



Fig. 1: Known experimental values for heavy particle emission of the odd-Z $T_z = +23/2$ nuclei.

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Table 1

Observed and predicted β -delayed particle emission from the odd-Z, $T_z = +23/2$ nuclei. Unless otherwise stated, all Q-values are taken from [2021Wa16] or deduced from values therein. J^π values for ^{145}Pm are taken from ENSDF

Nuclide	Ex	J^π	$T_{1/2}$	Q_β	$Q_{\beta p}$	$Q_{\beta\alpha}$	Experimental
^{145}Pm		$5/2^+$	17.7(4) y	0.165(3)	-7.806(3)	1.739(3)	[1959Br65]
^{149}Eu		$5/2^+$	93.1(4) d	0.695(4)	-6.864(7)	2.566(4)	[1970Ch09]
^{153}Tb		$5/2^+$	56.2(2) h	1.569(4)	-5.714(4)	3.397(4)	[1970Ch09]
^{157}Ho		$7/2^+$	12.6(2) m	2.592(24)	-4.031(24)	3.625(23)	[1972To05]
^{161}Tm		$7/2^+$	30.2(8) m	3.303(29)	-2.805(32)	5.101(28)	[1993A102]
^{165}Lu		$1/2^+$	10.74(10) m	3.850(40)	-1.822(36)	6.334(28)	[1982Ra19]
^{169}Ta		$(5/2^+)$	5.0(5) m	4.430(40)	-0.507(47)	7.580(39)	[1969Ar22]
^{173}Re		$(5/2^-)$	1.98(26) ms	5.170(40)	0.487(40)	8.738(40)	[1986Sz05]
^{177}Ir		$5/2^-$	26(2) s*	5.909(25)	1.726(34)	10.255(34)	[1990Bo19, 1967Si02]
^{181}Au		$(3/2^-)$	14.5(4) s	6.510(24)	2.817(29)	11.660(25)	[1995Bi01]
^{185}Tl		$(1/2^+)$	19.5(5) s	6.426(25)	3.272(30)	12.199(25)	[1991BoZV]
^{185m}Tl	0.4548(15)	$(9/2^-)$	1.7(2) s	6.881(25)	3.727(30)	12.654(25)	[1980ToZZ, 1976To06, 1977Si03]
^{189}Bi		$(9/2^-)$	688(3) ms	7.779(25)	4.983(36)	13.694(25)	[2007DoZW]
^{189m}Bi	0.182(8)	$(1/2^+)$	5.0(1) ms	7.961(26)	5.165(37)	13.876(26)	[2007DoZW]
^{193}At		$(1/2^+)$	28_{-4}^{+5} ms	8.258(26)	6.178(37)	15.352(26)	[2003Ke08]
$^{193m1}\text{At}$	0.010(5)**	$(7/2^-)$	21(5) ms	8.268(26)	6.188(37)	15.362(26)	[2003Ke08]
$^{193m2}\text{At}$	0.044(7)**	$(13/2^+)$	27_{-3}^{+4} ms	8.302(27)	6.222(38)	15.396(27)	[2003Ke08]
^{197}Fr		$(7/2^-)$	$0.6_{-0.3}^{+3.0}$ ms	8.740(60)	6.878(64)	16.154(58)	[2013Ka16]

* Weighted average of 30(2) s [1990Bo19] and 26(2) s [1967Si02].

