last updated 3/23/23

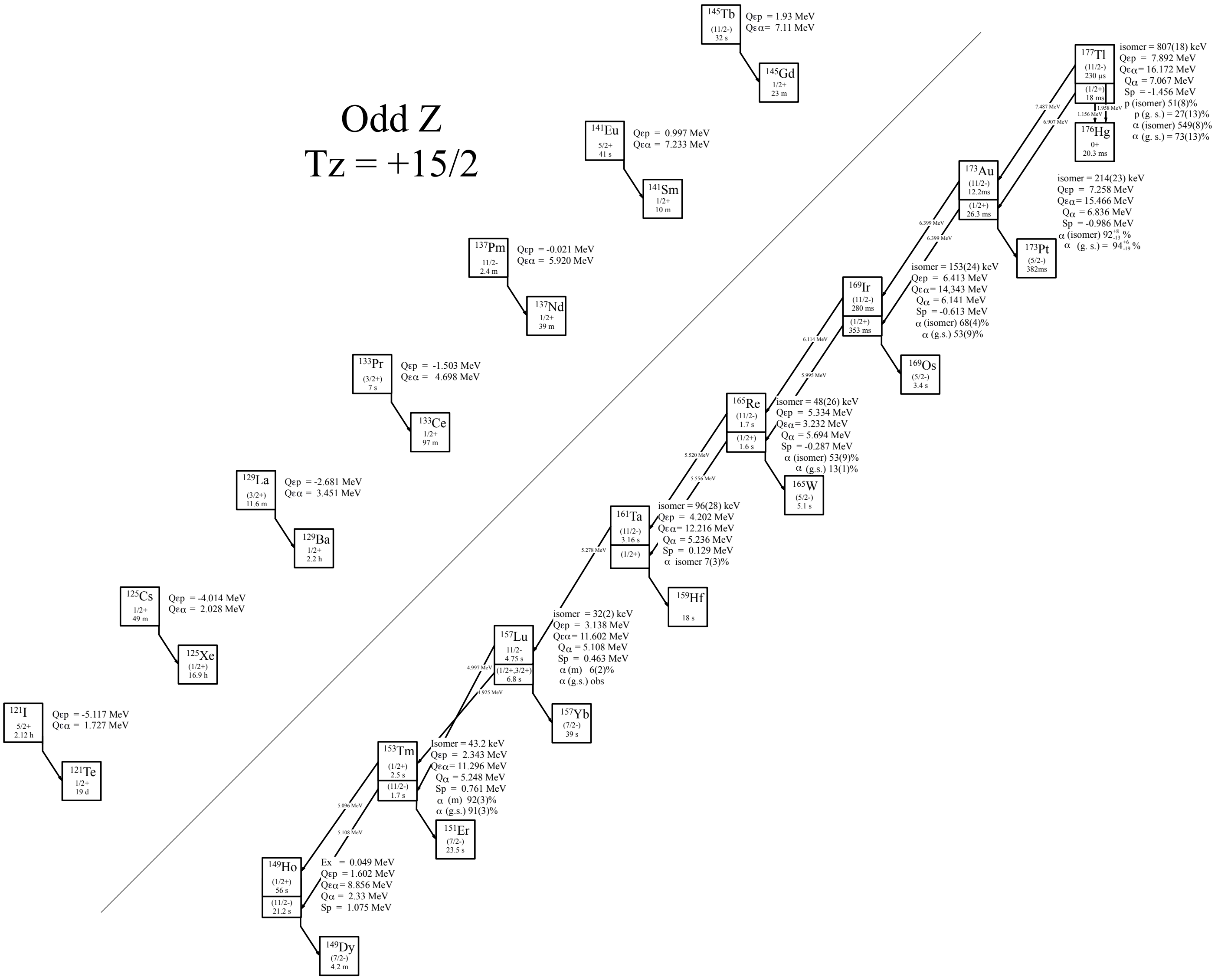

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +15/2 nuclei.

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. $J^{|pi}$ values for ^{121}I, ^{125}Cs, ^{129}La, ^{133}Pr, ^{137}Pm, ^{141}Eu, ^{145}Tb, ^{149}Ho, are taken from ENSDF.

