

Table 1

Observed and predicted β -delayed particle emission from the odd-Z, $T_z = +26$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values are taken from ENSDF.

Nuclide	Ex.	J^π	$T_{1/2}$	Q_ϵ	Q_{β^-}	$Q_{\beta^- \alpha}$	$BR_{\beta^- F}$	Experimental
$^{214}\text{Tl}^*$			11(2) s	-5.31(45)#	6.65(20)#	9.53(28)#		[2016Ca25]
$^{218}\text{Bi}^*$			33(1) s	-2.41(30)#	4.859(27)	11.154(27)		[2004De16]
$^{222}\text{At}^*$			549(10) s	-1.530(40)	4.581(16)	10.351(16)		[1989Bu09]
$^{226}\text{Fr}^*$		1^-	49(1) s	-1.227(12)	3.853(7)	8.904(6)		[1986Bo35]
$^{230}\text{Ac}^*$		(1^+)	122(3) s	-0.678(19)	2.976(16)	7.925(16)	**	[2025Ba22, 2001Yu03]
$^{234}\text{Pa}^*(\text{UX}_2)$		4^+	6.658(23) h	-0.274(3)	2.194(4)	7.232(4)		[1954Zi02]
$^{238}\text{Np}^*$		2^+	2.1024(5) d	0.147(1)	1.291(1)	7.065(2)		[2006Re09]
$^{238m}\text{Np}^*$	x		250(130) ns	0.147(1)+x	1.291(1)+x	7.065(2)+x		[1970Vi05]
$^{242}\text{Am}^*$		1^-	16.02(2) h	-0.751(1)	0.664(1)	7.060(2)		[2005Ma90]
$^{242m1}\text{Am}$	0.049	5^-	141.9(17) y	-0.702(1)	0.713(1)	7.109(2)		1979Ze05
$^{242m2}\text{Am}$	2.20(8)	(2,3)	13.9(2) ms***	1.45(8)	2.86(8)	9.26(8)		[1996Ba52, 1976Be55, 1975Va21, 1965Fi04, 1968Er01, 1976We03, 1967Fi03]
					$Q_{\epsilon p}$	$Q_{\epsilon \alpha}$		
^{246}Bk		$2^{(-)}$	1.8092) d	1.350(60)	-5.222(60)	6.825(60)		[1976Ah03]
^{250}Es		(6^+)	8.6(1) h	2.06(10)#	-3.91(10)#	8.18(10)#		[1977Fr03]
^{254}Md			10(3) m	2.55(10)#	-2.85(10)#	9.86(10)#		[1970Fi12]
^{258}Lr			3.91(22) s [@]	3.30(14)#	-1.50(10)#	11.46(10)#		[2014Ha04, 1992Gr02, 1976BeZY, 1971Es01]
^{262}Db			$33.8^{+4.4}_{-3.5}$ s	3.86(27)#	-0.59(25)#	12.35(19)#		[2014Ha04]
^{266}Bh			$10.0^{+2.6}_{-1.7}$ s	4.49(29)#	0.43(28)#	13.29(28)#		[2020Ha27]
^{270}Mt			$0.48^{+0.66}_{-0.38}$ s	5.60(31)#	1.94(42)#	14.67(31)#		[2012Mo25]
^{274}Rg			12^{+16}_{-5} ms	5.42(44)#	2.54(47)#	17.08(33)#		[2012Mo25]
^{278}Nh			$1.4^{+1.9}_{-0.5}$ ms	6.19(49)#	3.33(52)#	17.41(45)#		[2012Mo25]

* 100% β^- emitter.

** [2001Yu03] report a branching ratio of $1.19(40) \times 10^{-6}\%$. However, a more recent study with better statistics report the nonobservation of this decay and set a limit as $< 4.3 \times 10^{-8}\%$ [2025Ba22].

*** Weighted average of 10.2(9) ms [1975Va21], 14.0(4) ms [1965Fi04], 14.0(2) ms [1968Er01], 13.9(5) ms [1976We03], and 14.0(7) ms [1967Fi03].

