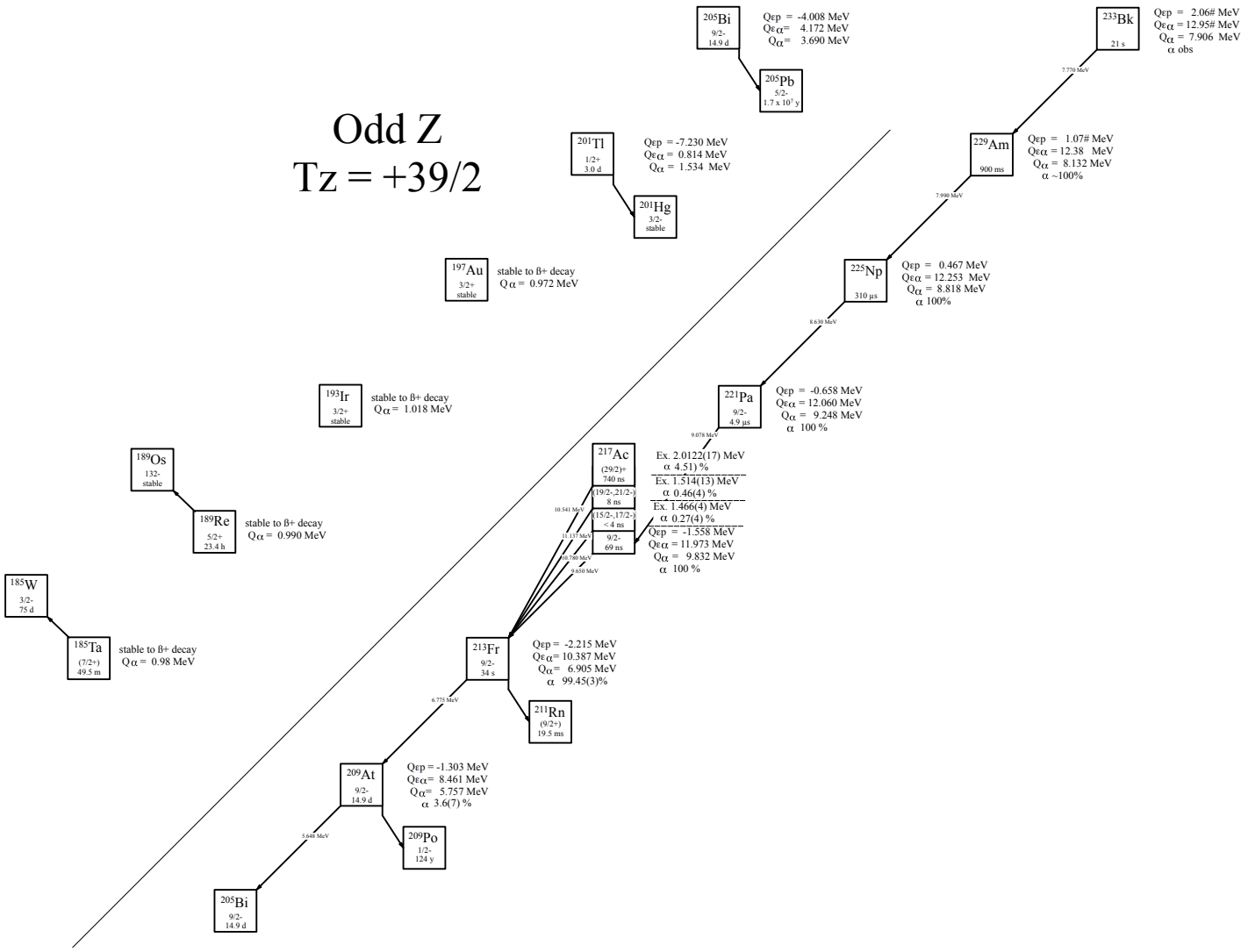

Fig. 1: Known experimental values for heavy particle emission of the odd-Z T_z= +39/2 nuclei.