Nuclide	Ex	J^{π}	$T_{1/2}$	Q_{ε}	$Q_{\varepsilon p}$	$BR_{\beta p}$	$Q_{\varepsilon 2p}$	$Q_{\varepsilon\alpha}$	Experimental
^{121}I		5/2$^+$	2.12(1) h	2.297(26)	-5.117(9)	—	-10.759(5)	1.727(5)	[**1965An05**]
^{125}Cs		1/2$^+$	49(5) m	3.110(8)	-4.014(8)	—	-9.497(8)	2.028(27)	[**1962Pr09**]
^{129}La		(3/2$^+$)	7(3) s	3.737(22)	-2.681(22)	—	-7.581(21)	3.451(21)	[**1970Ab07**]
^{133}Pr		(3/2$^+$)	6.5(3) m	4.481(21)	-1.500(40)	—	-5.837(13)	4.698(16)	[**1972ArZP**]
^{137}Pm		11/2$^-$	2.4(1) m	5.511(18)	-0.021(17)	—	-4.034(17)	5.920(21)	[**1975No08**]
^{141}Eu		5/2$^+$	41.4(7) s	6.008(14)	0.997(27)		-2.487(30)	7.233(17)	[**1993Al03**]
^{145}Tb*		(11/2$^-$)	31.6(6) s	6.53(11)	1.93(11)		-1.460(111)	7.11(11)	[**1992Al03**]
^{149}Ho		(11/2$^-$)	21.1(2) s	6.048(13)	1.602(15)		-0.867(12)	8.856(23)	[**1993Al03**]
^{153}Tm		(11/2$^-$)	1.7(2) s	6.494(13)	2.343(16)		0.202(12)	11.296(15)	[**1989Ko02**]
^{153m}Tm	0.0432(2)	(1/2$^+$)	2.5(2) s	6.537(13)	2.386(16)		0.245(12)	11.337(15)	[**1988ScZV, 1989Ko02**]
^{157}Lu		(1/2$^+$, 3/2$^+$)	6.8(5) s**	7.012(14)	3.138(17)		1.191(14)	11.602(15)	[**1991Le15, 1991To09**]
^{157m}Lu	0.032(2)	(11/2$^-$)	4.75(10) s	7.044(14)	3.170(17)		1.223(14)	11.634(15)	[**1991Le15**]
^{161}Ta		(1/2$^+$)		7.540(30)	4.202(62)		2.477(30)	12.216(27)	
^{161m}Ta	0.096(28)***	(11/2$^-$)	3157^{+74}_{-79} ms	7.636(41)	4.298(68)		2.573(41)	12.312(39)	[**2005Sc22**]
^{165}Re		(1/2$^+$)	1.6(6) s	8.248(30)	5.334(37)		4.032(35)	13.232(33)	[**2012Th13**]
^{165m}Re	0.048(26)	(11/2$^-$)	1.74(6) s	8.200(40)	5.382(45)		4.080(44)	13.280(42)	[**2012Th13, 1999Po09**]
^{169}Ir		(1/2$^+$)	3.53(4) s	8.630(30)	6.413(39)		5.422(30)	14.343(35)	[**2005Sc22**]
^{169m}Ir	0.153(24)	(11/2$^-$)	280(3) ms	8.783(38)	6.567(46)		5.575(38)	14.496(42)	[**2005Sc22, 1999Po09**]
^{173}Au		(1/2$^+$)	26.3(12) ms	9.100(70)	7.258(40)		6.887(29)	15.466(35)	[**2012Th13**]
^{173m}Au	0.214(23)	(11/2$^-$)	12.2(1) ms	9.314(74)	7.472(46)		7.101(37)	15.680(42)	[**2012Th13, 1999Po09**]
^{177}Tl		(1/2$^+$)	18(5) ms	9.440(90)	7.892(40)		7.791(29)	16.172(67)	[**1999Po09**]
^{177m}Tl	0.807(18)	(11/2$^-$)	230(40) μs	10.247(92)	8.699(44)		8.598(34)	16.979(69)	[**1999Po09**]

* Possibly not the ground state.
** Weighted average of 9.6(8) s [1991Le5] and 5.7(5) s [1991To09].
*** From Q_α values for ^{161,161m}Ta [2012Th13] and 32(3) keV for the excitation energy of ^{157m}Lu.

Table 2
Particle separation and emission from the odd-Z, T_z = +15/2 nuclei. Unless otherwise stated, all Q-values and separation energies are taken from [2021Wa16] or deduced from values therein.