@ Weighted average of $3.54^{+0.46}_{-0.36}$ s [2014Ha04], $3.92^{+0.35}_{-0.31}$ s [1992Gr02], 4.35(59) s [1976BeZY] and 4.2(6) s [1971Es01].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, $T_z = +26$ 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
^{214}Tl	9.02(36)#	1.36(45)#			
^{218}Bi	6.33(30)#	4.33(20)#			
^{222}At	6.110(25)	5.312(31)#			
^{226}Fr	6.303(13)	4.143(17)			
^{230}Ac	6.013(22)	3.893(17)			
$^{234}\text{Pa}(\text{UX}_2)$	5.682(4)	4.076(16)			
^{238}Np	5.225(1)	4.691(4)			
^{238m}Np	5.225(1)-x	4.691(4)+x		$\approx 100\%$	[1970Vi05]
^{242}Am	4.776	5.589			
$^{242m1}\text{Am}$	4.727	5.638	0.45(1)%		[1990Ho02, 1979Ba67, 1979Ze05, 2005Ma90, 1983WeZU, 1979BaYF, 1961As03, 1959Ba22]
$^{242m2}\text{Am}$	2.58(8)	7.79(8)		100%	[1976Be55, 1975Va21, 1965Fi04, 1968Er01, 1976We03, 1967Fi03, 1996Ba52, 1993Ku16, 1992Ba67, 1992BaZW, 1985AcZZ, 1981Lu06, 1981VaZQ, 1983WeZT, 1979Va25, 1973Be04, 1973Be05, 1970Da05, 1969Ga24, 1968Er01, 1967Ca04, 1967Ga14, 1966Br23, 1966Ma24, 1965Li05, 1963Fi08, 1963Pe27, 1962Po09]
^{246}Bk	4.327(60)	6.074(60)			
^{250}Es	3.79(10)#	6.83(12)#			
^{254}Md	3.18(10)#	7.80(14)#			
^{258}Lr	2.75(10)#	8.904(19)	97.4(18)%		[2014Ha04, 1976BeZY, 1971Es01, 2020Ha27, 1992Gr02, 1971EsZX]
^{262}Db	2.35(16)#	9.05(10)#	48(4)%	52(4)%	[2014Ha04, 2020Ha27, 2012Mo25, 2010MoZV, 2007Mo43, 1999Dr09, 1993Zi06, 1992Ga31, 1992Go28, 1992Sc30, 1990JoZX, 1989Kr17, 1989ScZW, 1989YaZZ, 1988Gr30, 1979Dr07, 1977Be43, 1977BeWH, 1971Gh01]
^{266}Bh	1.98(21)#	9.426(77)#	$\approx 100\%$		[2020Ha27, 2012Mo25, 2010MoZV, 2009MoZU, 2007Mo43, 2006MoZV, 2006Qi03, 2005MoZS, 2004Mo42, 2000Wi15]
^{270}Mt	1.07(23)#	11.31(7)*	$\approx 100\%$		[2012Mo25, 2007Mo43, 2007MoZY, 2006MoZW, 2006MoZV, 2004Mo42]

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, $T_z = +26$ nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

^{274}Rg	0.96(25)#	11.478(86)	$\approx 100\%$	[2012Mo25, 2007Mo43, 2007MoZY, 2006MoZW, 2006MoZV, 2004Mo42]
^{278}Nh	0.59(27)#	11.993(79)	$\approx 100\%$	[2012Mo25, 2007Mo43, 2007MoZY, 2006MoZW, 2006MoZV, 2004Mo42]

* Q_α taken from highest energy α observed in [2012Mo25], 10.18(10)# in [2021Wa16].

Table 3

direct α emission from ^{242m}Am , Ex. = 2.20(8) MeV, $J^\pi = 5^-$, $T_{1/2} = 141.9(17)$ y*, $BR_\alpha = 0.45(1)\%$ *

