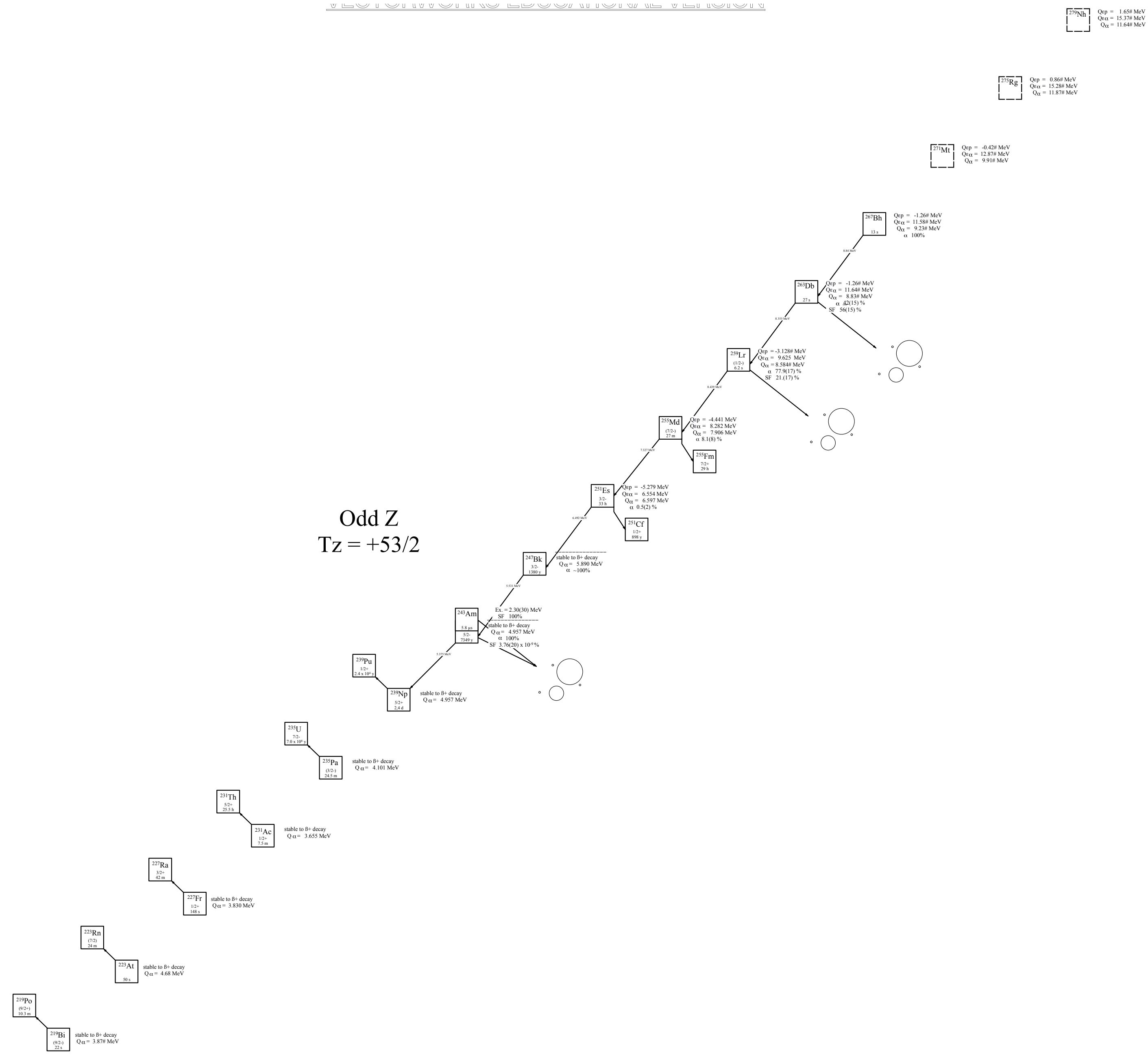

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +53/2 nuclei.