** Deduced from α energies.

Table 2

Particle separation, Q-values, and measured values for direct particle emission of the odd-Z, $T_z = +23/2$ 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
^{145}Pm	4.808(3)	12.777(3)	2.322(3)	$2.8(6) \times 10^{-7}\%$	[1962Nu01]
^{149}Eu	4.394(4)	11.977(4)	2.401(5)		
^{153}Tb	3.895(4)	11.238(4)	2.703(5)		
^{157}Ho	3.592(23)	10.160(25)	2.056(24)		
^{161}Tm	3.124(37)	9.147(28)	2.509(36)		
^{165}Lu	2.719(31)	8.292(27)	3.032(39)		
^{169}Ta	2.219(40)	7.342(47)	3.727(39)		
^{173}Re	1.746(40)	6.412(40)	4.312(40)		
^{177}Ir	1.205(23)	5.337(34)	5.082(34)	0.06(1)%	[1990Bo19, 1967Si02, 1986Ke03]
^{181}Au	0.730(22)	4.367(22)	5.751(3)	2.7(5)%	[1995Bi01, 1993BiZY, 1992BiZZ, 1990SaZU, 1984BrZR, 1984ScZQ, 1979Ha10, 1970Ha18, 1968De01, 1968Si01, 1965Si07]
^{185}Tl	0.702(23)	4.144(23)	5.688(5)		
^{185m}Tl	0.247(23)	43.689(23)	6.143(5)	obs	[1980ToZZ, 1976To06, 1992BiZW, 1991BoZV, 1980Sc09, 1977ToZS, 1976BoYC]
^{189}Bi	-0.457(23)	2.198(22)	7.268(3)	obs	[1997Wa05, 2007DoZW, 2001An11, 2000Sc46, 1998Kr23, 1997An09, 1995Ba75, 1995BaZP, 1993An19, 1985Co06, 1984ScZQ, 1978Va21, 1974Le02, 1973Ga08, 1973LiYK]
^{189m}Bi	-0.639(24)	2.016(23)	7.450(9)	83(5)%	[1997Wa05, 2007DoZW, 1983Ke08, 2001An11, 2000Sc46, 1998Kr23, 1997An09, 1995Ba75, 1995BaZP, 1993An19, 1985Co06, 1984ScZQ]
^{193}At	-0.710(24)	1.406(23)	7.572(7)	$\approx 100\%$ *	[2003Ke08]
$^{193m1}\text{At}$	-0.720(24)	1.396(23)	7.582(9)	$\approx 100\%$ *	[2003Ke08, 1995Le15]
$^{193m2}\text{At}$	-0.754(25)	1.362(24)	7.616(10)	24(10)%	[2003Ke08]
^{197}Fr	-0.990(58)	0.854(57)	7.888(15)**	100%*	[2013Ka16]

* Based on short half-life.

** Deduced from α energy, 7.896(53) in [2021Wa16].

Table 3direct α emission from $^{145}\text{Pm}^*$, $J^\pi = 5/2^+$, $T_{1/2} = 17.7(4)$ y^{**}, $BR_\alpha = 2.8(6) \times 10^{-7}\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{daughter}(^{141}\text{Pr})$	coincident γ -rays	R_0 (fm)	HF
2.304(40)	2.240(40)	100%	$5/2^+$	0.0	—	1.5958(78)	$1.3^{+0.5}_{-0.3}$

* All values from [1962Nu01], except where noted.

** [1959Br65].

Table 4direct α emission from ^{177}Ir , $J^\pi = 5/2^-$, $T_{1/2} = 26(2)$ s^{*}, $BR_\alpha = 0.06(1)\%$ ^{**}.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{181}\text{Au})$	coincident γ -rays	R_0 (fm)	HF
5.126(10)	5.011(10)	100%	$(5/2^-)$	0.0	—			

* Weighted average of 30(2) s [1990Bo19] and 26(2) s [1967Si02].

** [1990Bo19].

*** [1067Si02].

Table 5direct α emission from $^{181}\text{Au}^*$, $J^\pi = (3/2^-)$, $T_{1/2} = 14.5(4)$ s, $BR_\alpha = 2.7(5)\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{177}\text{Ir})$	coincident γ -rays	R_0 (fm)	HF
5.313(10)	5.196(10)	0.2 (1)%	$2.4(13) \times 10^{-3}\%$		0.435		1.5322(52)	21^{+21}_{-8}
5.360(10)	5.242(10)	$\approx 0.1\%$	$\approx 1.2 \times 10^{-3}\%$		0.390		1.5322(52)	≈ 80
5.421(5)	5.301(5)	0.6(1)%	$7.1(18) \times 10^{-3}\%$		0.332		1.5322(52)	24^{+9}_{-6}
5.485(5)	5.364(5)	9(1)%	0.11(2)%		0.2659	0.0856, 0.1802, 0.2659	1.5322(52)	$3.3^{+1.1}_{-0.7}$
5.529(5)	5.407(5)	6(1)%	0.071(18)%	$7/2^-$	0.2231	0.052, 0.054, 0.0624, 0.0751, 0.0856, 0.0968, 0.1178, 0.1480, 0.1778, 0.2231	1.5322(52)	$8.0^{+3.0}_{-1.9}$
5.603(5)	5.479(5)	100(1)%	1.2(2)%	$3/2^-$	0.1480	0.052, 0.0624, 0.0856, 0.0968, 0.148	1.5322(52)	$1.1^{+0.3}_{-0.2}$
5.670(5)	5.545(5)	7(1)%	0.083(19)%	$1/2^-$	0.0856	0.0856	1.5322(52)	30^{+10}_{-7}
5.707(5)	5.581(5)	7(1)%	0.083(19)%		0.0453		1.5322(52)	45^{+16}_{-11}
5.753(5)	5.626(5)	98(1)%	1.2(2)%	$5/2^+$	0.0	—	1.5322(52)	$5.2^{+1.5}_{-1.1}$

