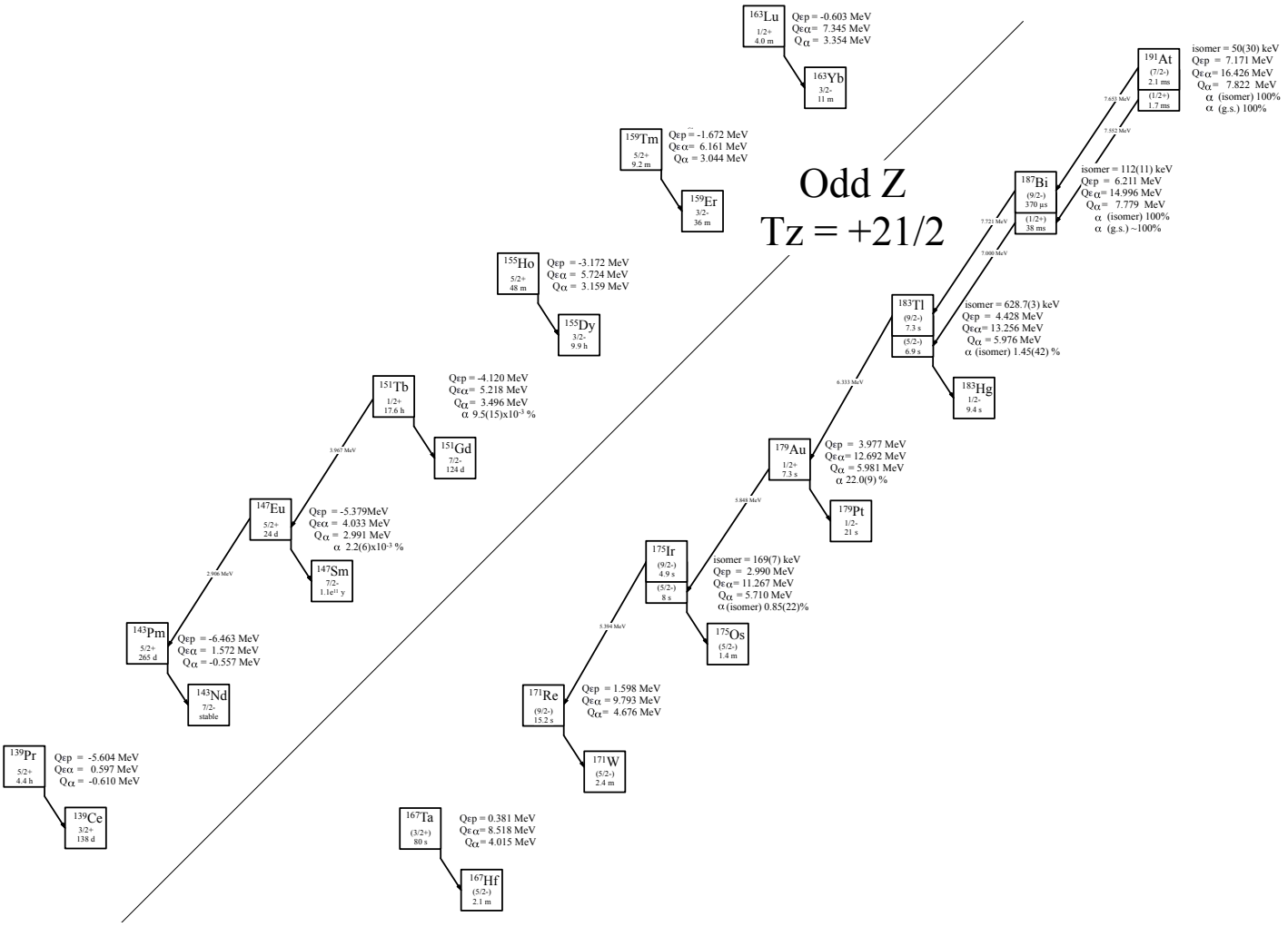


**Fig. 1**: Known experimental values for heavy particle emission of the odd-Z $T_z$= +21/2 nuclei.

Last updated 3/29/23

**Table 1**
Observed and predicted $\beta$-delayed particle emission from the odd-$Z$, $T_z$ = +21/2 values for are taken from ENSDF.

