

Table 1

Observed and predicted β -delayed particle emission from the even- Z , $T_z = +31/2$ nuclei. J^π values for ^{167}Er , ^{171}Yb , ^{175}Hf , ^{179}W , ^{183}Os , ^{187}Pt , ^{191}Hg and ^{195}Pb are taken from ENSDF. 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
^{167}Er		$7/2^+$	stable	-1.010(5)	—	—	
^{171}Yb		$1/2^-$	stable	-0.097(1)	—	—	
^{175}Hf		$5/2^-$	70(2) d	0.684(2)	-4.826(2)	2.304(2)	[1963Ra14]
^{179}W		$7/2^-$	37.00(17) m	1.062(15)	-4.149(15)	3.446(15)	[1969Bi10]
^{183}Os		$9/2^+$	13.0(5) h	2.150(50)	-2.707(50)	4.269(50)	[1960Ne03]
^{187}Pt		$3/2^-$	2.35(3) h	2.860(40)	-0.974(24)	6.699(25)	[1973Se13]
^{191}Hg		$3/2^-$	49(10) m	3.206(23)	-0.574(22)	6.533(36)	[1974Va19]
^{195}Pb		$3/2^-$	≈ 15 m	4.417(12)	1.157(6)	7.635(7)	[1982Hi04]
^{199}Po		$(3/2^-)$	312(6) s	5.559(12)	3.540(10)	10.492(12)	[1993Wa04]
^{199m}Po	0.312(2)	$(13/2^+)$	252(6) s	5.871(12)	3.852(10)	10.804(12)	[1993Wa04]
^{203}Rn		$(3/2^-)$	44(2) s*	5.979(12)	4.469(10)	12.189(12)	[1996Ta18, 1971Ho01]
^{203m}Rn	0.364(2)	$(13/2^+)$	26.7(5) s	6.343(12)	4.833(10)	12.553(12)	[1996Ta18]
^{207}Ra		$(3/2^-)$	1.2(2) s	6.360(60)	5.358(59)	13.252(59)	[1996Ta18, 1971Ho01]
^{207m}Ra	0.509(10)	$(13/2^+)$	55(7) ms**	6.869(61)	5.867(60)	13.761(60)	[2021Ni08, 1987He10]
^{211}Th		$(3/2^-)$	36_{-6}^{+13} ms***	6.73(10)	6.145(87)	14.301(88)	[2023Ch24, 1995Uu01]
^{211m}Th	0.769(21)	$(13/2^+)$	83(8) μs	7.50(23)	6.914(89)	15.070(90)	[2021Au03]
^{215}U			$0.73_{-0.29}^{+1.33}$ ms	7.08(13)	6.91(11)	15.32(12)	[2015Ya13]

* Weighted average of 42(3) s [1996Ta18] and 45(2) s [1971Ho01].