* All values from [1995Br01].

Table 6direct α emission from $^{185m}\text{Tl}^*$, $E_\alpha = 454.8(15)$ keV^{**}, $J^\pi = (9/2^-)$, $T_{1/2} = 14.5(4)$ s, $BR_\alpha = \text{obs.}$

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{daughter}(^{177}\text{Ir})$	coincident γ -rays	R_0 (fm)	HF
6.108(5)	5.976(5)	100(6)%						
6.143(5)	6.010(5)	19(6)%						

* All values from [1976To09, 1980ToZZ], except where noted.

** [1977Si03].

Table 7
direct α emission from $^{189}\text{Bi}^*$, $J^\pi = (9/2^-)$, $T_{1/2} = 688(5)\text{s}^{**}$, $BR_\alpha = \text{obs}^{***}$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{185}\text{Tl})^\oplus$	coincident γ -rays $^\oplus$	R_0 (fm)	HF
6.692(15)	6.55(15)	1.3(9)%	1.2(9)%	(11/2 $^-$)	0.576(8)	1.5000(29)	1.5000(29)	19^{+57}_{-8}
6.816(5)	6.672(5)	100(2)%	95(2)%	(9/2 $^-$)	0.4548(15)	0.169, 0.286	1.5000(29)	0.67(6)
6.981(7)	6.833(7)	1.4(6)%	1.3(6)%	(3/2 $^+$)	0.286(1)	0.286	1.5000(29)	200^{+170}_{-60}
7.268(6)	7.114(6)	3.3(6)%	3.1(7)%	(1/2 $^+$)	0.0	—	1.5000(29)	760^{+240}_{-160}

* All values from [1997Wa05], except where noted.

** [2007DoZW].

*** Assumed to be 100% in [1997Wa05]. This value is used in this table for I_α (abs) and HF.

$^\oplus$ [2005Wu07].

Table 8
direct α emission from $^{189\text{m}}\text{Bi}^*$, $Ex = 182(8)$ keV, $J^\pi = (1/2^+)$, $T_{1/2} = 5.0(1)\text{ms}^{**}$, $BR_\alpha = \text{obs}^{***}$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{185}\text{Tl})$	coincident γ -rays	R_0 (fm)	HF
7.268(7)	7.114(7)	14(6)%	10(3)%		0.182(7)		1.5000(29)	$1.7^{+0.7}_{-0.4}$
7.450(6)	7.292(6)	100(3)%	73(5)%	(1/2 $^+$)	0.0	—	1.5000(29)	0.90(9)

* All values from [1997Wa05], except where noted.

** [2007DoZW].

Table 9
direct α emission from $^{193}\text{At}^*$, $J^\pi = (1/2^+)$, $T_{1/2} = 28^{+5}_{-4}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{189}\text{Bi})$	coincident γ -rays	R_0 (fm)	HF
7.388(5)	7.235(5)	100%	(1/2 $^+$)		0.182(8)	1.5519(62)	1.29(31)

* All values from [2003Ke08].

Table 10
direct α emission from $^{193\text{m}1}\text{At}^*$, $Ex = 10(5)$ keV, $J^\pi = (7/2^-)$, $T_{1/2} = 21(5)$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (rel)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{189}\text{Bi})$	coincident γ -rays	R_0 (fm)	HF
7.480(5)	7.325(5)	2(2)%	2(2)%	(7/2 $^-$)	0.0946(5)		1.5519(62)	≈ 100
7.580(5)	7.423(5)	100%	98(2)%	(9/2 $^-$)	0.0	—	1.5519(62)	4.1(11)

* All values from [2003Ke08].

