Odd Z
Tz = +28

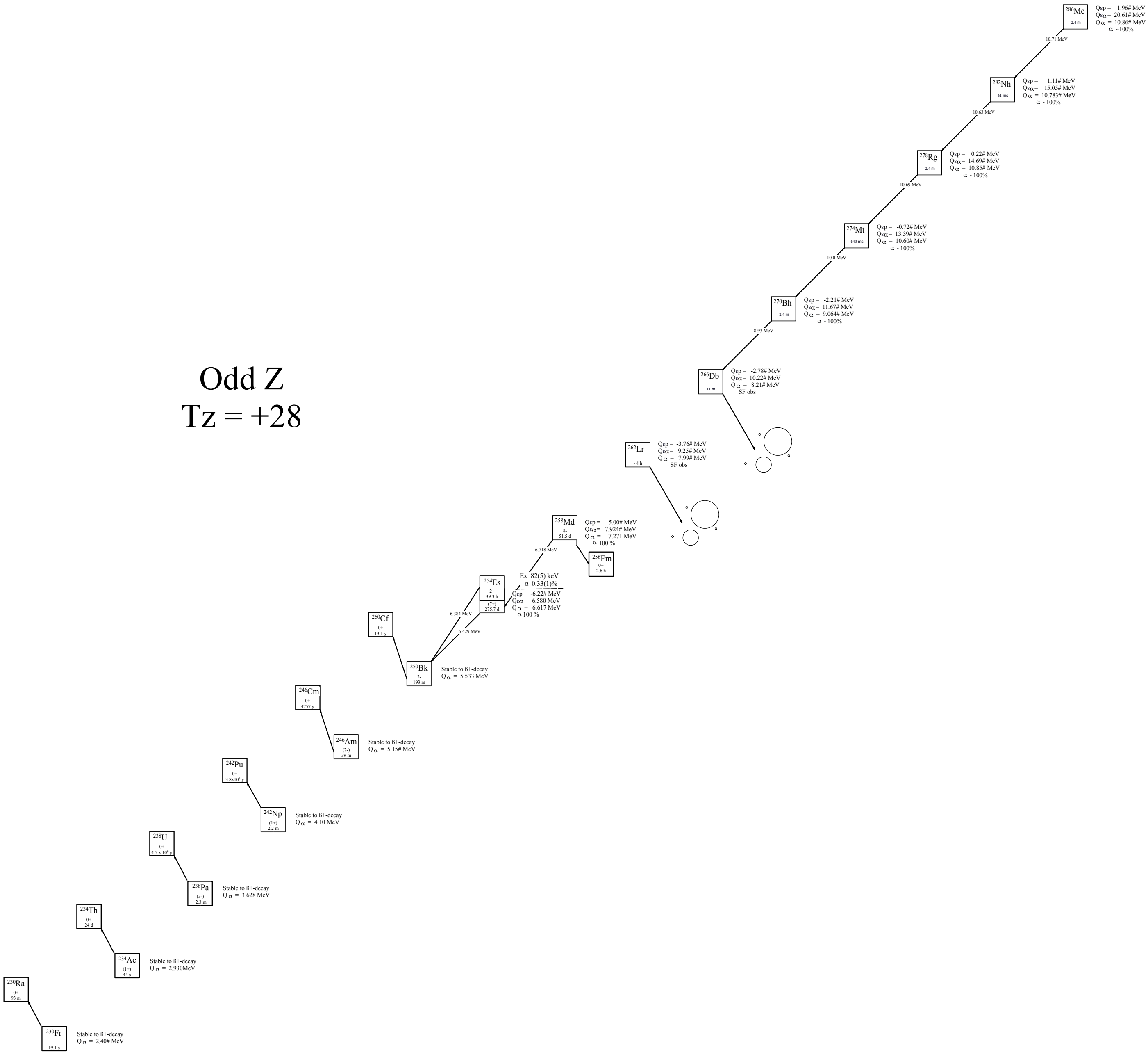

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +28 nuclei.

Last updated on 4/25/25

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +28 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values are taken from ENSDF.