** Weighted average of 55(9) ms [2021Ni08] and 55(10) ms [1987He10].

*** Weighted average of 36_{-8}^{+15} ms [2023Ch24] and 37_{-11}^{+28} ms [1995Uu01].

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the even- Z , $T_z = +31/2$ 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
^{167}Er	7.508(1)	14.255(1)	0.667(1)		
^{171}Yb	6.800(1)	12.964	1.558		
^{175}Hf	6.200(2)	11.508(2)	2.400(2)		
^{179}W	5.986(54)	10.992(15)	2.762(15)		
^{183}Os	5.51(11)	10.01(51)	3.207(52)		
^{187}Pt	4.802(29)	8.457(24)	4.553(55)		
^{191}Hg	5.047(23)	8.700(24)	3.669(33)	$< 5 \times 10^{-6}\%$	[1963Ka17]
^{195}Pb	4.090(15)	7.254(16)	4.429(23)		
^{199}Po	3.154(28)	5.071(7)	6.074(2)	7.5(3)%	[1996Ta18, 1993Wa04, 1971Ho01, 1968Go12, 1991Gr12, 1985St02, 1984Co13, 1967Le08, 1967Si04, 1967Ti04, 1967Tr04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23]
^{199m}Po	2.842(28)	4.759(7)	6.386(3)	24.7(9)%*	[1996Ta18, 1993Wa04, 1967Le08, 2015We13, 2016We13, 2014Ma66, 1991Gr12, 1985St02, 1984Co13, 1973BoXL, 1971Ho01, 1968Go12, 1967Si09, 1967Ti04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23, 1962Be26, 1961Be25]
^{203}Rn	2.878(28)	4.241(8)	6.630(2)	66(9)%	[1996Ta18, 1993Wa04, 1978HoZZ, 1971Ho01, 1967Va07, 1967Va17, 1965Nu04]
^{203m}Rn	2.514(28)	3.877(8)	6.994(3)	78(7)%	[1998Bo14, 1996Ta18, 1995Le04, 1993Wa04, 1967Va17, 2015We13, 1995Le09, 1987He10, 1971Ho01, 1967Va07, 1965Nu04]
^{207}Ra	2.528(65)	3.354(59)	7.272(5)***	obs [@]	[1967Va22, 2021Au03, 2021Ni08, 2021NiZW, 1995Uu01, 1987He10]
^{207m}Ra	2.019(66)	2.845(60)	7.781(11)	26(20)%	[2021Ni08, 1996Le09, 1987He10, 2021Au03, 2021NiZW]
^{211}Th	2.18(11)	2.560(86)	7.941(10) ^{@@}	$\approx 100\%$ [@]	[2023Ch24, 1995Uu01, 2015Ya13, 2009LaZV, 1995Le15, 1995LeZY]
^{211m}Th	1.41(11)	1.791(89)	8.706(66)	4(3)%	[2021Au03]
^{215}U	1.86(13)	1.81(10)	8.588(30) ^{@@}	100%	[2015Ya13, 2016Zh33, 2015WaZT, 2014WaZU]

* Weighted average of 24(1)% [1993Wa04] and 27.5(20)% [1967Le08].

** Weighted average of 80(10)% [1998Bo14] and 75(10)% [1987He10].

*** Deduced from α energy, 7.273(58) in [2021Wa16].

@ Not measured, but estimated to be close to 100% based on half-life.

@@ Deduced from α energy, 7.937(63) in [2021Wa16].

@@@ Deduced from α energy, 8.588(59) in [2021Wa16].

Table 3
direct α emission from ^{199}Po , $J_i^\pi = (3/2^-)$, $T_{1/2} = 312(6)$ s*, $BR_\alpha = 7.5(3)\%$ *

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{195}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
6.074(2)	5.952(2)**	7.5(3)%*	(3/2 ⁻)	0.0	—	1.4883(18)	1.96(12)

* [1993Wa04].

** Weighted average of 5.953(2) MeV [1996Ta18], 5.952(2) MeV [1993Wa04] and 5.952(2) MeV [1968Go12].

Table 4
direct α emission from ^{199m}Po , Ex. = 312(2) MeV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 252(6)$ s*, $BR_\alpha = 24.7(9)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{195}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
6.183(1)	6.059(1)***	7.5(3)%*	(13/2 ⁺)	0.2029(7) [@]	—	1.4883(18)	1.43(8)

* [1993Wa04].

** Weighted average of 24(1)% [1993Wa04] and 27.5(20)% [1967Le08].

*** [1996Ta16].

[@] [2014Hu18].

Table 5
direct α emission from ^{203}Rn , $J_i^\pi = (3/2^-)$, $T_{1/2} = 44(2)$ s*, $BR_\alpha = 66(9)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{199}\text{Po})$	coincident γ -rays	R_0 (fm)	HF
6.630(2)	6.499(2)***	66(9)%**	(3/2 ⁻)	0.0	—	1.45066(31)	1.4(3)

* Weighted average of 4293 [1996Ta18] and 45(2) s [1971Ho01].