Table 11
direct α emission from $^{193\text{m}2}\text{At}^*$, $Ex = 44(7)$ keV, $J^\pi = (13/2^+)$, $T_{1/2} = 27^{+4}_{-3}$ ms, $BR_\alpha = 24(10)\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{189}\text{Bi})$	coincident γ -rays	R_0 (fm)	HF
7.256(5)	7.106(5)	24(10)%	(13/2 $^+$)	0.357.6(5)		1.5519(62)	$2.0^{+1.9}_{-0.8}$

* All values from [2003Ke08].

Table 12
direct α emission from $^{197}\text{Fr}^*$, $J^\pi = (7/2^-)$, $T_{1/2} = 0.6^{+30}_{-3}$ ms, $BR_\alpha = 100\%$.

E_α (c.m.)	E_α (lab)	I_α (abs)	J_f^π	$E_{\text{daughter}}(^{193}\text{At})$	coincident γ -rays	R_0 (fm)	HF
7.888(15)	7.728(15)	100%	(7/2 $^-$)	0.010(5)		1.603(20)	0.53(27)

* All values from [2013Ka16].

References used in the Tables

- [1] **1959Br65** A. R. Brosi, B. H. Ketelle, H. C. Thomas, R. J. Kerr, Phys. Rev. **113**, 239 (1959). <https://doi.org/10.1103/PhysRev.113.239>
- [2] **1962Nu01** M. Nurmia, P. Kauranen, A. Siivola, Phys. Rev. **127**, 943 (1962). <https://doi.org/10.1103/PhysRev.127.943>
- [3] **1965Si07** A. Siivola, UCRL-11828, p. 25 (1965).
- [4] **1967Si02** A Siivola, Nucl Phys **A92**, 475 (1967). [https://doi.org/10.1016/0375-9474\(67\)90230-8](https://doi.org/10.1016/0375-9474(67)90230-8)
- [5] **1968De01** A G Demin, T Fenyess, I Mahunka, V G Subbotin, L Tron, Nucl Phys **A106**, 337 (1968). [https://doi.org/10.1016/0375-9474\(67\)90878-0](https://doi.org/10.1016/0375-9474(67)90878-0)
- [6] **1968Si01** A Siivola, Nucl Phys **A109**, 231 (1968). [https://doi.org/10.1016/0375-9474\(68\)90571-X](https://doi.org/10.1016/0375-9474(68)90571-X)
- [7] **1969Ar22** R. Arlt, Z. Malek, G. Muziol, H. Strusny, Izv. Akad. Nauk SSSR, Ser. Fiz. 33, 1232 (1969); Bull. Acad. Sci. USSR, Phys. Ser. 33, 1144 (1970).
- [8] **1970Ch09** Y Y Chu, E M Franz, G Friedlander, Phys Rev **C1**, 1826 (1970). <https://doi.org/10.1103/PhysRevC.1.1826>
- [9] **1970Ha18** P. G. Hansen, H. L. Nielsen, K. Wilsky, M. Alpsten, M. Finger, A. Lindahl, R. A. Naumann, O. B. Nielsen, Nucl. Phys. **A148**, 249 (1970). oi: 10.1016/0375-9474(70)90622-6. [https://doi.org/10.1016/0375-9474\(70\)90622-6](https://doi.org/10.1016/0375-9474(70)90622-6)
- [10] **1972To05** J. P. Torres, P. Paris, P. Kilcher, Nucl. Phys. **A185**, 574 (1972). [https://doi.org/10.1016/0375-9474\(72\)90033-4](https://doi.org/10.1016/0375-9474(72)90033-4)
- [11] **1973Ga08** H Gauvin, R L Hahn, Y Le Beyec, M Lefort, J Livet, Nucl Phys **A208**, 360 (1973). [https://doi.org/10.1016/0375-9474\(73\)90381-3](https://doi.org/10.1016/0375-9474(73)90381-3)
- [12] **1973LiYK** J. Livet, (thesis), REPT FRNC-TH-412, mf.
- [13] **1974Le02** Y Le Beyec, M Lefort, J Livet, N T Porile, A Siivola, Phys Rev C **9**, 1091 (1974). <https://doi.org/10.1103/PhysRevC.9.1091>