Nuclide	J^π	Ex.	$T_{1/2}$	Q_ε	Q_{β^-}	$Q_{\beta^-\alpha}$	Experimental
^{222}Bi			obs		6.46(30)#	11.08(42)#	[**2010Al24**]
^{226}At			obs	-2.89(50)#	5.91(30)#	9.93(30)#	[**2010Al24**]
^{230}Fr*			19.1(5) s	-2.68(20)#	4.970(12)	8.495(12)	[**1987Ku04**]
^{234}Ac*			44(7) s	-2.089(16)	4.228(14)	8.080(17)	[**1986Gi08**]
^{238}Pa*		(3$^-$)	2.3(1) m	-1.63(28)#	3.586(16)	8.036(16)	[**1968Tr07**]
^{242}Np*		(1$^+$)	2.2(2) m	-1.20(28)#	2.70(20)	7.87(20)	[**1979Ha26**]
^{246}Am*		(7$^-$)	39(3) m	-0.401(14)#	2.377(18)#	8.032(18)	[**1968Fi03**]
^{250}Bk*		2$^-$	192.7(3) m	-0.038(11)	1.782(3)	8.090(3)	[**1979Re01**]
					$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	
^{254}Es		(7$^+$)	275.7(5) d	0.653(12)	-6.22(36)#	6.580(11)	[**1975Ah04**]
^{254m}Es	0.082(5)	2$^+$	39.3(2) h	0.735(13)	-6.23(36)#	6.662(12)	[**1962Un01**]
^{258}Md		8$^-$	51.50(29) d	1.26(20)#	-5.00(41)#	7.924(12)#	[**1993Mo18**]
^{262}Lr			≈4 h	2.00(41)#	-3.76(55)#	9.25(28)#	[**1989HuZU**]
^{266}Db			11^{+21}_{-4} m	2.60(50)#	-2.78(62)#	10.22(46)#	[**2022Og08**]
^{270}Bh			$2.4^{+4.4}_{-0.9}$ m	2.80(55)#	-2.21(69)#	11.67(55)#	[**2022Og08**]
^{274}Mt			$0.64^{+0.76}_{-0.23}$ s	3.84(60)#	-0.72(76)#	13.39(59)#	[**2022Og08**]
^{278}Rg			$4.6^{+5.5}_{-1.6}$ ms	4.27(64)#	0.22(77)#	14.69(64)#	[**2022Og08**]
^{282}Nh			61^{+73}_{-22} ms	4.90(68)#	1.11(87)#	15.05(68)#	[**2022Og08**]
^{286}Mc			20^{+98}_{-9} ms	5.41(68)#**	1.96(88)#**	20.61(68)#**	[**2022Og08**]

* 100% β^--emitter.
** Deduced from measured E_α and mass excesses of daughter nuclei [2021Wa16].

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +28 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
^{222}Bi		2.825(50)#			
^{226}At	7.21(42)#	3.29(42)#			
^{230}Fr	7.165(15)	2.40(30)#			
^{234}Ac	6.782(16)	2.930(15)			
^{238}Pa	6.350(22)	3.628(21)			
^{242}Np	6.07(28)#	4.10(20)			
^{246}Am	5.473(22)#	5.15(20)#			
^{250}Bk	5.088(4)	5.533(18)			
^{254}Es	4.596(5)	6.617(1)	100%*		[**2008Ah02**, 1999Po35, 1988Po05, 1987Po22, 1985Ok04, 1975Ah04, 1972Bb24, 1971Bb10, 1966Mc02, 1965Me02, 1964Mc13, 1958Sc35, 1956Jo09, 1955Ha35]
^{254m}Es	4.678(7)	6.699(5)	0.33(1)%		[**1973Ah04**, 1972AhZS, 1972HaWO, 1972HaWR, 1967Fi03, 1964Mc13, 1956Jo09, 1954Ch23, 1954Fi14]
^{258}Md	4.189(6)	7.271(2)	100%		[**1993Mo18**, 1970Fi12, 1968Hu06]
^{262}Lr	3.64(28)#	7.99(20)#		obs	[**1989HuZU, 1987LoZR**, 1990HuZV, 1991HeZT]
^{266}Db	3.24(46)#	8.21(20)#		obs	[**2022Og08, 2013Og01, 2007Og02**, 2023Ko22, 2012OgZZ, 2011Og07, 2007Og05, 2007Og01]
^{270}Bh	2.75(47)#	9.064(95)#	100%**		[**2022Og08, 2013Og01, 2007Og02**, 2023Ko22, 2012OgZZ, 2011Og07, 2007Og05, 2007Og01]
^{274}Mt	1.801(53)#	10.60(23)#	100%**		[**2022Og08, 2013Og01, 2007Og02**, 2023Ko22, 2012OgZZ, 2011Og07, 2007Og05, 2007Og01]
^{278}Rg	1.86(55)#	10.85(95)#	100%**		[**2022Og08, 2013Og01, 2007Og02**, 2023Ko22, 2012OgZZ, 2011Og07, 2007Og05, 2007Og01]
^{282}Nh	1.51(56)#	10.783(95)#	100%**		[**2022Og08, 2013Og01, 2007Og02**, 2023Ko22, 2012OgZZ, 2011Og07, 2007Og05, 2007Og01]
^{286}Mc	1.20(57)#***	10.86(2)	100%**		[**2022Og08**, 2023Ko22]