| Nuclide | Ex | $J^\pi$ | $T_{1/2}$ | $Q_\varepsilon$ | $Q_{\varepsilon p}$ | $Q_{\varepsilon\alpha}$ | Experimental |
|---|---|---|---|---|---|---|---|
| $^{139}$Pr | | $5/2^+$ | 4.41(4) h | 2.129(3) | -5.604(4) | 0.597(4) | [**1968Li08**] |
| $^{143}$Pm | | $5/2^+$ | 265(10) d | 1.042(3) | -6.463(3) | 1.572(4) | [**1963Pa21**] |
| $^{147}$Eu | | $5/2^+$ | 24.1(6) d | 1.721(2) | -5.379(5) | 4.033(3) | [**1971Av09**] |
| $^{151}$Tb | | $1/2^+$ | 17.609(14) h | 2.565(4) | -4.120(7) | 5.218(4) | [**1984Gr15**] |
| $^{155}$Ho | | $5/2^+$ | 48(2) m | 3.116(17) | -3.172(49) | 5.724(18) | [**1972To07**] |
| $^{159}$Tm | | $5/2^+$ | 9.15(17) m | 3.991(28) | -1.672(39) | 6.161(30) | [**1982By03**] |
| $^{163}$Lu | | $1/2^+$ | 3.97(13) m | 4.500(30) | -0.603(38) | 7.345(28) | [**1983Ge08**] |
| $^{167}$Ta | | $(3/2^+)$ | 80(4) s | 5.120(40) | 0.381(41) | 8.518(32) | [**1992HeZV**] |
| $^{171}$Re | | $(9/2^-)$ | 15.2(4) s | 5.840(40) | 1.598(40) | 9.793(40) | [**1987Ru05**] |
| $^{175}$Ir | | $(1/2^+)$ | 8(1) s | 6.711(17) | 2.990(31) | 11.267(31) | [**2004GoZZ**] |
| $^{175m}$Ir | 0.169(7)* | $(9/2^-)$ | 4.9(4) s | 6.880(18) | 3.159(32) | 11.436(32) | [**2004GoZZ**] |
| $^{179}$Au | | $1/2^+$ | 7.3(3) s | 7.280(14) | 3.977(22) | 12.692(17) | [**2021Ha32**] |
| $^{183}$Tl | | $(5/2^-)$ | 6.9(7) s | 7.217(12) | 4.428(21) | 13.256(12) | [**1992BoZO**] |
| $^{183m}$Tl | 0.6287(3) | $(9/2^-)$ | 53.3(3) ms | 7.846(12) | 5.077(21) | 13.885(12) | [**2022Ve01, 2011Ve01**] |
| $^{187}$Bi | | $(1/2^+)$ | 38(2) ms** | 8.604(11) | 6.211(23) | 14.996(12) | [**2006An11, 1999Ba45**] |
| $^{187m}$Bi | 0.112(11) | $(9/2^-)$ | 370(20) $\mu$s | 8.716(16) | 6.211(25) | 14.996(16) | [**2006An11**] |
| $^{191}$At | | $(1/2^+)$ | $1.7^{+1.1}_{-0.5}$ ms | 8.933(18) | 7.171(26) | 16.426(17) | [**2003Ke08**] |
| $^{191m}$At | 0.050(30) | $(7/2^-)$ | $2.1^{+0.4}_{-0.3}$ ms | 8.983(35) | 7.221(40) | 16.476(34) | [**2003Ke08**] |

* Excitation calculated as 169(7) keV, based on an unhindered $\alpha$-decay of the $^{175}$Ir isomer to the ground state of $^{171}$Re, and the $\alpha$-energy of the $^{175}$Ir ground state to an unhindered to the 189.8 keV in $^{171}$Re.