Nuclide	S_p	BR_p	S_{2p}	Q_α	BR_α	Experimental
^{121}I	4.172(4)	—	11.348(8)	-0.031(10)	—	
^{125}Cs	3.711(8)	—	10.725(9)	-0.269(9)	—	
^{129}La	3.243(21)	—	9.661(22)	0.341(23)		
^{133}Pr	2.758(24)	—	8.746(31)	0.961(25)		
^{137}Pm	2.163(18)	—	7.715(18)	1.440(18)		
^{141}Eu	1.759(18)	—	7.003(19)	1.722(18)		
^{145}Tb*	1.929(114)	—	6.74(11)	1.10(11)		
^{149}Ho	1.075(12)	—	5.481(14)	2.33(11)		
^{153}Tm	0.761(12)	—	4.928(15)	5.248(1)	91(3)%	[**1989Ko02, 1982De11, 1982Bo04, 1996Pa01**, 1989Wo02, 1988To13, 1988ScZW, 1988ScZO, 1988ScZV, 1979Be52, 1979Ho10, 1978AfZZ, 1973BoXL, 1973BoXW]
^{153m}Tm	0.718(12)	—	4.885(15)	5.291(1)	92(3)%	[**1988To13, 1988ScZV, 1989Ko02**, 1996Pa01, 1989Wo02, 1988ScZW, 1988ScZO, 1982Bo04, 1982De11, 1979Be52, 1979Ho10, 1978AfZZ, 1973BoXL, 1973BoXW]
^{157}Lu	0.463(12)	—	4.392(16)	5.108(3)	obs	[**1991Le15, 1991To09**, 1993ToZY]
^{157m}Lu	0.431(12)	—	4.360(16)	5.140(3)	6(2)%	[**1996Pa01, 1991Le15, 1992Ha10, 1983To01, 1979Ho10**, 1991Le15, 1991To09, 1993ToZY, 1981HoZM, 1979Al16, 1979Be52, 1979BeYR, 1978AfZZ, 1977Ha49, 1972GaZR]
^{161}Ta	0.129(23)	—	3.648(45)	5.406(28)**		
^{161m}Ta	0.031(36)	—	3.552(53)	5.332(37)	7(3)%	[**2012Th13, 2005Sc22, 1996Pa01, 1992Ha10, 1979Ho10**, 1986Ru05, 1988MeZY, 1987HaZO, 1984Gr14, 1981HoZM]
^{165}Re	-0.287(23)		2.703(45)	5.694(6)	14(8)%	[**2012Th13**], 2005Sc22]
^{165m}Re	-0.335(35)		2.655(52)	5.742(27)	13(1)%	[**2012Th13**, 2005Sc22, 1996Pa01, 1981Ho10]
^{169}Ir	-0.613(22)		1.838(46)	6.141(4)	53(9)%***	[**2012Th13, 2005Sc22, 1999Po05**, 1996Pa01, 1984ScZQ, 1981DeZA, 1978Ca11, 1978CaZF, 1978ReZZ]
^{169m}Ir	-0.766(33)		1.685(52)	6.294(24)	68(4)%$^{@}$	[**2012Th13, 2005Sc22, 1999Po05, 1996Pa01**]
^{173}Au	-0.986(21)		0.998(45)	6.891(4)$^{@@}$	94^{+6}_{-19} %	[**2012Th13, 1999Po09**, 2001Ko14, 1996Pa01, 1984ScZQ, 1983Sc24]
^{173m}Au	-1.200(31)		0.784(51)	7.105(23)	92^{+8}_{-13} %	[**2012Th13, 1999Po09**, 2001Ko14]
^{177}Tl	-1.156(19)	27(13)%	0.51(44)	7.067(7)	73(13)%	[**1999Po09**]
^{177m}Tl	-1.963(26)	51(8)%	-0.30(44)	7.874(19)	49(8)%	[**1999Po09**, 2004Ke04]

* Possibly not the ground state.
** Deduced from α energy, 5.236(24) in [2021Wa16].
*** Weighted average of 50(18)% [1999Po09], 57(9)% [2012Th13], and 42(15)% [2005Sc22].
$^{@}$ Weighted average of 84(8)% [1999Po09], 78(6)% [2012Th13], 72(13)% [1996Pa01], and 59(4)% [2005Sc22].
$^{@@}$ Deduced from α energy, 6.836(5) in [2021Wa16].