* [1985Ok04] report a β^- branch of $1.74(8)\times10^{-4}$%.
** Only α-decay has been observed.
*** Deduced from measured E_α and mass excesses of daughter nuclei [2021Wa16].

Table 3
direct α emission from ^{254}Es*, J^{π} = (7^{+}), $T_{1/2}$ = 275.7(5) d*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{250}Bk)	coincident γ-rays (keV)	HF$^{@}$
5.879(3)	5.786(3)	6.1(3)×10^{-4}%	5.6(3)×10^{-4}%		0.739		238(25)
5.888(3)	5.795(3)	4.0(2)×10^{-4}%	3.7(2)×10^{-4}%		0.730		400(40)
5.902(3)	5.809(3)	1.2(5)×10^{-3}%	1.1(5)×10^{-3}%		0.716		160^{+140}_{-50}
5.928(3)	5.835(3)	3.3(9)×10^{-3}%	3.0(8)×10^{-3}%		0.689		84^{+32}_{-19}
5.964(3)	5.870(3)	2.6(8)×10^{-3}%	2.4(7)×10^{-3}%		0.654		160^{+70}_{-40}
5.979(3)	5.885(3)	1.0(4)×10^{-3}%	9.3(4)×10^{-4}%	(9^{+})	0.637		520(50)
6.018(3)	5.923(3)	1.7(7)×10^{-3}%	1.6(6)×10^{-3}%		0.600		470^{+290}_{-140}
6.032(3)	5.937(3)	8.2(4)×10^{-4}%	7.5(4)×10^{-4}%		0.586		1.20(12)×10^{3}
6.072(3)	5.976(3)	0.105(5)%	0.096(5)%	8^{+}	0.5450	310.2, 390.3, 460.8	15.4(16)
6.096(3)	6.000(3)	5.3(1)×10^{-3}%	4.9(10)×10^{-3}%	(9^{-})	0.520		410^{+110}_{-80}
6.142(2)	6.045(2)	2.2(2)×10^{-3}%	2.1(2)×10^{-3}%	8^{+}	0.4748	320.6, 390.3	1.63(21)×10^{3}
6.151(2)	6.054(2)	0.22(6)%	0.20(5)%	7^{+}	0.4648	310.2, 380.4	19^{+7}_{-4}
6.174(3)	6.077(3)	4.9(11)×10^{-3}%	4.5(10)×10^{-3}%	9^{-}	0.442		$1.1^{+0.3}_{-0.2}$×10^{3}
6.185(2)	6.088(2)	0.083(2)%	0.076(2)%	(8^{-})	0.431	346.6	76(7)
6.211(2)	6.113(2)	0.59(11)%	0.54(10)%	6^{+}	0.4050	320.6	14^{+4}_{-3}
6.246(2)	6.148(2)	2.2(3)×10^{-3}%	2.0(3)×10^{-3}%	6^{+}	0.3696	285.2	$5.9^{+1.2}_{-0.9}$×10^{3}
6.263(2)	6.164(2)	0.033(2)%	0.030(2)%	6^{+}	0.3539	269.5	470(50)
6.277(2)	6.178(2)	0.038(2)%	0.035(2)%	8^{-}	0.339		480(50)
6.289(2)	6.190(2)	0.015(8)%	0.0142(7)%	10^{+}	0.3273		1.35(14)×10^{3}
6.300(2)	6.201(2)	5.9(5)×10^{-3}%	5.4(5)×10^{-3}%	5^{+}	0.3165	35.6, 42.6, 238.2, 280.9	4.0(5)×10^{3}
6.353(3)	6.253(3)	0.0113(6)%	0.0104(5)%	8^{+}	0.263		3.8(4)×10^{3}
6.368(2)	6.268(2)	0.26(6)%	0.243(5)%	7^{-}	0.248		194(17)
6.380(2)	6.280(2)	0.18(6)%	0.168(5)%	9^{+}	0.2355		322^{+31}_{-29}
6.413(3)	6.312(3)	1.5(2)×10^{-3}%	1.4(2)×10^{-3}%	4^{-}	0.203		$5.6^{+1.1}_{-0.9}$×10^{4}
6.424(2)	6.323(2)	0.050(1)%	0.046(1)%	7^{+}	0.192		1.9(2)×10^{3}
6.450(2)	6.348(2)	0.98(1)%	0.90(1)%	6^{-}	0.167		129(11)
6.462(2)	6.360(2)	3.31(1)%	3.04(1)%	8^{+}	0.1547		44(4)
6.487(3)	6.385(3)	0.163(7)%	0.150(5)%	6^{+}	0.129		1.17(11)×10^{3}
6.502(3)	6.400(3)	0.049(2)%	0.045(2)%	3^{+}	0.114		4.6(5)×10^{3}
6.520(3)	6.417(3)	2.50(2)%	2.29(2)%	5^{-}	0.0975	35.6, 61.9	108(9)
6.532(2)	6.429(2)	100%	91.8(2)%	7^{+}	0.0844		3.1(3)
6.581(2)	6.477(2)	0.34(1)%	0.31(1)%	4^{+}	0.0356	35.6	1.55(14)×10^{3}
6.616(3)	6.512(3)	2.6(3)×10^{-3}%	2.4(3)×10^{-3}%	2^{-}	0.0	——	$2.9^{+0.5}_{-0.4}$×10^{5}