- [14] **1976BoYC** C. Bourgeois, M. Bouet, A. Caruette, A. Ferro, R. Foucher, J. Fournet, A. Hoglund, L. Kotfila, G. Landois, C. F. Liang, B. Merlant, J. Obert, A. Peghaire, J. C. Putaux, J. L. Sarrouy, W. Watzig, A. Wojtasiewicz, V. Berg, and the ISOCELE Collaboration, Univ. Paris, Ann. Rept. , p. N19 (1976).
- [15] **1976To06** K S Toth, M A Ijaz, J Lin, E L Robinson, B O Hannah, E H Spejewski, J D Cole, J H Hamilton, A V Ramayya, Phys Lett **63B**, 150 (1976). [https://doi.org/10.1016/0370-2693\(76\)90636-5](https://doi.org/10.1016/0370-2693(76)90636-5)
- [16] **1977Si03** R. R. Silbar, Phys. Rev. **C15**, 1158 (1977). <https://doi.org/10.1103/PhysRevC.15.1158>
- [17] **1977ToZS** K. S. Toth, J. Lin, M. A. Ijaz, E. L. Robinson, C. R. Bingham, H. K. Carter, ORNL-5306, p. 83 (1977).
- [18] **1978Va21** V. M. Vakhtel, S. G. Kadenskii, A. A. Martynov, V. I. Furman, Yad. Fiz. **28**, 1241 (1978); Sov. J. Nucl. Phys. **28**, 639 (1978).
- [19] **1979Ha10** E Hagberg, P G Hansen, P Hornshoj, B Jonson, S Mattsson, P Tidemand-Petersson, Nucl Phys **A318**, 29 (1979). [https://doi.org/10.1016/0375-9474\(79\)90467-6](https://doi.org/10.1016/0375-9474(79)90467-6)
- [20] **1980Sc09** U J Schrewe, P Tidemand-Petersson, G M Gowdy, R Kirchner, O Klepper, A Plochocki, W Reisdorf, E Roeckl, J L Wood, J Zylicz, R Fass, D Schardt, Phys Lett **91B**, 46 (1980). [https://doi.org/10.1016/0370-2693\(80\)90659-0](https://doi.org/10.1016/0370-2693(80)90659-0)
- [21] **1980ToZZ** K. S. Toth, unpublished. (November 1980).
- [22] **1982Ra19** S. Rastikerdar, C. Garrett, W. Gelletly, J. Phys. (London) **G8**, 1301 (1982). <https://doi.org/10.1088/0305-4616/8/9/013>
- [23] **1983Ke08** B. D. Kern, K. S. Toth, D. M. Moltz, J. Lin, F. T. Avignone III, H. Noma, G. A. Leander, Phys. Rev. **C28**, 2168 (1983). <https://doi.org/10.1103/PhysRevC.28.2168>
- [24] **1984BrZR** C. Bourgeois, P. Kilcheb, M. G. Porouet, B. Roussiere, J. Sauvage for the ISOCELE Collaboration, Univ. Paris, Inst. Phys. Nucl. , Ann. Rept. , p. E13 (1984)
- [25] **1984ScZQ** J. Schneider GSI-84-3 (thesis) (1984).
- [26] **1985Co06** E. Coenen, K. Deneffe, M. Huyse, P. Van Duppen, J. L. Wood, Phys. Rev. Lett. **54**, 1783 (1985). <https://doi.org/10.1103/PhysRevLett.54.1783>
- [27] **1986Ke03** J G Keller, K -H Schmidt, F P Hessberger, G Munzenberg, W Reisdorf, H -G Clerc, C -C Sahn, Nucl Phys **A452**, 173 (1986). [https://doi.org/10.1016/0375-9474\(86\)90514-2](https://doi.org/10.1016/0375-9474(86)90514-2)
- [28] **1986Sz05** A. Szymanski, G. W. A. Newton, V. J. Robinson, H. E. Sims, Radiochim. Acta **40**, 61 (1986).

