



Fig. 1: Known experimental values for heavy particle emission of the even-Z $T_z = +16$ nuclei.

Last updated 10/12/2023

Table 1

Observed and predicted β -delayed particle emission from the even- Z , $T_z = +16$ 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
^{168}Er		0^+	stable	-2.930(30)	—	—	
^{172}Yb		0^+	stable	-1.882(5)	—	—	
^{176}Hf		0^+	stable	-1.194(1)	—	—	
^{180}W		0^+	$1.8(2) \times 10^{18}$ y	-0.703(2)	—	—	[2004Co26]
^{184}Os		0^+	$1.12(23) \times 10^{13}$ y	-0.033(4)	—	—	[2014Pe22]
^{188}Pt		0^+	10.2(3) d	0.524(9)	-3.891(5)	3.974(7)	[1963Gr08]
^{192}Hg		0^+	4.85(20) h	0.761(22)	-3.602(16)	3.909(18)	[1961Ja10]
^{196}Pb		0^+	37(3) m	2.148(14)	-1.624(24)	4.999(18)	[1961Su01]
^{200}Po		0^+	11.6(1) m	3.429(24)	1.001(10)	8.130(14)	[1970Ra14]
^{204}Rn		0^+	75(1) s*	3.905(24)	2.052(9)	9.976(24)	[1971Ho01, 1967Va17]
^{208}Ra		0^+	1.2(2) s	4.393(15)	3.074(10)	11.178(24)	[1967Va22]
^{212}Th		0^+	31.7(13) ms	4.811(24)	3.990(11)	12.351(15)	[2010He25]
^{216}U		0^+	$2.25^{+0.63}_{-0.40}$ ms	5.240(40)	4.856(29)	13.342(36)	[2021Zh22]
^{216m}U	2.206(23)	8^+	$0.89^{+0.27}_{-0.17}$ ms	7.446(46)	7.062(37)	15.548(43)	[2021Zh22]

* Weighted average of 74(2) s [1971Ho01] and 75(2) s [1967Va17].

Table 2

Particle separation, Q -values, and measured values for direct particle emission of the even- Z , $T_z = +16$ 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
^{168}Er	7.999(5)	14.983(1)	0.554(1)		
^{172}Yb	7.334(1)	13.726(1)	1.309(0)		
^{176}Hf	6.700(1)	12.210(1)	2.254(1)		
^{180}W	6.568(1)	11.779(0)	2.515(1)	100%	[2004Co26, 2005Zd04, 2004CoZY, 2003Ce01, 2003Da05, 2002Bi16, 2002BiZZ, 2002DaZT]
^{184}Os	5.732(8)	10.584(1)	2.959(2)	100%	[2014Pe22, 1976Sp04]
^{188}Pt	5.561(28)	9.399(5)	4.007(5)		
^{192}Hg	5.503(16)	9.283(16)	3.385(16)		
^{196}Pb	4.482(14)	7.742(8)	4.238(17)	$\leq 3 \times 10^{-5}\%$	[1963Ka17]
^{200}Po	3.433(13)	5.452(12)	5.982(2)	11.3(3)%*	[1996Ta18, 1993Wa04, 1967Le08, 1992WaZV, 1970DaZM, 1970Ra14, 1971Ho01, 1970Jo26, 1969Ha03, 1967Le08, 1967Le21, 1967Si09, 1967Tr04, 1967Tr06, 1965Br17, 1965Br27, 1965Si22, 1965Ti03, 1964Br23, 1962Be26, 1961Be25, 1961Fo05, 1954Ro39]
^{204}Rn	3.096(13)	4.606(11)	6.547(2)	72(1)%**	[1996Ta18, 1993Wa04, 1971Ho01, 1967Va17, 2022Zh45, 2014WaZU, 1992WaZV, 1967Va07, 1965Nu04]
^{208}Ra	2.712(20)	3.717(12)	7.273(5)	obs	[1967Va22, 2022Zh45, 2015Ma37, 2015Ma63, 2014WaZU, 1968Lo15]
^{212}Th	2.322(55)	2.910(14)	7.958(5)	$\approx 100\%$	[2010He25, 2022Zh45, 2015De22, 2015Ma37, 1996Ik01, 1980Ve01]
^{216}U	2.027(87)	2.206(30)	8.531(26)	100%	[2021Zh22, 2022Zh45, 2015De22, 2015WaZT, 2014WaZU]
^{216m}U	0.021(90)	0.000(38)	10.737(35)	100%	[2022Zh45, 2021Zh22, 2016Zh33]

* Weighted average of 11.1(3)% [1993Wa04] and 12.2(6)% [1967Le08].

