{186}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
7.044(20)	6.896(20)	0.3(1%)	0.3(1)%	0 ⁺	0.650	—	1.5114(26)	2.5 ^{+1.3} _{-0.7}
7.163(20)	7.012(20)	3.4(4)%	3.3(4)%	0 ⁺	0.532	—	1.5114(26)	0.58 ^{+0.09} _{-0.07}
7.695(10)	7.533(10)	100.0(4)%	96.4(4)%	0 ⁺	0.0	—	1.5114(26)	1.0

* All values from [2001An07, 2000An14].

Table 11direct α emission from $^{194}\text{Rn}^*$, $J^\pi = 0^+$, $T_{1/2}=780(160)\mu\text{s}$, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{186}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
7.862(10)	7.700(10)	100%	0 ⁺	0.0	—	1.590(11)	1.0

* All values from [2006An36].

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