- [29] **1990Bo19** U. Bosch, P. Koschel, W. -D. Schmidt-Ott, V. Freystein, T. Hild, F. Meissner, H. Salewski, U. Ellmers, R. Michaelsen, *Z. Phys. A* **336**, 359 (1990).
- [30] **1990SaZU** J. Sauvage, C. Bourgeois, P. Kilcher, F. Le Blanc, B. Roussiere, M. I. Macias-Marques, F. Braganca Gil, M. G. Porquet, H. Dautet, and the ISOCELE Collaboration, IPNO-DRE 90-11 (1990).
- [31] **1991BoZV** V. A. Bolshakov, G. V. Veselov, A. G. Dernyatin, K. A. Mezilev, Yu. N. Novikov, A. G. Polyakov, A. V. Popov, V. A. Sergienko, Yu. Ya. Sergeev, V. I. Tikhonov, Program and Thesis, Proc. 41st Ann. Conf. Nucl. Spectrosc. Struct. At. Nuclei, Minsk, p. 116 (1991).
- [32] **1992BiZW** Yu. S. Blinnikov, V. A. Bolshakov, A. G. Dernyatin, K. A. Mezilev, Yu. N. Novikov, A. G. Polyakov, A. V. Popov, Yu. Ya. Sergeev, V. A. Sergienko, V. I. Tikhonov, G. V. Veselov, V. M. Zeleznyakov, *Leningrad Nucl. Phys. Inst.*, 1990-1991 Ann. Rept. , p. 63 (1992).
- [33] **1992BiZZ** C. R. Bingham, Y. A. Akovali, H. K. Carter, W. D. Hamilton, M. M. Jarrio, M. B. Kassim, J. Kormicki, J. Schwarzenberg, K. S. Toth, M. Zhang, *Contrib. 6th Intern. Conf. on Nuclei Far from Stability + 9th Intern. Conf. on Atomic Masses and Fundamental Constants, Bernkastel-Kues, Germany*, PE47 (1992).
- [34] **1993Al02** H. Alloul, A. Mahajan, H. Casalta, O. Klein *Phys. Rev. Lett.* **70**, 1171 (1993). <https://doi.org/10.1103/PhysRevLett.70.1171>
- [35] **1993An19** A N Andreyev, D D Bogdanov, V I Chepigin, V A Gorshkov, K V Mikhailov, A P Kabachenko, G S Popeko, S Saro, G M Ter-Akopian, A V Yeremin, Sh S Zeinalov, *Nucl Instrum Methods Phys Res A* **330**, 125 (1993). [https://doi.org/10.1016/0168-9002\(93\)91313-C](https://doi.org/10.1016/0168-9002(93)91313-C)
- [36] **1993BiZY** C. R. Bingham, Y. A. Akovali, H. K. Carter, W. D. Hamilton, M. M. Jarrio, M. B. Kassim, J. Kormicki, J. Schwarzenberg, K. S. Toth, M. Zhang, *Proc. 6th Intern. Conf. on Nuclei Far from Stability + 9th Intern. Conf. on Atomic Masses and Fundamental Constants, Bernkastel-Kues, Germany, 19-24 July, 1992*, R. Neugart, A. Wöhr, Eds. , p. 735 (1993).
- [37] **1995Ba75** J. C. Batchelder, K. S. Toth, D. M. Moltz, T. J. Ognibene, M. W. Rowe, C. R. Bingham, E. F. Zganjar, B. E. Zimmerman, *Phys. Rev. C* **52**, 1807 (1995). <https://doi.org/10.1103/PhysRevC.52.1807>
- [38] **1995BaZP** J. C. Batchelder, K. S. Toth, D. M. Moltz, T. J. Ognibene, M. W. Rowe, C. R. Bingham, E. F. Zganjar, B. E. Zimmerman, *Proc. Intern. Conf on Exotic Nuclei and Atomic Masses, Arles, France, June 19-23, 1995*, p. 541 (1995).
- [39] **1995Bi01** C. R. Bingham, M. B. Kassim, M. Zhang, Y. A. Akovali, K. S. Toth, W. D. Hamilton, H. K. Carter, J. Kormicki, J. von Schwarzenberg, M. M. Jarrio, *Phys. Rev. C* **51**, 125 (1995). <https://doi.org/10.1103/PhysRevC.51.125>
- [40] **1995Le15** M. Leino, J. Aysto, T. Enqvist, A. Jokinen, M. Nurmi, A. Ostrowski, W. H. Trzaska, J. Uusitalo, K. Eskola, *Acta Phys. Pol.* **B26**, 309 (1995).