Last updated 3/14/25

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +53/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. All J^π values are taken from ENSDF.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ε	Q_{β^-}	$Q_{\beta^-\alpha}$	Experimental
^{219}Bi*		(9/2$^-$)	22(7) s	-4.30(45)#	3.64(20)#	9.74(30)#	[**2012Be28**]
^{223}At*			50(7) s	-3,65(20)#	3.038(16)	8.502(21)	[**1989Bu09**]
^{227}Fr*		1/2$^+$	148(2)s	-3.203(15)	2.505(6)	7.047(10)	[**1981Vo03**]
^{231}Ac*		1/2$^+$	7.5(2) m	-2.454(17)	1.947(13)	6.341(13)	[**1973Ch24**]
^{235}Pa*		(3/2$^-$)	24.5(2) m**	-1.729(19)	1.370(14)	6.228(14)	[**1986Mi10, 1968Tr07**]
^{239}Np*		5/2$^+$	2.3565(4) d	-1.262(2)	0.723(1)	6.147(2)	[**1990Ab06**]
					$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	
^{243}Am		5/2$^-$	7349(12) y***	-0.580(3)	—	—	[**2020Ma63, 2007Ag02, 1980Ag05**]
^{243m}Am	2.30(30)		5.8(7) μs$^@$	1,72(30)	5.23(36)	8.90(30)	[**1973Br04, 1972Wo07, 1970Po01**]
^{247}Bk		3/2$^-$	1380(250) y	-0.044(6)	—	—	[**1965Mi08**]
^{251}Es		3/2$^-$	33(1) h	0.377(6)	-5.729(6)	6.554(7)	[**1970Ah01**]
^{255}Md		(7/2$^-$)	27(2) m	1.042(7)	-4.441(6)	8.282(7)	[**1970Fi12**]
^{259}Lr		(1/2$^-$)	6.22(28) s$^{@@}$	1.770(70)#	-3.128(71)#	9.625(71)#	[**1992Ha22, 1992Gr02**]
^{263}Db			27^{+10}_{-7} s	2.35(23)#	-2.28(26)#	10.61(17)#	[**1992Kr01**]
^{267}Bh			13^{+6}_{-3} s$^{@@@}$	2.96(37)#	-1.26(39)#	11.58(30)#	[**2009Mo12, 2000Ei05, 2000Wi15**]
^{271}Mt				3.41(41)#	-0.42(45)#	12.87(42)#	
^{275}Rg				3.73(56)#	0.86(58)#	15.28(53)#	
^{279}Nh				4.44(72)#	1.65(72)#	15.37(69)#	

* 100% β^- emitter.
** Weighted average of 24.6(2) m [1986Mi10] and 24.2(3) m [1968Tr07].
*** Weighted average of 7345(14) y [2020Ma63], 7357(23) y [2007Ag02] and 7358(42) y [1980Ag05].
@ Weighted average of 5.0(10) μs [1972Wo07] and 6.5(10) μs [1970Po01].
@@ Weighted average of 6.14(36) s [1992Ha22] and 6.34(46) s [1992Gr02].
@@@ Deduced from times of 12 decay chains from [2009Mo12] (1 event), [2000Ei05] (6 events), and [2000Wi15] (5 events).