E_α (c.m.)	E_α (lab)***	I_α (rel)	I_α (abs)***	J_f^π @	$E_{daughter}(^{238}\text{Np})^\oplus$	coincident γ -rays (keV)@	HF@
5.0583	4.9747**	$2 \times 10^{-3}\%$	$9 \times 10^{-6}\%$ **		0.581**		2.3×10^3
5.116(5)	5.031(5)	0.02(1)%	$9.0(45) \times 10^{-5}\%$		0.524	26.4, 35.9, 43.8, 44.0, 62.3, 79.7, 139.1 358.3, 417.6, 461.6, 497.5	600_{-200}^{+600}
5.157(3)	5.072(3)	0.28(8)%	$1.1(3) \times 10^{-3}\%$		0.484***		80_{-18}^{+33}
5.1672	5.0818**	0.03%	$1.4 \times 10^{-4}\%$ **		0.470**		820
5.179(4)	5.093(4)	0.24(8)%	$9.5(32) \times 10^{-4}\%$	(6 ⁺)	0.460	140 $_{-40}^{+70}$	
24.4, 26.4, 35.0, 35.9, 43.1, 49.4, 53.7, 1.79(5)						59.3, 60.2, 62.3, 66.9, 73.7, 86.7, 92.5, 95.2, 96.8, 109.6, 111.2, 117.2, 121.7, 136.0, 152.7, 153.9, 163.3, 206.4	
5.2309(9)	5.1444(9)	6.3(2)%	0.025(1)%	6 ⁻	0.408	35.0, 43.3, 59.3, 76.0, 95.2, 121.7, 122.8, 132.6, 152.7, 153.9, 174.8, 196.5, 232.4	11.0(5)
5.2397	5.1531**	0.02%	$9 \times 10^{-5}\%$ **		0.399**		3.5×10^3
5.2605	5.1735**	0.04%	$1.80 \times 10^{-4}\%$ **	(6 ⁻)	0.377	24.4, 26.4, 32.7, 35.9, 43.3, 43.8, 46.8, 49.4, 60.2, 62.3, 73.7, 76.0, 79.5, 79.7, 86.7, 95.7, 109.6, 117.8, 122.8, 136.0, 152.7, 153.2, 156.4, 182.9, 189.1, 196.5, 215.5, 232.4, 270.6	2.4×10^3
5.29598	5.20848	100.0(8)%	0.401(3)%	5 ⁻	0.342	24.4, 26.4, 35.0, 35.9, 43.1, 49.4, 53.7, 59.3, 60.2, 62.3, 66.9, 73.7, 86.7, 92.5, 95.2, 96.8, 109.6, 111.2, 121.7, 136.0, 152.7, 153.9, 163.3, 206.4	1.79(5)
5.3021	5.2145**	0.03%	$1.35 \times 10^{-4}\%$ **		0.334**	6.1×10^3	
5.336622	5.2484(22)	1.1(1)%	$4.5(5) \times 10^{-3}\%$	(1) ⁻	0.299	46.8, 95.7, 116.9, 156.4, 182.9	290_{-30}^{+40}
5.3380	5.2498**	0.04%	$1.80 \times 10^{-4}\%$ **	(6 ⁻)	0.297	35.0, 43.8, 44.0, 59.3, 79.7, 95.2, 121.7, 131.5, 139.1, 190.9	7.5×10^3
5.360(3)	5.271(3)	1.2(1)%	$5.0(5) \times 10^{-3}\%$	4 ⁺	0.276	35.0, 59.3, 95.2, 121.7, 153.9	369(35)
5.405(3)	5.316(3)	0.7(1)%	$2.7(5) \times 10^{-3}\%$	5 ⁻	0.233	24.4, 26.4, 35.0, 35.9, 43.1, 49.4, 53.7, 59.3, 60.2, 62.3, 73.7, 86.7, 92.5, 95.2, 96.8, 109.6, 111.2, 121.7, 136.0, 152.7	$1.2_{-2}^{+3} \times 10^3$
5.421(5)	5.331(5)	0.17(11)%	$6.8(45) \times 10^{-4}\%$	3 ⁻	0.216	24.4, 26.4, 32.7, 35.9, 46.8, 49.4, 60.2, 62.3, 73.7, 79.5, 86.7, 95.7, 109.6, 136.0, 153.2, 156.4, 182.9, 189.1, 215.5	$6_{-3}^{+13} \times 10^3$
5.4593(18)	5.3691(18)	1.2(2)%	$5.0(9) \times 10^{-3}\%$	4 ⁻	0.179	24.4, 26.4, 35.9, 43.1, 49.4, 60.2, 62.3, 73.7, 86.7, 92.5, 109.6, 136.0, 152.7	$1.4_{-0.2}^{+0.3} \times 10^3$
5.5034(21)	5.4124(21)	1.1(2)%	$4.5(9) \times 10^{-3}\%$	3 ⁻	0.136	24.4, 26.4, 35.9, 49.4, 60.2, 62.3, 73.7, 86.7, 109.6, 136.0	$2.8_{-0.5}^{+0.8} \times 10^3$
5.5497	5.4580**	0.16%	$6.30 \times 10^{-4}\%$ **	3 ⁺	0.087	24.4, 26.4, 60.2, 86.7	2.7×10^3
5.6098	5.5171**	$7 \times 10^{-3}\%$	$2.70 \times 10^{-5}\%$ **	3 ⁺	0.026	26.4	2.0×10^6

* [1979Ze05].

** Values taken from [1979Ba67], modified by -0.2 keV s recommended in [1991Ry01].

*** Values taken from [1990Ho02], except where noted.

@ [2015Br06].

@@ R_0 (fm) = 1.50725(14). Deduced from interpolated between 1.51631(11) fm (240Pu) and 1.498180(88) fm (244Cm).

