



Fig. 1: Known experimental values for heavy particle emission of the odd-Z $T_z = +25/2$ nuclei.

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Table 1

Observed and predicted β -delayed particle emission from the odd-Z, $T_z = +25/2$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein.

Nuclide	Ex	J^π	$T_{1/2}$	Q_ϵ	$Q_{\epsilon p}$	$Q_{\epsilon\alpha}$	Experimental
^{143}Pr		$7/2^+$	13.56(2) d*	-1.462(3)	—	—	[1971Ba28, 1957Pe09, 1965Is01]
^{147}Pm		$7/2^+$	2.62346(27) y	0.105(2)	-9.657(34)	0.139(3)	[1999Po32]
^{151}Eu		$5/2^+$	$4.6(12) \times 10^{18}$ y***	stable	—	—	[2014Ca03]
^{155}Tb		$3/2^+$	5.32(6) d	0.820(10)	-6.801(10)	0.901(10)	[1970Ch09]
^{159}Ho		$7/2^-$	33.05(11) m	1.838(3)	-5.148(3)	2.316(3)	[1982Vy02]
^{163}Tm		$1/2^+$	1.810(5) h	2.439(3)	-3.977(6)	4.014(6)	[1982Vy02]
^{167}Lu		$7/2^+$	51.5(10) m	3.060(40)	-2.929(39)	5.216(38)	[1976Me06]
^{171}Ta		$(5/2^+)$	23.3(3) m	3.710(40)	-1.703(33)	6.445(28)	[1972Ch45]
^{175}Re		$(5/2^-)$	5.89(5) m	4.340(40)	-0.837(40)	7.718(40)	[1984Sz07]
^{179}Ir		$(5/2^-)$	79(1) s	4.938(18)	0.283(30)	9.126(30)	[1992Bo19]
^{183}Au		$(5/2^-)$	44.6(19) s	5.582(17)	1.571(23)	10.404(18)	[1995Bi01]
^{187}Tl		$(1/2^+)$	≈ 45 s	5.674(15)	1.981(22)	10.904(16)	[1981Mi12]
^{187m}Tl	0.333(8)***	$(9/2^-)$	15.60(12) s	6.007(17)	2.314(23)	11.237(18)	[1981Mi12]
^{191}Bi		$(9/2^-)$	12.1(4) s [@]	7.052(10)	3.838(10)	12.454(15)	[2013Ny01, 2003Ke04]
^{191m}Bi	0.234(8)	$(1/2^+)$	116(5) ms ^{@@}	7.052(10)	3.838(10)	12.454(15)	[2013Ny01, 2003Ke04, 1999An36]
^{195}At		$(1/2^+)$	309(20) ms ^{@@@}	7.646(11)	5.264(11)	14.396(12)	[2013Ny01, 2003Ke04]
^{195m}At	0.033(8)***	$(7/2^-)$	144(3) ms ^a	7.679(14)	5.297(14)	14.429(14)	[2013Ny01, 2003Ke04]
^{199}Fr		$(1/2^+)$	5_{-2}^{+7} ms	8.331(16)	6.191(15)	15.463(15)	[2013Uu01]
$^{199m1}\text{Fr}$	0.057(26)***	$(7/2^-)$	7_{-2}^{+3} ms	8.388(16)	6.191(15)	15.463(15)	[2013Uu01]
$^{199m2}\text{Fr}$	≤ 0.300 ***	$(13/2^+)$	$1.6_{-0.6}^{+1.6}$ ms	$\leq 8.631(31)$	$\leq 6.548(30)$	$\leq 15.811(30)$	[2013Uu01]
^{203}Ac			56_{-25}^{+269} μs	8.977(23) ^b	7.187(22) ^b	16.722(22) ^b	[2024WaXX]

* weighted average of 13.57(2) d [1971Ba28], 13.59(4) d [1957Pe09] and 13.55(2) d [1965Is01].

** Reported as 4.62 (95 stat.) (68 syst.) $\times 10^{18}$ y [2014Ca03].

*** Deduced from α energies.

@ Weighted average of 11.7(4) s [2013Ny01] and 12.4(4) s [2003Ke04].

@@ Weighted average of 114(6) ms [2013Ny01], 121_{-7}^{+8} ms [2003Ke04] and 115(10) ms [1999An36].

@@@ Weighted average of 290(20) ms [2013Ny01] and 328(20) ms [2003Ke04].

^a Weighted average of 143(3) ms [2013Ny01] and 147(5) ms [2003Ke04].