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +53/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	Q_α	BR_α	BR_{SF}	Experimental
^{219}Bi	6.60(36)#	3.87(36)#			
^{223}At	6.347(42)	4.68(20)			
^{227}Fr	6.354(12)	3.830(15)			
^{231}Ac	6.042(17)	3.655(14)			
^{235}Pa	5.613(14)	4.101(19)			
^{239}Np	5.286(1)	4.597(14)			
^{243}Am	4.831(1)	5.439(1)	100%	$3.76(20)\times10^{-9}$%	[**2002Da21, 2002Sa53**, 2023Ko26, 2020Ma63, 2018Ca05, 2007Ag02, 1998Ya17, 1996Sa23, 1996Sa23, 1996Wo05, 1992Ga01, 1991Po14, 1986AmZY, 1984Va41, 1980Ag05, 1979Po20, 1977St35, 1974Po17, 1969Al14, 1969En02, 1968Ba22, 1968Ba25, 1968Va09, 1967Fa01, 1966Gv01, 1964Ba26, 1963Ba65, 1960Be10, 1959Ba22, 1958Wa69, 1956Hu96, 1955St98, 1954As05, 1953AsZZ, 1953Di27]
^{243m}Am	2.53(30)	7.74(30)		100%	[**1973Br04, 1972Wo07, 1970Po01**, 1980Bj02, 1973Be04, 1973Na35, 1971Re11, 1970ReZN]
^{247}Bk	4.416(5)	5.890(5)	≈ 100%		[**1969Fr01**, 1965Mi08, 1956Ch77]
^{251}Es	3.948(5)	6.597(1)	0.5(2)%		[**1979Ah03, 1970Ah01**, 1956Ha80]
^{255}Md	3.349(6)	7.906(2)	8.1(8)%*		[**2000Ah02, 1971Ho16, 1970Fi12, 1965Si14**, 2005He27, 1958Ph40]
^{259}Lr	2.92(12)#	8.584(71)#	77.9(17)%	22.1(17)%**	[**1992Ha22, 1992Gr02**, 2020Ha27, 1971Es01, 1971EsZX, 1970GhZY]
^{263}Db	2.57(28)#	8.83(15)#	42(15)%***	56^{+13}_{-15}%***	[**2003Kr20, 1992Kr01**, 2002KrZY, 1995GrZV, 1992GaZU, 1991KrZS, 1987GrZN]
^{267}Bh	2.14(36)#	9.23(20)#	100%		[**2020Ha27, 2009Mo12, 2000Ei05, 2000Wi15**]
^{271}Mt	1.30(41)#	9.91(20)#			
^{275}Rg	1.09(59)#	11.87(30)#			
^{279}Nh	0.67(74)#	11.64(75)#			

* Weighted average of 10.0(14)% [1971Ho16], 7(1)% [1970Fi12] and 9(2)% [1965Si14].
** Weighted average of 20(3)% [1992Ha22] and 23(2)% [1992Gr02].
*** [1992Kr01] report BR_α = 43(15)% and BR_{SF} = 57^{+13}_{-15}%, neglecting BR_ε, which was assumed to be small. [2003Kr20] report a $BR_\varepsilon = 3^{+4}_{-1}$%. The BR for α and SF are adjusted by the evaluator to reflect this.

Table 3
direct α emission from ^{243}Am*, J^{π} = 5/2$^-$, T$_{1/2}$ = 7349(12) y**, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{239}Np)***	coincident γ-rays (keV)***	R$_0$ (fm)	HF
4.7760	4.6974	4.4(5)×10^{-3}%	3.8(4)×10^{-3}%	(5/2$^-$)	0.6623	31.1, 43.1, 43.5, 74.7, 86.7, 117.6, 544.5, 587.6, 631.1	1.50633(42)	3.3(4)
5.0185	4.9359	3.0(3)×10^{-3}%	2.6(3)×10^{-3}%		0.427		1.50633(42)	215^{+29}_{-23}
5.0335	4.9506	3.2(3)×10^{-3}%	2.8(3)×10^{-3}%		0.411		1.50633(42)	255^{+31}_{-25}
5.0843	5.0006	3.6(5)×10^{-3}%	3.1(4)×10^{-3}%	(9/2$^+$)	0.3591		1.50633(42)	510(50)
5.0959	5.0120	6.0(5)×10^{-3}%	5.2(4)×10^{-3}%	(9/2$^+$)	0.3473		1.50633(42)	366(28)
5.1209	5.0366	9.5(6)×10^{-3}%	8.2(5)×10^{-3}%	(13/2$^-$)	0.3174	195	1.50633(42)	365(23)
5.1763	5.0911	0.0129(7)%	0.0112(6)%		0.267		1.50633(42)	567(31)
5.1989	5.1133	0.0219(12)%	0.0190(10)%	(11/2$^-$)	0.2413	71.2, 169	1.50633(42)	489(26)
5.2651	5.1784	1.606(8)%	1.391(7)%	9/2$^-$	0.1731	31.1, 43.1, 43.5, 50.6, 55.4, 74.7, 86.7, 98.5, 117.6, 141.9	1.50633(42)	18.04(21)
5.3204	5.2328	13.30(3)%	11.52(2)%	7/2$^-$	0.1177	31.1, 43.1, 43.5, 74.7, 86.7, 117.6	1.50633(42)	4.82(5)
5.3636	5.2753	100.%	86.6(7)%	5/2$^-$	0.0747	31.1, 43.5, 74.7	1.50633(42)	1.149(15)
5.4073	5.3183	0.219(3)%	0.19(3)%	7/2$^+$	0.0311	31.1	1.50633(42)	980^{+190}_{-140}
5.4385	5.3490	0.28(4)%	0.24(3)%	5/2$^+$	0.0	—	1.50633(42)	$1.20^{+0.17}_{-0.14}\times10^3$

* All values from [2002Da21], except where noted. E_{α} uncertainties are in units of the last significant decimal figure [2022Da21].
** Weighted average of 7345(14) y [2020Ma63], 7357(23) y [2007Ag02] and 7358(42) y [1980Ag05].
*** [2014Br18].