** Weighted average of 73(1)% [1993Wa04] and 70(2)% [1971Ho01].

*** Based on short half-life

Table 3

direct α emission from $^{180}\text{W}^*$, $J_f^\pi = 0^+$, $T_{1/2} = 1.8(2) \times 10^{18}$ y, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter} (^{176}\text{Hf})$	coincident γ -rays	R_0 (fm)	HF
2.5164(16)	2.4605(16)	100%	0^+	0.0	—	1.4631(61)	1.59(18)

* All values taken from [2004Co26].

Table 4direct α emission from ^{200}Po , $J_i^\pi = 0^+$, $T_{1/2} = 11.6(1)$ m*, $BR_\alpha = 11.3(3)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{196}\text{Pb})$	coincident γ -rays	R_0 (fm)	HF
5.983(2)	5.863(2)***	11.3(3)%**	0^+	0.0	—	1.4803(16)	1.007(28)

* [1970Ra14].

** Weighted average of 11.1(3)% [1993Wa04] and 12.2(6)% [1967Le08].

*** [1996Ta18].

Table 5direct α emission from ^{204}Rn , $J_i^\pi = 0^+$, $T_{1/2} = 75(1)$ s*, $BR_\alpha = 72(1)\%$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{200}\text{Po})$	coincident γ -rays	R_0 (fm)	HF
6.5472(14)	6.4188(14)***	72(1)%**	0^+	0.0	—	1.5026(16)	1.014(20)

* Weighted average of 74(2) s [1971Ho01] and 75(2) s [1967Va17].

** Weighted average of 73(1)% [1993Wa04] and 70(2)% [1971Ho01].

*** Weighted average of 6.420(2) MeV [1996Ta18], 6.4189(25) MeV [1993Wa04] and 6.416(3) MeV [1967Va17].

Table 6direct α emission from ^{208}Ra *, $J_i^\pi = 0^+$, $T_{1/2} = 1.2(2)$ s, $BR_\alpha = \text{obs}$ **.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{204}\text{Rn})$	coincident γ -rays	R_0 (fm)	HF
7.273(5)	7.133(5)***	$\approx 100\%$ **	0^+	0.0	—	1.5029(36)	1.03(17)

* All values from [1967Va22].

** Not observed, estimated to be $\approx 100\%$ based on half-life.**Table 7**direct α emission from ^{212}Th *, $J_i^\pi = 0^+$, $T_{1/2} = 31.7(13)$ ms, $BR_\alpha = \approx 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{208}\text{Ra})$	coincident γ -rays	R_0 (fm)	HF
7.959(5)	7.809(5)	$\approx 100\%$	0^+	0.0	—	1.5058(26)	1.15(5)

* All values from [2010He25].

Table 8direct α emission from ^{216}U *, $J_i^\pi = 0^+$, $T_{1/2} = 2.25_{0.40}^{+0.63}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{212}\text{Th})$	coincident γ -rays	R_0 (fm)	HF
8.532(17)	8.374(17)	100%	0^+	0.0	—	1.486(33)	$0.48_{-0.09}^{+0.14}$

* All values from [2021Zh22].

Table 9direct α emission from ^{216m}U *, $E_x = 2.206(23)$ MeV, $J_i^\pi = 8^+$, $T_{1/2} = 0.89_{0.17}^{+0.27}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{212}\text{Th})$	coincident γ -rays	R_0 (fm)	HF
10.355(27)	10.163(27)	$\approx 5\%$ **	$\approx 5\%$	(2^+)	0.383(31)	—	1.486(33)	$\approx 1 \times 10^5$
10.738(16)	10.539(16)	100%**	$\approx 95\%$	0^+	0.0	—	1.486(33)	$\approx 3.1(9) \times 10^4$

* All values from [2022Zh45].

** One α was observed for this transition compared to 19 for the transition to the ground state.**References used in the Tables**[1] **1954Ro39** S. Rosenblum, H. Tyren, Compt. Rend. Acad. Sci. **239**, 1205 (1954).

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