^b Deduced from α energy and mass of daughter [2021Wa16].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, $T_z = +25/2$ 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}Pr	5.824(2)	14.716(4)	1.729(2)		
^{147}Pm	5.405(1)	13.994(7)	1.601(1)		
^{151}Eu	4.891(1)	13.167(2)	1.964(1)	100%*	[2014Ca03, 2012Pa16]
^{155}Tb	4.833(10)	12.461(10)	0.978(10)		
^{159}Ho	4.211(4)	11.144(3)	1.496(10)		
^{163}Tm	3.683(5)	10.110(6)	2.176(6)		
^{167}Lu	3.222(38)	9.174(37)	2.777(38)		
^{171}Ta	2.755(40)	8.216(28)	3.381(47)		
^{175}Re	2.350(40)	7.470(40)	4.007(40)		
^{179}Ir	1.826(17)	6.390(30)	4.782(30)		
^{183}Au	1.312(16)	5.306(11)	5.465(3)	0.8(2)%	[1995Bi01, 1992BiZZ, 1984BrZR, 1982Bo04, 1982BoZL, 1970Ha18, 1970Ma24, 1968De01, 1968Si01, 1965Si07]
^{187}Tl	1.195(14)	5.164(8)	5.322(7)		
^{187m}Tl	0.862(16)	4.831(11)	5.655(11)	0.15(5)%	[1991Wa21, 1980Sc09, 1976To06, 1976BoYC]
^{191}Bi	0.112(15)	3.201(11)	6.780(3)	51(10)%	[2013Ny01, 2003Ke04, 1999An36, 2000Sc46, 1999Ta20, 1999TaZS, 1998Kr23, 1993An19, 1991Wa21, 1985Co06, 1982LeZN, 1978Va21, 1974Le02, 1972Ga27]
^{191m}Bi	-0.122(16)	2.967(13)	7.014(7)	68(5)%	[2013Ny01, 2003Ke04, 1999An36, 2024WaXX, 1993An19, 1991Wa21, 1985Co06, 1982LeZN, 1978Va21, 1974Le02, 1972Ga27]
^{195}At	-0.245(16)	2.164(12)	7.344(6)	$\approx 100\%$	[2013Ny01, 2003Ke04, 2024WaXX, 1999Ta20, 1999TaZS, 1996PuZZ, 1995Le15, 1995NoZW, 1984YaZY]
^{195m}At	-0.278(18)	2.131(14)	7.377(10)	88(4)%	[2013Ny01, 2003Ke04, 1999Ta20, 1999TaZS,

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, $T_z = +25/2$ nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

					1996PuZZ, 1995Le15, 1995NoZW, 1984YaZY]
^{199}Fr	-0.713(19)	1.451(16)	7.817(10)	100%	[2013Uu01, 2024WaXX]
$^{199m1}\text{Fr}$	-0.770(32)	1.394(31)	7.874(28)	100%	[2013Uu01, 2013Ka16, 1999Ta20, 1999TaZS, 2024WaXX]
$^{199m2}\text{Fr}$	$\geq -1.013(19)$	$\geq 1.151(16)$	$\leq 8.117(10)$	100%	[2013Uu01]
^{203}Ac	-1.214(26)***	0.589(23)***	8.382(16)**	100%	[2024WaXX]

* Only decay available.

** Deduced from α energy.

*** Deduced from α energy and mass of daughter [2021Wa16].

Table 3

direct α emission from $^{151}\text{Eu}^*$, $J^\pi = 5/2^+$, $T_{1/2} = 4.6(12) \times 10^{18}$ y, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{147}\text{Pm})$	coincident γ -rays	R_0 (fm)	HF
1.9489(86)	1.8973(86)	100%	$7/2^-$	0.0	—	1.583(16)	18_{-9}^{+11}

* All values from [2014Ca13].

Table 4

direct α emission from $^{183}\text{Au}^*$, $J^\pi = (5/2^-)$, $T_{1/2} = 44.6(19)$ s, $BR_\alpha = 0.8(2)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{179}\text{Ir})$	coincident γ -rays	R_0 (fm)	HF
5.075(10)	4.964(10)	0.2(1)%	0.0016(9)%		0.394		1.5330(75)	6_{-3}^{+8}
5.198(10)	5.084(10)	0.4(1)%	0.0032(11)%		0.271		1.5330(75)	13_{-4}^{+9}
5.275(5)	5.160(5)	0.6(1)%	0.0048(14)%		0.1932	0.0925, 0.0997, 0.1932	1.5330(75)	23_{-7}^{+12}
5.469(5)	5.349(5)	100(1)%	0.8(2)%	$(5/2^-)$	0.0	—	1.5330(75)	$1.3_{-0.4}^{+0.6}$

* All values from [1995Bi01].

Table 5

direct α emission from ^{187m}Tl , $E_x = 333(8)$ keV*, $J^\pi = (9/2^-)$, $T_{1/2} = 15.60(12)$ s**, $BR_\alpha = 0.15(5)\%***$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{183}\text{Au})$	coincident γ -rays	R_0 (fm)	HF
5.648(10)	5.528(10) [@]	0.15(5)%***	$(9/2^-)$	0.0124(4) ^{@@}		1.494(10)	$0.9_{-0.4}^{+0.6}$

* Deduced from α energies of ^{191}Bi decay.

** [1981Mi12].

*** [1991Wa21].

@ [1980Sc09].

@@ [2016Ba19].