Table 4
direct α emission from ^{247}Bk*, J^{π} = 3/2$^-$, T$_{1/2}$ = 1380(250) y**, BR_{α} = ≈100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}***	$E_{daughter}$(^{243}Am)***	coincident γ-rays (keV)***	R$_0$ (fm)	HF
5.546(5)	5.456(5)	3.3(5)%	1.5(2)%	(7/2$^-$)	0.345(1)		1.4896(15)	11^{+4}_{-3}
5.592(5)	5.501(5)	16(2)%	7(1)%	(5/2$^-$)	0.300(2)		1.4896(15)	$4.5^{+1.7}_{-1.3}$
5.622(5)	5.531(5)	100(6)%	45(2)%	3/2$^-$	0.265(10)	265	1.4896(15)	1.1(3)
5.702(5)	5.610(5)	≈0.9%	≈0.4%	(11/2$^+$)	0.1894(6)		1.4896(15)	≈300
5.747(5)	5.654(5)	12.2(14)%	5.5(6)%	(9/2$^+$)	0.1434(2)	25.2, 34, 41.8, 42,2, 67, 84.0, 101.3, 109.2	1.4896(15)	45^{+15}_{-12}
5.782(5)	5.688(5)	29(3)%	13(1)%	7/2$^+$	0.1092(2)	25.2, 41.8, 42.2, 67, 84.0, 109.2	1.4896(15)	30(6)
5.804(5)	5.710(5)	38(3)%	17(1)%	5/2$^+$	0.0840(1)	41.8, 42.2, 84.0	1.4896(15)	31(6)
5.849(5)	5.754(5)	9.6(10)%	4.3(4)%	7/2$^-$	0.0422(2)	42.2	1.4896(15)	210(50)
5.889(5)	5.794(5)	12.2(12)%	5.5(5)%	5/2$^-$	0.0	—	1.4896(15)	280(60)

* All values from [1969Fr01], except where noted. E_{α} is adjusted by +1.0 keV as recommended in [1991Ry01].
** [1965Mi08].
*** [2014Ne14].

Table 5
direct α emission from ^{251}Es*, J^{π} = 3/2$^-$, T$_{1/2}$ = 33(1) h**, BR_{α} = 0.5(2)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}@	$E_{daughter}$(^{247}Bk)@	coincident γ-rays (keV)@	R$_0$ (fm)	HF
6.514(3)	6.410(3)	4.1(7)%	0.017(7)%	(9/2)$^+$	0.0828	40.8, 42.0	1.47482(56)	33^{+28}_{-11}
6.526(3)	6.422(3)	3.7(7)%	0.015(7)%	(7/2$^-$)	0.0716		1.47482(56)	40^{+40}_{-10}
6.556(3)	6.452(3)	4.1(9)%	0.017(7)%	7/2$^+$	0.0408	40.8	1.47482(56)	50^{+50}_{-20}
6.567(3)	6.462(3)	11.6(13)%	0.047(19)%	(5/2$^-$)	0.0299	29.9	1.47482(56)	21^{+16}_{-7}
6.597(3)	6.492(3)	100(3)%	0.41(16)%	3/2$^-$	0.0	—	1.47482(56)	$3.3^{+2.4}_{-1.0}$

* All values from [1979Ah03], except where noted. E_{α} is adjusted by +0.8 keV as recommended in [1991Ry01].
** [1970Ah01].
*** Deduced from I_{α}/I_{Kx} = 0.008(2) [1970Ah01] and I_{Kx}/I_{ε} =0.64(5) [2005Ah09].
@ [2015Ne04].