* All values from [2008Ah02], except where noted.
** [1975Ah04].
*** There is also a β^{-} branch of 1.74(8)×10^{-4}% [1985Ok04].
$^{@}$ R_0 = 1.5000(35) fm. Value is interpolated between 1.50113(23) (^{252}Cf) and 1.4989(35) (^{256}Fm).

Table 4
direct α emission from ^{254m}Es*, Ex. = 82(5) keV, J^{π} = 2^{+}, $T_{1/2}$ = 39.3(2) h*, BR_{α} = 0.33(1)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{250}Bk)	coincident γ-rays (keV)	HF$^{@}$
6.383(3)	6.282(3)	0.21(4)%	5.3(10)×10^{-4}%	5^{+}	0.316	34.5, 42.7, 238.1***, 280.9***	620^{+160}_{-110}
6.400(2)	6.299(2)	0.64(8)%	1.6(2)×10^{-3}%		0.298		250^{+50}_{-40}
6.428(2)	6.327(2)	2.9(3)%	7.3(7)×10^{-3}%	4^{+}	0.270	34.5, 58.6***, 42.7, 52.2***, 79.9, 96.3, 177.3, 211.8, 236.0***	75(10)
6.461(2)	6.359(2)	11.1(7)%	0.027(2)%	3^{+}	0.2367***	34.5, 79.9***, 121.3***, 202.3***	$28.7^{3.3}_{-3.1}$
6.486(2)	6.384(2)	100(2)%	0.248(8)%	2^{+}	0.2118	34.5, 42.7, 52.2***, 79.9, 96.3, 177.3, 211.8	4.2(4)
6.520(2)	6.417(2)	2.4(3)%	5.9(7)×10^{-3}%	(1^{+})	0.1753	50.1, 71.3, 90.7, 104.0, 126.0, 175.1***	260(40)
6.560(3)	6.457(3)	0.16(5)%	4.0(13)×10−4%	(5^{-})***	0.1373***	34.5, 45,8***, 57.1***, 80.3***, 102.8***	$5.8^{+3.0}_{-1.6}$×10^{3}
6.568(2)	6.465(2)	0.83(9)%	2.0(2)×10^{-3}%	6^{+}	0.1319	34.5, 42.7, 52.2***, 96.3	1.2(2)×10^{3}
6.575(4)	6.471(4)	≈0.11%	≈2.6×10^{-4}%		0.1253	34.5, 90.7	≈10^{4}
6.619(2)	6.515(2)	1.9(2)%	4.6(5)×10^{3}%		0.079	34.5,42.7	930^{+140}_{-120}
6.664(2)	6.559(2)	7.7(5)%	0.019(1)%	3^{-}	0.0345	34.5	360(40)
6.698(4)	6.593(4)	5.3(7)%	0.013(2)%	2^{-}	0.0	——	740^{+140}_{-110}