Table 3
direct α emission from ^{153}Tm, $T_{1/2}$= 1.7(2) s*, BR_α = 91(3)%*.

E_α(c.m.)	E_α(lab)	I_α(abs)*	$E_{daughter}$(^{149}Ho)	coincident γ-rays	R_0 (fm)	HF
5.247(2)	5.110(2)**	91(3)%	0.0	—	1.5621(20)	1.40(18)

* [1989Ko02]
** Weighted average of 5.111(2) MeV [1982De11], 5.103(3) MeV [1982Bo04] (adjusted to 5.108(3) in [1991Ry02]), and 5.112(5) MeV [1996Pa01].

Table 4
direct α emission from ^{153m}Tm*, Ex = 43.2(2) keV**, $T_{1/2}$= 2.5(2) s***, BR_α = 92(3)%**.

E_α(c.m.)	E_α(lab)	I_α(rel)***	I_α(abs)***	$E_{daughter}$(^{149}Ho)	coincident γ-rays	R_0 (fm)	HF
4.709(10)	4.586(10)	@	@	0.564	0.344, 0.171	1.5621(20)	$<6.4\times10^3$
5.034(15)	4.902(15)	@@	@@	0.220	0.171	1.5621(20)	$<1.6\times10^4$
5.233(4)	5.096(4)	100%	$\approx$ 100%	0.049		1.5621(20)	1.76(17)

* All values from [1988To13], unless otherwise stated.
** [1989Ko02].
*** [1988ScZV].
@ [1988To13] lists this transition as a possible doublet to the $5/2^+$ 564 keV state from both the $11/2^-$ ground state and $1/2^+$ isomer, however the change in spin greatly favors decay from the $1/2^+$ isomer. I_α4.586/I_α(5.096 + 5.108) = 4.5(6)$\times0^{-5}$ [1988To13].
@@ [1988To13] lists this transition as a possible doublet to the $3/2^+$ 220 keV keV state from both the $11/2^-$ ground state and $1/2^+$ isomer, however the change in spin greatly favors decay from the $1/2^+$ isomer. I_α4.902/ I_α(4.586 + 5.108) = 1.8(4)$\times10^{-5}$ [1988To13].

Table 5
direct α emission from ^{157}Lu*, $T_{1/2}$= 6.8(5) s**, BR_α = obs.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{153}Tm)	coincident γ-rays
5.054(5)	4.925(5)	obs	0.043	

* All values from [1991Le15], except where noted.
** Weighted average of 9.6(8) s [1991Le5] and 5.7(5) s [1991To09].

Table 6
direct α emission from ^{157m}Lu, Ex = 32(2) keV*, $T_{1/2}$= 4.75(10) s*, BR_α = 6(2)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{153}Tm)	coincident γ-rays	R_0 (fm)	HF
5.129(2)	4.998(2)***	6(2)%	0.0	—	1.5787(76)	$2.7^{+1.5}_{-0.8}$

* [1991Le15].
** [1979Ho10].
*** Weighted average of 4.997(4) MeV [1996Pa01], 4.998(5) MeV [1991Le15], 4.995(6) MeV [1992Ha10], 4.999(5) MeV [1983To01] (adjusted to 5.003(3) in [1991Ry02]), and 4.994(5) MeV [1979Ho10] (adjusted to 4.999(3) in [1991Ry02]).

Table 7
direct α emission from ^{161m}Ta, Ex = 96(28) keV, $T_{1/2}$= 3157^{+74}_{-79} ms*, BR_α = 7(3)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{157}Lu)	coincident γ-rays	R_0 (fm)	HF
5.278(2)	5.147(2)***	6(2)%	0.032	—	1.560(11)	$0.7^{+0.7}_{-0.3}$

* [2005Sc22].
** [2012Th13].
*** Weighted average of 5.140(7) MeV [1996Pa01], 5.149(5) MeV [1992Ha10], 5.142(6) MeV [2012Th13], 5.151(4) MeV [2005Sc22], and 5.148(5) MeV [1996Ru05].

Table 8
direct α emission from ^{165}Re*, $T_{1/2}$= 1.6(6) s, BR_α = 14(8)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}$(^{161}Ta)	coincident γ-rays	R_0 (fm)	HF
5.694(6)	5.556(6)	14(8)%	0.0	—	1.566(11)	2^{+4}_{-1}

* All values from [2012Th13].