Table 6

direct α emission from ^{191}Bi , $J^\pi = (9/2^-)$, $T_{1/2} = 12.1(4)$ s*, $BR_\alpha = 51(10)\%**$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{187}\text{Tl})$	coincident γ -rays	R_0 (fm)	HF
6.450(4)	6.315(4)***	100% [@]	49(10)%	$(9/2^-)$	0.333(8)	1.5030(34)	$1.1_{-0.3}^{+0.4}$	
6.723(15)	6.582(15) [@]	0.78% [@]	0.40%	$(3/2^+)$	0.300	0.300	1.5030(34)	200
6.783(7)	6.641(7)***	3% [@]	1.5(3)%	$(1/2^+)$	0.0	—	1.5030(34)	670

* Weighted average of 11.7(4) s [2013Ny01] and 12.4(4) s [2003Ke04].

** [2003Ke04].

*** [2013Ny01].

@ [1999An36].

Table 7direct α emission from ^{191m}Bi , Ex = 234(8) keV*, $J^\pi = (1/2^+)$, $T_{1/2} = 116(5)$ ms**, $BR_\alpha = 68(5)\%$ ***.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{187}\text{Tl})$	coincident γ -rays	R_0 (fm)	HF
6.723(15)	6.582(15)	0.24% ^{@@}	0.163(12)%	(3/2 ⁺)	0.300	0.300	1.5030(34)	36
7.022(4)	6.875(4) [@]	100% ^{@@}	68(5)%	(1/2 ⁺)	0.0	—	71.5030(34)	1.03(12)

* Deduced from α energies.** Weighted average of 114(6) ms [2013Ny01], 121_{-7}^{+8} ms [2003Ke04] and 115(10) ms [1999An36].

*** [2003Ke04].

[@] [2013Ny01].^{@@} [1999An36].**Table 8**direct α emission from ^{195}At , $J^\pi = (1/2^+)$, $T_{1/2} = 309(20)$ ms*, $BR_\alpha = \approx 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{191}\text{Bi})$	coincident γ -rays	R_0 (fm)	HF
7.100(3)	6.954(3)**	$\approx 100\%$	(1/2 ⁺),	0.234(8)	—	1.5482(95)	$1.6_{-0.3}^{+0.4}$

* Weighted average of 290(20) ms [2013Ny01] and 328(20) ms [2003Ke04].

** Weighted average of 6.956(4) MeV [2013Ny01] and 6.953(3) MeV [2003Ke04]

Table 9direct α emission from ^{195m}At , Ex = 33(8) keV, $J^\pi = (7/2^-)$, $T_{1/2} = 144(3)$ ms*, $BR_\alpha = 88(4)\%$ ***.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{191}\text{Bi})$	coincident γ -rays	R_0 (fm)	HF
7.223(3)	7.075(3)***	100%	84(4)%	—	0.1486	0.1486	1.5482(95)	49_{-11}^{+13}
7.373(4)	7.222(4) [@]	4.7(5)%	4.0(5)%	(9/2 ⁻)	0.0	—	1.5482(95)	$7.2_{-1.4}^{+1.6}$

* Weighted average of 143(3) ms [2013Ny01] and 147(5) ms [2003Ke04].

** [2013Ny01].

*** Weighted average of 7.076(5) MeV [2013Ny01] and 7.075(4) MeV [2003Ke04]

[@] Weighted average of 7.222(4) MeV [2013Ny01] and 7.221(4) MeV [2003Ke04]**Table 10**direct α emission from ^{199}Fr *, $J^\pi = (1/2^+)$, $T_{1/2} = 5_{-2}^{+7}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{195}\text{At})$	coincident γ -rays	R_0 (fm)	HF
7.801(20)	7.644(20)	100%	(1/2 ⁺)	0.0	—	1.576(11)	$1.7_{-0.8}^{+2.4}$

* All values from [2013Uu01].

Table 11direct α emission from $^{199m1}\text{Fr}$, Ex. = 57(26) keV, $J^\pi = (7/2^-)$, $T_{1/2} = 7_{-2}^{+3}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{195}\text{At})$	coincident γ -rays	R_0 (fm)	HF
7.825(15)	7.668(15)	100%	—	0.033(8)	—	1.576(11)	$2.8_{-1.1}^{+1.4}$

* All values from [2013Uu01].

Table 12direct α emission from $^{199m2}\text{Fr}$ *, Ex. = ≤ 300 keV, $J^\pi = (13/2^+)$, $T_{1/2} = 1.6_{-0.6}^{+1.6}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{195}\text{At})$	coincident γ -rays	R_0 (fm)	HF
7.968(20)	7.808(20)	100%	(13/2 ⁺)	—	—	1.576(11)	≥ 1.7

* All values from [2013Uu01].

Table 13direct α emission from $^{203}\text{Ac}^*$, $T_{1/2} = 56_{-25}^{+269} \mu\text{s}$, $BR_{\alpha} = 100\%$.

E_{α} (c.m.)	E_{α} (lab)	I_{α} (abs)	J_{π}^{α}	E_{daughter} (^{199}Fr)	coincident γ -rays	R_0 (fm)	HF
8.382(16)	8.217(16)	100%					

* All values from [2024WaXX].

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