Table 4
direct α emission from ^{258}Lr , $T_{1/2} = 3.91(22)$ s*, $BR_{\alpha} = 97.4(18)\%$ **.

E_{α} (c.m.)	E_{α} (lab)**	I_{α} (rel)	I_{α} (abs)**	J_f^{π}	$E_{daughter}(^{254}\text{Md})$	coincident γ -rays (keV)	R_0 (fm) [@]	HF
8.685(20)	8.550(20)	47(9)%	21(4)%		0.105(22) + x		1.484(14)	$6.4^{+3.4}_{-2.5}$
8.730(10)	8.595(10)	100(9)%	46(3)%		0.060(14) + x		1.484(14)	$4.1^{+1.8}_{-1.3}$
8.757(10)	8.621(10)	45(7)%	20(3)%		0.033(14)+ x		1.484(14)	11^{+6}_{-14}
8.790(10)	8.654(10)	18.1(44)%	8.3(19)%		x		1.484(14)	35^{+20}_{-13}

* Weighted average of $3.54^{+0.46}_{-0.36}$ s [2014Ha04], $3.92^{+0.35}_{-0.31}$ s [1992Gr02], 4.35(59) s [1976BeZY] and 4.2(6) s [1971Es01].

** [2014Ha04].

*** Weighted average of values from [1976BeZY] and [11971Es01]. Both papers report 4 closely spaced α transitions which were fit in their spectra as a multiplet. The reported values are 8.648(10) MeV 10(2)%, 8.614(10) MeV 35(5)%, 8.589(10) MeV 45(7)% 8.510(20) MeV 10(5)% [1976BeZY] and 8.68(2) MeV 7(2)%, 8.65(2) MeV 16(3)%, 8.62(2) 47(3)%, 8.59(2) 30(4)% [1971Es01].

@ Interpolated between 1.4762(10) fm (^{256}No) and 1.492(14) fm (^{260}Rf).

Table 5
direct α emission from ^{262}Db *, $T_{1/2} = 33.8^{+4.4}_{-3.5}$ s, $BR_{\alpha} = 48(4)\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (rel)	I_{α} (abs)	J_f^{π}	$E_{daughter}(^{258}\text{Lr})$	coincident γ -rays (keV)	R_0 (fm)**	HF
8.591(40)	8.460(40)	100(7)%	33.6(37)%		x+0.224(57)		1.482(27)	4^{+4}_{-2}
8.815(40)	8.680(40)	43(8)%	14.4(27)%		x		1.482(27)	40^{+50}_{-30}

* All values from [2014Ha01].

** Interpolated between 1.492(14) fm (^{260}Rf) and 1.471(23) fm (^{264}Sg)

Table 6
direct α emission from ^{266}Bh *, $T_{1/2} = 10.0^{+2.6}_{-1.7}$ s, $BR_{\alpha} \approx 100\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (rel)	I_{α} (abs)	J_f^{π}	$E_{daughter}(^{262}\text{Db})$	coincident γ -rays (keV)	R_0 (fm)	HF
8.75-9.54	8.62-9.40							

* All values from [2020Ha27].

Table 7
direct α emission from ^{270}Mt *, $T_{1/2} = 0.48^{+0.66}_{-0.38}$ s, $BR_{\alpha} \approx 100\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (rel)	I_{α} (abs)	J_f^{π}	$E_{daughter}(^{266}\text{Bh})$	coincident γ -rays (keV)	R_0 (fm)	HF
10.18(7)	10.03(7)				0.23(10)+x			
10.41(7)	10.26(7)				x			

* All values from [2012Mo25].

Table 8
direct α emission from ^{274}Rg *, $T_{1/2} = 12^{+16}_{-5}$ ms, $BR_{\alpha} \approx 100\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (rel)	I_{α} (abs)	J_f^{π}	$E_{daughter}(^{262}\text{Db})$	coincident γ -rays (keV)	R_0 (fm)	HF
10.81(6)	10.65(6)							
11.32(7)	11.15(7)							
11.48(7)	11.31(7)							

* All values from [2012Mo25], based on 3 decay chains.

Table 9direct α emission from $^{278}\text{Nh}^*$, $T_{1/2} = 1.4^{+1.9}_{-0.5}$ ms, $BR_{\alpha} \approx 100\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (rel)	I_{α} (abs)	J_f^{π}	$E_{\text{daughter}}(^{262}\text{Db})$	coincident γ -rays (keV)	R_0 (fm)	HF
11.69(4)	11.52(4)							
11.85(4)	11.68(4)							
11.99(6)	11.82(6)							

* All values from [2012Mo25], based on 3 decay chains.

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