Last updated 1/21/24

Table 1
Observed and predicted β-delayed particle emission from the odd-Z, T_z = +39/2 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	$Q_{\varepsilon p}$	$Q_{\varepsilon\alpha}$	Experimental
^{185}Ta*		$(7/2^+)$	49.5(15) m	-3.070(7)	——	——	[**1955Po26**]
^{189}Re*		$5/2^+$	23.4(4) h	-2.17(20)#	——	——	[**1965Bl06**]
^{193}Ir		$3/2^+$	stable	-1.142(2)	——	——	
^{197}Au		$3/2^+$	stable	-0.720(1)	——	——	
^{201}Tl		$1/2^+$	3.0380(17) d	0.482(14)	-7.230(30)	0.814(14)	[**2004De02**]
^{205}Bi		$9/2^-$	14.91(7) d	2.705(5)	-4.008(5)	4.172(5)	[**2004Ku33**]
^{209}At		$9/2^-$	5.41(5) h	3.482(5)	-1.303(5)	8.461(5)	[**1968GuZX**]
^{213}Fr		$9/2^-$	34.14(6) s	2.142(6)	-2.215(5)	10.387(5)	[**2013Fi08**]
^{217}Ac		$9/2^-$	69(4) ns	2.813(13)	-1.558(12)	11.973(12)	[**1985De14**]
^{217m1}Ac	1.1466(4)**	$(15/2^-, 17/2^-)$	<4 ns	3.960(13)	-0.411(12)	13.120(12)	[**1985De14, 1982GoZU**]
^{217m2}Ac	1.514(30)***	$(19/2^-, 21/2^-)$	8(2) ns	4.327(33)	-0.044(32)	13.487(32)	[**1985De14, 1973No02**]
^{217m3}Ac	2.0122(7)	$(29/2)^+$	740(40) ns	4.825(13)	-0.454(12)	13.985(12)	[**1985De14**]
^{221}Pa		$9/2^-$	4.9(8) μs	3.440(60)	-0.658(60)	12.060(60)	[**1995AnZY**]
^{225}Np			$0.31^{+0.75}_{-13}$ ms	4.250(90)	0.467(92)	12.253(92)	[**2019Mi08, 2015De22**]
^{229}Am			$0.9^{+2.1}_{-0.7}$ s	4.79(12)	1.07(15)#	12.38(11)	[**2015De22**]
^{233}Bk			21^{+48}_{-17} s	5.48(25)#	2.06(38)#	12.95(24)#	[**2015De22**]

* 100% β^- emitter.

** [1985De14] report the energy of this α-emitting level as either 1.150 MeV $(15/2^-)$ or 1.147 $(17/2^-)$. The value of 1.1466(4) is from [2018Si] based on the γ cascade form the $(29/2^+)$ isomer.

*** [1985De14] report the energy of this α-emitting level as either 1.498 MeV $(19/2^-)$ or 1.529 $(21/2^-)$.

Table 2
Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, T_z = +39/2 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
^{185}Ta	7.184(42)	16.256(81)	0.98(13)		
^{189}Re	6.600(9)	15.661(56)#	0.990(16)		
^{193}Ir	5.943(2)	14.764(10)	1.018(8)		
^{197}Au	5.784(1)	14.025(1)	0.972(1)		
^{201}Tl	4.966(14)	12.665(14)	1.534(14)		
^{205}Bi	3.245(5)	9.882(4)	3.690(15)		
^{209}At	2.704(5)	7.407(5)	5.757(2)	3.6(7)%	[**2017Lo13, 1969Go23, 1968GuZX**, 1963Uh01, 1956HuXX, 1955Mo68, 1951Ba14]
^{213}Fr	2.184(6)	6.485(5)	6.905(1)	99.45(3)%	[**2016Pr08, 2005Ku06**, 2019Mi08, 2017Lo13, 2013Fi08, 2012Mo08, 1982Bo04, 1976RaZG, 1974Ho27, 1973BoXL, 1971ReZG, 1967Va20, 1964Gr04, 1961Gr42]
^{217}Ac	1.878(14)	6.194(13)	9.832(10)	100%	[**1985De14**, 2019Mi08, 1982GoZU, 1982SaZO, 1981MaYW, 1977BaYU, 1973No02, 1973No09, 1972No06]
^{217m1}Ac	0.731(14)	5.047(13)	10.979(10)	0.27(4)%	[**1985De14**, 1982GoZU, 1982SaZO, 1972No06]
^{217m2}Ac	0.364(33)	4.680(33)	11.346(32)	0.46(13)%	[**1985De14**, 1982GoZU, 1973No02]
^{217m3}Ac	-0.134(14)	4.182(13)	11.844(10)	4.51(17)%	[**1985De14**, 1982GoZU, 1982SaZO, 1981MaYW, 1973No02, 1972No06]
^{221}Pa	1.604(61)	5.773(79)	9.248(58)	100%	[**1995AnZY, 1989Mi17**, 2019Mi08, 1989MiZK, 1989MiZZ, 1987MiZO, 1983Hi12]
^{225}Np	1.414(93)	5.30(12)	8.818(70)	100%	[**2015De22, 1994Ye08**, 2019Mi08, 1994AnZY, 1993AnZS, 1993AnZY
^{229}Am	1.222(30)*	4.716(82)*	8.132(20)*	≈100%	[**2015De22**]
^{233}Bk	0.586(31)**	4.212(38)#	7.906(20)**	obs	[**2015De22**]

* Deduced from α energy. S_p = 1.22(11)# MeV, S_{2p} = 4.98(13)# MeV, Q_α = 8.137(54# MeV) in [2021Wa16].