* All values from [1973Ah04], except where noted. E_{α} values are adjusted by +1.9 keV as recommended in [1991Ry01].
** [1962Un01].
*** [2019Si11].
$^{@}$ R_0 = 1.5000(35) fm. Value is interpolated between 1.50113(23) (^{252}Cf) and 1.4989(35) (^{256}Fm).

Table 5
direct α emission from ^{258}Md*, J^{π} = (7^{+}), T$_{1/2}$ = 275.7(5) d*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(rel)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{254}Es)	coincident γ-rays (keV)	HF**
6.802(2)	6.697(2)	5.2(21)%	3.4(14)%	9^{-}	0.4692	80.1, 91.0, 171.1, 298.1, 389.1	180^{+130}_{-60}
6.824(2)	6.718(2)	100(19)%	65.8(13)%	8^{-}	0.4479	71.1, 80.1, 86.9, 91.0, 171.1, 205.7, 276.8, 296.7,367.8, 376.8, 447.9	$11.7^{+2.0}_{-1.7}$
6.870(4)	6.763(4)	31.6(18)%	20.8(12)%	(7^{-},8^{-})	0.4038	189.7, 214.7	58^{+10}_{-9}
6.895(2)	6.788(2)	15.1(15)%	9.9(10)%	8^{-}	0.3768	80.1, 86.9, 91.0, 171.1, 205.7, 296.7, 376.8	161^{+33}_{-28}
7.100(2)	6.99(2)	≤0.3%	≤0.2%	9^{+}	0.1711	80.1, 91.0, 171.1	$\geq 6.1\times10^{4}$
7.191(2)	7.08(2)	≤0.3%	≤0.2%	8^{+}	0.0801	80.1	$\geq 1.5\times10^{5}$
7.272(2)	7.159(2)	≤0.3%	≤0.2%	7^{+}	0.0	—–	$\geq 3.1\times10^{5}$

* All values from [1993Mo18],
** R$_0$ = 1.4921(62) fm. Value is interpolated between 1.4989(35) (^{256}Fm) and 1.4852(51) (^{260}No).

Table 6
direct α emission from ^{270}Bh, T$_{1/2}$ = $2.4^{+4.4}_{-0.9}$ m*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{266}Db)	coincident γ-rays (keV)	HF***
9.06(2)	8.93(2)**	100%***				

* [2022Og08].
** [2011Og07].
*** Only α-decay has been observed.

Table 7
direct α emission from ^{274}Mt, T$_{1/2}$ = $0.64^{+0.76}_{-0.23}$ s*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{270}Bh)	coincident γ-rays (keV)	HF**
10.1(11)	10.0(11)**	100%***				

* [2022Og08].
** [2011Og07].
*** Only α-decay has been observed.

Table 8
direct α emission from ^{278}Rg, T$_{1/2}$ = $4.6^{+5.5}_{-1.6}$ ms*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{274}Mt)	coincident γ-rays (keV)	HF**
10.84(8)	10.69(8)**	100%***				

* [2022Og08].
** [2011Og07].
*** Only α-decay has been observed.

Table 9
direct α emission from ^{282}Nh, T$_{1/2}$ = 61^{+73}_{-22} ms*, BR_{α} = 100%***.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_{f}	$E_{daughter}$(^{278}Rg)	coincident γ-rays (keV)	HF**
10.78(8)	10.63(8)**	100%***				

* [2022Og08].
** [2011Og07].
*** Only α-decay has been observed.

Table 10
direct α emission from ^{286}Mc*, $T_{1/2}$ = 20^{+98}_{-9} ms, BR_α = 100%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{282}Nh)	coincident γ-rays (keV)	HF**
10.86(2)	10.71(2)	100%**				

* All values from [2022Og08].
** Only α-decay has been observed.

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