Table 9
direct α emission from ^{165m}Re*, Ex = 48(26) keV**, $T_{1/2}$= 1.74(6) s, BR_α = 13(1)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{161}$Ta)	coincident γ-rays	R_0 (fm)	HF
5.657(6)	5.520(6)	13(1)%	0.096		1.566(11)	$1.5\,^{+0.4}_{-0.3}$

* All values from [2012Th13], except where noted.
** [1999Po09].

Table 10
direct α emission from ^{169}Ir, $T_{1/2}$= 353(4) ms*, BR_α = 53(9)%**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{165}$Re)	coincident γ-rays	R_0 (fm)	HF
6.141(4)	5.995(4)***	53(9)%**	0.0	—–	1.5639(39)	$1.0\,^{+0.6}_{-0.3}$

* [2012Th13].
** Weighted average of 50(18)% [1999Po09], 57(9)% [2012Th13], and 42(15)% [2005Sc22].
*** Weighted average of 6.005(8) MeV [1999Po09], and 5.993(4) MeV [2005Sc22].

Table 11
direct α emission from ^{169m}Ir*, Ex = 153(24) keV**, $T_{1/2}$= 280(3) ms***, BR_α = 68(4)%*@.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{165}$Re)	coincident γ-rays	R_0 (fm)	HF
6.263(3)	6.114(3)@@	68(4)%***	0.048		1.5639(39)	1.85(18)

* All values from [2012Th13], except where noted.
** [1999Po09].
*** [2005Sc22].
@ Weighted average of 84(8)% [1999Po09], 78(6)% [2012Th13], 72(13)% [1996Pa01], and 59(4)% [2005Sc22].
@@ Weighted average of 6.106(5) MeV [1999Po09], 6.119(9) MeV [1996Pa01], and 6.117(3) MeV [2005Sc22].

Table 12
direct α emission from ^{173}Au, $T_{1/2}$= 26.3(12) ms*, BR_α = 94^{+6}_{-19} %*.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{169}$Ir)	coincident γ-rays	R_0 (fm)	HF
6.891(4)	6.732(4)**	94^{+6}_{-19} %*	0.0	—–	1.5529(80)	$2.9^{+0.6}_{-0.5}$

* [2012Th13].
** [1999Po09].

Table 13
direct α emission from ^{173m}Au, Ex = 214(23) keV*, $T_{1/2}$= 12.2(1) ms**, BR_α = 92^{+8}_{-13} %**.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{169}$Ir)	coincident γ-rays		
6.891(4)	6.732(4)*@	92^{+8}_{-13} %**	0.153		1.5529(80)	$1.43^{+0.27}_{-0.24}$

* [1999Po09].
** [2012Th13].

Table 14
direct α emission from ^{177}Tl*, $T_{1/2}$= 18(5)ms, BR_α = 73(13)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{173}$Au)	coincident γ-rays	R_0 (fm)	HF
7.067(7)	6.907(7)	73(13)%	0.0	—–	1.545(21)	$1.6^{+1.2}_{-0.8}$

* All values taken from [1999Po09].

Table 15
direct p emission from ^{177}Tl*, $T_{1/2}$= 18(5)ms, BR_p = 27(13)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}(^{176}Hg)$	coincident γ-rays
1.163(20)	1.156(20)	27(13)%	0.0	—

* All values taken from [1999Po09].

Table 16
direct α emission from ^{177m}Tl*, Ex = 807(18) keV, $T_{1/2}$= 230(40) μs, BR_α = 49(8)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	$E_{daughter}(^{173}Au)$	coincident γ-rays	R_0 (fm)	HF
7.660(13)	7.487(13)	49(8)%	0.214		1.545(21)	$2.2^{+1.4}_{-1.0}$

* All values taken from [1999Po09].

Table 17
direct p emission from ^{177m}Tl*, Ex = 807(18) keV, $T_{1/2}$= 230(40) μs, BR_p = 51(8)%.

E_p(c.m.)	E_p(lab)	I_p(abs)	$E_{daughter}(^{176}Hg)$	coincident γ-rays
1.969(10)	1.958(10)	51(8)%	0.0	—

* All values taken from [1999Po09].

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