** Deduced from α energy. S_p = 0.85(31)# MeV, Q_α = 8.17(21)# MeV) in [2021Wa16].

Table 3
direct α emission from ^{209}At, J^{π} = 9/2$^-$, $T_{1/2}$ = 5.41(5) h*, BR_{α} = 3.6(7)%**.

E_{α}(c.m.)	E_{α}(lab)***	I_{α}(rel)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{205}Bi)	coincident γ-rays	R_0 (fm)	HF
5.216(2)	5.116(2)$^{@}$	0.10(5)%$^{@}$	0.0036(9)		0.542(4)		1.4432915)	$2.5^{+3.0}_{-0.9}$
5.758(4)	5.648(4)	100%	3.697)%	9/2$^-$	0.0	——	1.4432915)	$1.8^{+0.5}_{-0.3}$

* [1968GuZX].
** [2017Lo13].
*** [1969Go23].
$^{@}$ Only reported in [1969Go23].

Table 4
direct α emission from ^{213}Fr, J^{π} = 9/2$^-$, $T_{1/2}$ = 34.14(6) s*, BR_{α} = 99.45(3)%**.

E_{α}(c.m.)***	E_{α}(lab)	I_{α}(rel)***	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{209}At)	coincident γ-rays	R_0 (fm)	HF
4.083(2)	4.007(2)	weak	weak	(5/2,7/2)	2.8206(10) 0.8554(5), 0.8675(5)	0.4083(5), 0.6894(5),		
5.806(2)	5.697(2)	0.010(5)%	0.010(5)%	(7/2)$^-$	1.0977(7)	0.4083(5), 0.6894(5)	1.4450(19)	$0.25^{+0.25}_{-0.9}$$^{@@@}$
5.823(2)	5.713(2)	0.020(3)%	0.020(3)%	(5/2,7/2)$^-$	1.0812(7)	0.4083(5), 0.6729(5)	1.4450(19)	$0.15^{+0.3}_{-0.2}$$^{@@@}$
6.115(2)	6.000(2)	0.020(10)%	0.020(10)%	(9/2)$^-$	0.7890(7)	0.3807(5), 0.4083(5)	1.4450(19)	4^{+4}_{-1}
6.158(2)	6.043(2)	0.040(6)%	0.040(6)%	7/2$^-$	0.7457(5)	0.7457(5)	1.4450(19)	$2.8^{+0.5}_{-0.4}$
6.327(2)	6.208(2)$^{@}$	0.070(11)%	0.070(11)%	11/2$^-$	0.5770(5)	0.5770(5)	1.4450(19)	$8.9^{+1.7}_{-1.3}$
6.496(2)	6.374(2)$^{@}$	0.12(2)%	0.12(2)%	7/2$^-$	0.4083(5)	0.4083(5)	1.4450(19)	27^{+6}_{-4}
6.904(2)	6.775(2)$^{@@}$	100%	99.23(3)%	9/2$^-$	0.0	——	1.4450(19)	1.31(6)

* [2013Fi08].
** [2005Ku06].
*** Deduced from table 2 and figure 8 in [2016Pr08]. The authors list γ-ray intensities and energies following the α decay of ^{213}Fr. Note that α's are not directly measured in this work, and are deduced assuming a Q_{α} of 6.9040(18) MeV for ^{213}Fr.
$^{@}$ α also observed in [2005Ku06].
$^{@@}$ Weighted average of 6.775(4) MeV [2005Ku06] and 6.775(2) MeV [1982Bo04].
$^{@@@}$ Unphysically low HF indicate that the apparent β branching reported in [2016Pr08] for these levels is too high, likely due to the levels being fed from above (*i.e.* pandemonium).

Table 5
direct α emission from ^{217}Ac, J^{π} = 9/2$^-$, $T_{1/2}$ = 69(4) ns*, BR_{α} = 100%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
9.831(10)	9.650(10)**	100%	9/2$^-$	0.0	——	1.5460(33)	0.98(10)

* From [1985De14]. [1973No09] reported a half-life of 111(7) ns, which results in a HF equal to 1.58(17). The g.s. to g.s. α-decay is expected to be unhindered. Therefore, the value from [1985De14] is adopted.
** [1973No09].