Table 6
direct α emission from ^{255}Md*, J^{π} = (7/2^{-}), $T_{1/2}$ = 27(2) m**, BR_{α} = 8.1(8)%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{251}Es)	coincident γ-rays (keV)	R_0 (fm)	HF
7.390(5)	7.274(5)	5.4(5)%	0.041(6)%		0.515		1.4825(13)	21^{+5}_{-4}
7.444(4)	7.327(4)	100%	0.75(8)%	7/2^{-}	0.4614	405.5, 453.1	1.4825(13)	$1.9^{+0.4}_{-0.3}$
7.837(8)	7.714(8)	1.1(2)%	8(2)$\times10^{3}$		0.068		1.4825(13)	$5.1^{+2.0}_{-1.3}\times10^{3}$
7.876(8)	7.752(8)	1.1(2)%	8(2)$\times10^{3}$		0.030		1.4825(13)	$7.0^{+2.7}_{-1.7}\times10^{3}$

* All values from [2000Ah02], except where noted.
** [[1970Fi12].
*** Weighted average of 10.0(14)% [1971Ho16], 7(1)% [1970Fi12] and 9(2)% [1965Si14].

Table 7
direct α emission from ^{259}Lr*, J^{π} = (1/2^{-}), $T_{1/2}$ = 6.22(28) s*, BR_{α} = 77.9(17)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{255}Md)	coincident γ-rays (keV)	R_0 (fm)	HF
8.571(10)	8.439(10)	77.9(17)%**				1.485(19)	$1.3^{+0.8}_{-0.5}$

* Weighted average of 6.14(36) s [1992Ha22] and 6.34(46) s [1992Gr02].
** Weighted average of 20(3)% [1992Ha22] and 23(2)% [1992Gr02] for BR_{SF}. α decay is the only other expected channel.

Table 8
direct α emission from ^{263}Db*, J^{π} = (1/2^{-}), $T_{1/2}$ = 27^{+10}_{-7} s, BR_{α} = 42(15)%**.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{259}Lr)	coincident γ-rays (keV)	R_0 (fm)	HF
8.484(27)	8.355(27)	42(15)%**				1.475(18)	$0.9^{+1.2}_{-0.6}$

* All values from [1992Kr01], except where noted.
** [1992Kr01] report BR_{α} = 43(15)% and BR_{SF} = 57^{+13}_{-15}%, neglecting BR_{ε}, which was assumed to be small. [2003Kr20] report a BR_{ε} =3^{+4}_{-1}%. The BR for α and SF are adjusted by the evaluator to reflect this.

Table 9
direct α emission from ^{267}Bh*, $T_{1/2}$ = 13^{+6}_{-3} s**, BR_α = 100%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{263}Db)	coincident γ-rays (keV)	R_0 (fm)	HF
8.86	8.73	22%	17%				1.451(72)	2^{+12}_{-2}
8.97	8.84	100%	75%				1.451(72)	$1.0^{+5.2}_{-0.9}$
9.05	8.91	11%	8%				1.451(72)	20^{+54}_{-20}

* 12 decay chains were assigned to the decay of ^{267}Bh [2009Mo12, 2000Ei05, 2000Wi15] along with 4 tentative assignments in [2009Mo12], of which 3 have significantly longer decay times than the others. The events with E_α, decay time and ref. listed below. The events are grouped by energy into 3 peaks; 8.73 MeV (2 events), 8.84 MeV (9 events) and 8.91 (1 event). Note that [2020Ha27] discusses that these events may be due to ^{266}Bh as the energies are very similair.

E_α (MeV)	decay t(s)	Ref.
8.84	11.95	[2009Mo12]
8.81	24.5	[2000Ei05]
8.85	34.4	[2000Ei05]
8.72	2.9	[2000Ei05]
8.84	26.7	[2000Ei05]
8.91	10.5	[2000Ei05]
8.81	18.4	[2000Ei05]
8.83	5.26	[2000Wi15]
8.87	24.67	[2000Wi15]
8.87	45.15	[2000Wi15]
8.73	2.71	[2000Wi15]
8.84	21.83	[2000Wi15]
8.76 (tentative)	112.2	[2009Mo12]
8.71(tentative)	5.38	[2009Mo12]
8.75 (tentative)	155.57	[2009Mo12]
8.84 (tentative)	176.77	[2009Mo12]

** Deduced from the decay times listed above.

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