** [19789HoZZ].

*** Weighted average of 6.499(2) MeV [1996Ta18] and 6.4993(25) MeV [1993Wa04].

Table 6
direct α emission from ^{203m}Rn , Ex. = 364(2) MeV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 26.7(5)$ s*, $BR_\alpha = 78(7)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{199}\text{Po})$	coincident γ -rays	R_0 (fm)	HF
6.682(1)	6.551(1)*	78(7)%**	(13/2 ⁺)	0.312(2)	—	1.4883(18)	1.18(14)

* [1996Ta18].

** Weighted average of 80(10)% [1998Bo14] and 75(10)% [1987He10].

Table 7
direct α emission from ^{207}Ra *, $J_i^\pi = (3/2^-)$, $T_{1/2} = 1.2(2)$ s, $BR_\alpha = \text{obs}$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{203}\text{Rn})$	coincident γ -rays	R_0 (fm)	HF
7.272(5)	7.131(5)	obs**	(3/2 ⁻)	0.0	—	1.5158(39)	1.28(25)***

* All values taken from [1967Va22].

** Not measured, but estimated to be close to 100% based on half-life.

*** Result obtained using a BR of 100%

Table 8
direct α emission from ^{207m}Ra , Ex. = 509(10) MeV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 55(7)$ ms*, $BR_\alpha = 26(20)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{203}\text{Rn})$	coincident γ -rays	R_0 (fm)	HF
7.467(8)	7.323(8)**	26(20)%**	(13/2 ⁺)	0.364(2)	—	1.5158(39)	1.1 ^{+4.1} _{-0.6}

* Weighted average of 55(9) ms [2021Ni08] and 55(10) ms [1987He10].

** [2021Ni08].

*** Weighted average of 7.331(15) MeV [1996Le09] and 7.320(10) MeV [1987He10].

Table 9

direct α emission from ^{211}Th , $J_i^\pi = (3/2^-)$, $T_{1/2} = 36_{-6}^{+13}$ ms*, $BR_\alpha \approx 100\%$.

$E_\alpha(\text{c.m.})$	$E_\alpha(\text{lab})$	$I_\alpha(\text{abs})$	J_f^π	$E_{\text{daughter}}(^{207}\text{Ra})$	coincident γ -rays	R_0 (fm)	HF
7.941(10)	7.790(10)**	$\approx 100\%$	$(3/2^-)$	0.0	—	1.5064(68)	$1.0_{-0.2}^{+0.4}$

* Weighted average of 36_{-8}^{+15} ms [2023Ch24] and 37_{-11}^{+28} ms [1995Uu01].

** Weighted average of 7.788(14) MeV [2023Ch24] and 7.792(14) MeV [1995Uu01].

Table 10

direct α emission from $^{211m}\text{Th}^*$, Ex. = 769(21) MeV, $J_i^\pi = (13/2^+)$, $T_{1/2} = 83(8)$ μs , $BR_\alpha = 4(3)\%$.

$E_\alpha(\text{c.m.})$	$E_\alpha(\text{lab})$	$I_\alpha(\text{abs})$	J_f^π	$E_{\text{daughter}}(^{207}\text{Ra})$	coincident γ -rays	R_0 (fm)	HF
8.200(15)	8.045(15)	4(3)%	$(13/2^+)$	0.364(2)		1.5158(39)	$0.3_{-0.2}^{+1.1}$ **

* All values taken from [2021Au03].

** The low HF value suggests that the BR is towards the lower value of the uncertainty. A value of 1.4% for the BR gives a HF = 1.0.

Table 11

direct α emission from $^{215}\text{U}^*$, $J_i^\pi =$, $T_{1/2} = 0.73_{-0.29}^{+1.33}$ ms, $BR_\alpha = 100\%$.

$E_\alpha(\text{c.m.})$	$E_\alpha(\text{lab})$	$I_\alpha(\text{abs})$	J_f^π	$E_{\text{daughter}}(^{211}\text{Th})$	coincident γ -rays	R_0 (fm)	HF
8.588(30)	8.428(30)	100%					

* All values taken from [2015Ya13].

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