Table 6
direct α emission from ^{217m1}Ac, Ex. = 1.1466(4)**, J^{π} = (15/2$^-$, 17/2$^-$), $T_{1/2}$ = <4 ns***, BR_{α} = 0.27(4)%.

E_{α}(c.m.)	E_{α}(lab)	I_{α}(abs)	J^{π}_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
10.982(15)	10.780(15)	100%	9/2$^-$	0.0	——	1.5460(33)	$>3.8 \times 10^3$

* All values from [1985De14], except where noted.
*** [1985De14] report the energy of this α-emitting level as either 1.150 MeV (15/2$^-$) or 1.147 (17/2$^-$). The value of 1.1466(4) is from [2018Si] based on the γ cascade form the (29/2$^+$) isomer.
*** [1982GoZU].

Table 7
direct α emission from ^{217m2}Ac*, Ex. = 1.514(30)**, J^π = (19/2$^-$, 21/2$^-$), $T_{1/2}$ = 8(2) ns***, BR_α = 0.46(13)%.

E_α(c.m.)	E_α(lab)	I_α(abs)	J^π_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
11.346(15)	11.137(15)	0.46(13)%	9/2$^-$	0.0	——	1.5460(33)	$1.9^{+1.4}_{-0.8}\times 10^4$

* All values from [1985De14], except where noted.
** [1985De14] report the energy of this α-emitting level as either 1.498 MeV (19/2$^-$) or 1.529 (21/2$^-$).
*** [1973No02].

Table 8
direct α emission from ^{217m3}Ac*, Ex. = 2.0122(7), J^π = (29/2$^-$), $T_{1/2}$ = 740(40) ns, BR_α = 4.51(17)%.

E_α(c.m.)	E_α(lab)	I_α(rel)	I_α(abs)	J^π_f	$E_{daughter}$(^{213}Fr)	coincident γ-rays	R_0 (fm)	HF
10.739(10)	10.541(10))	100(4)%	4.07(16)%	13/2$^+$	1.105	1.105	1.5460(33)	$1.7^{+1.1}_{-0.5}\times 10^5$
11.346(15)	11.137(15)	11.3(32)%	0.46(13)%	7/2$^-$	0.498	0.498	1.5460(33)	$1.8^{+1.1}_{-0.5}\times 10^7$
11.843(15)	11.625(15)	2.95(50)%	0.12(2)%	9/2$^-$	0.0	——	1.5460(33)	$4.3^{+2.6}_{-1.3}\times 10^8$

* All values from [1985De14], except where noted.

Table 9
direct α emission from ^{221}Pa, J^π = 9/2$^-$, $T_{1/2}$ = 4.9(8) μs*, BR_α = 100%.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{217}Ac)	coincident γ-rays	R_0 (fm)	HF
9.245(21)	9.078(21)	100%	9/2$^-$	0.0	——	1.5671(97)	1.3(4)

* [1995AnZY].
** Weighted average of 9.075(30) MeV [1995AnZY] and 9.080(30) MeV [1989Mi17].[

Table 10
direct α emission from ^{225}Np, $T_{1/2} = 0.31^{+0.75}_{-13}$ ms*, BR_α = 100%.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{221}Pa)	coincident γ-rays	R_0 (fm)	HF
8.786(20)	8.630(20)	100%	9/2$^-$	0.0	——	1.534(15)	$0.7^{+1.6}_{-0.3}$

* From [2019Mi08]. Using this half-life gives a HF equal to $0.7^{+1.6}_{-0.3}$, indicating an unhindered transition. [2015De22] report a value of $3.8^{+7.6}_{-2.7}$ ms which gives a HF of 8^{+3}_{-1}.
** [1994Ye08].

Table 11
direct α emission from ^{229}Am*, $T_{1/2} = 0.9^{+2.1}_{-0.7}$ s, BR_α = ≈100%**.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{225}Np)	coincident γ-rays	R_0 (fm)	HF
8.132(20)	7.990(20)	100%		0.0	——	1.534(15)	$1.0^{+2.9}_{-0.9}$

* All values from [2015De22].
** Only α decay observed.

Table 12
direct α emission from ^{233}Bk*, $T_{1/2} = 21^{+48}_{-17}$ s, BR_α = obs.

E_α(c.m.)	E_α(lab)**	I_α(abs)	J^π_f	$E_{daughter}$(^{229}Am)	coincident γ-rays	R_0 (fm)	HF
7.906(20)	7.770(20)	obs		0.0	——	1.525(46)	***

* All values from [2015De22].
** Only α decay observed.
*** Using a BR of 100%, a HF of 4^{+10}_{-4} is obtained.

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