- [41] **1997An09** A N Andreyev, N Bijmens, T Enqvist, M Huyse, P Kuusiniemi, M Leino, W H Trzaska, J Uusitalo, P Van Duppen, *Z Phys A* **358**, 63 (1997). <https://doi.org/10.1007/s002180050276>
- [42] **1997Wa05** J Wauters, J C Batchelder, C R Bingham, D J Blumenthal, L T Brown, L F Conticchio, C N Davids, T Davinson, R J Irvine, D Seweryniak, K S Toth, W B Walters, P J Woods, E F Zganjar, *Phys Rev C* **55**, 1192 (1997). <https://doi.org/10.1103/PhysRevC.55.1192>
- [43] **1998Kr23** J. Krause, I. Berkes, J. Camps, M. De Jesus, P. De Moor, P. Herzog, M. Massa, T. Phalet, P. Schuurmans, N. Severijns, A. Van Geert, D. Venos, B. Verecke, B. Will, D. Zakoucky, and the NICOLE and ISOLDE Collaborations, *Phys. Rev. C* **58**, 3181 (1998). <https://doi.org/10.1103/PhysRevC.58.3181>
- [44] **2000Sc46** P. Schuurmans, I. Berkes, P. Herzog, N. Severijns, and the NICOLE and the ISOLDE Collaboration, *Hyperfine Interactions* **129**, 163 (2000). <https://doi.org/10.1023/A:1012657715807>
- [45] **2001An11** A. N. Andreyev, D. Ackermann, P. Cagarda, J. Gerl, F. P. Hessberger, S. Hofmann, M. Huyse, A. Keenan, H. Kettunen, A. Kleinbohl, A. Lavrentiev, M. Leino, B. Lommel, M. Matos, G. Munzenberg, C. J. Moore, C. D. O'Leary, R. D. Page, S. Reshitko, S. Saro, C. Schlegel, H. Schaffner, M. J. Taylor, P. Van Duppen, L. Weissman, R. Wyss, *Eur. Phys. J. A* **10**, 129 (2001). <https://doi.org/10.1007/s100500170123>
- [46] **2003Ke08** H Kettunen, T Enqvist, T Grahn, P T Greenlees, P Jones, R Julin, S Juutinen, A Keenan, P Kuusiniemi, M Leino, A -P Leppanen, P Nieminen, J Pakarinen, P Rahkila, J Uusitalo, *Eur Phys J A* **17**, 537 (2003). <https://doi.org/10.1140/epja/i2002-10162-1>
- [47] **2005Wu07** S. -C. Wu, *Nucl.Data Sheets* **106**, 619 (2005). <https://doi.org/10.1016/j.nds.2005.11.002>
- [48] **2007DoZW** C. Dossat, Ch. Theisen, A. Burger, E. Clement, A. Gorgen, W. Korten, S. Eeckhaudt, P. Jones, T. Grahn, P. T. Greenlees, R. Julin, S. Juutinen, M. Leino, A. -P. Leppanen, M. Nyman, J. Pakarinen, P. Rahkila, J. Saren, C. Scholey, J. Sorri, J. Uusitalo, M. Venhart, *Proc. Inter. Conf. Proton Emitting Nuclei and Related Topics (PROCON 2007), Lisbon, Portugal, 17-23*

June 2007, L. S. Ferreira Ed. p. 196 (2007); AIP Conf. Proc. 961 (2007). <https://doi.org/10.1063/1.2827256>

- [49] **2013Ka16** Z. Kalaninova, A. N. Andreyev, S. Antalic, F. P. Hessberger, D. Ackermann, B. Andel, M. C. Drummond, S. Hofmann, M. Huyse, B. Kindler, J. F. W. Lane, V. Liberati, B. Lommel, R. D. Page, E. Rapisarda, K. Sandhu, S. Saro, A. Thornthwaite, P. Van Duppen, *Phys. Rev. C* **87**, 044335 (2013). <https://doi.org/10.1103/PhysRevC.87.044335>
- [50] **2021Wa16** M Wang, W J Huang, F G Kondev, G Audi, S Naimi, *Chin Phys C* **45**, 030003 (2021). <https://doi.org/10.1088/1674-1137/abddaf>