** Weighted average of 40(2) ms [2006An11] and 32(3) ms [1999Ba45].

**Table 2**
Particle separation, Q-values, and measured values for direct particle emission of the odd-$Z$, $T_z$ = +21/2 nuclei. Unless otherwise stated, all S and Q-values are taken from [2021Wa16] or deduced from values therein.

| Nuclide | $S_p$ | $S_{2p}$ | $Q_\alpha$ | $BR_\alpha$ | Experimental |
|---|---|---|---|---|---|
| $^{139}$Pr | 4.552(4) | 12.266(4) | -0.610(10) | —— | |
| $^{143}$Pm | 4.300(3) | 11.524(3) | -0.557(5) | —— | |
| $^{147}$Eu | 3.837(4) | 10.855(3) | 2.991(3) | 0.0022(6)% | [**1967Go32, 1962Si14**, 1964To04, 1960To05, 1953Ra02] |
| $^{151}$Tb | 3.148(7) | 9.760(5) | 3.496(4) | 0.0095(15)% | [**1974To07, 1967Go32**, 1975ToZT, 1970ToZV, 1969To04, 1967Ko09, 1967Ch32, 1967Ch28, 1966Ch22, 1964Ma19, 1960Ma47, 1960To05, 1953Ra02] |
| $^{155}$Ho | 2.935(19) | 9.304(18) | 3.159(18) | | |
| $^{159}$Tm | 2.556(38) | 8.315(36) | 3.044(33) | | |
| $^{163}$Lu | 2.259(32) | 7.471(40) | 3.354(40) | | |
| $^{167}$Ta | 1.781(40) | 6.487(39) | 4.015(40) | | |
| $^{171}$Re | 1.248(31) | 5.538(40) | 4.676(40) | | |
| $^{175}$Ir | 0.688(16) | 4.419(31) | 5.710(5) | 0.85(22)% | [**2004GoZZ, 1986Ke03, 1967Si02**, 1992Sc16] |
| $^{175m}$Ir | 0.518(17) | 4.250(32) | 5.879(9)* | $\approx$ 70%** | [**2004GoZZ**] |
| $^{179}$Au | 0.280(15) | 3.519(23) | 5.981(5) | 22.0(9)% | [**2021Ha32, 1986Ke03**, 2004Ra28, 1996Pa01, 1980Da09, 1968De01, 1968Si01, 1965Si07] |
| $^{183}$Tl | 0.299(14) | 3.294(22) | 5.976(9) | | |
| $^{183m}$Tl | -0.330(14) | 2.665(22) | 6.605(9) | 1.45(42)% | [**2022Ve01**, 2011Ve01, 2006An11, 2004Ra28, 1987To09, 1984ScZQ, 1980Sc09] |
| $^{187}$Bi | -1.009(15) | 1.203(23) | 7.779(4) | $\approx$100%*** | [**2006An11, 1999Ba45**, 2003Ke08, 1998DaZR, 1984ScZQ] |
| $^{187m}$Bi | -1.121(19) | 1.091(25) | 7.891(12) | $\approx$100%*** | [**2006An11, 1999Ba45**, 2003Ke08, 1998DaZR, 1984ScZQ] |
| $^{191}$At | -1.138(21) | 0.649(26) | 7.822(14) | 100%@ | [**2003Ke08**, 2005Ke10, 2005Su03] |
| $^{191m}$At | -1.188(40) | 0.599(40) | 7.872(33) | 100%@ | [**2003Ke08**, 2005Ke10, 2005Su03] |

* Deduced from $\alpha$ energies, 5.431(31) MeV in [2021Wa16].

** Assuming an unhindered (HF =1.0) to the ground state of $^{171}$Re.

*** Based on half-life.

**Table 3**
direct $\alpha$ emission from $^{147}$Eu, $J^{\pi} = 5/2^{+}$, $T_{1/2}$ = 24.1(6) d*, $BR_{\alpha}$ = 0.0022(6)%**.

| $E_{\alpha}$(c.m.) | $E_{\alpha}$(lab) | $I_{\alpha}$(abs) | $J^{\pi}_{f}$ | $E_{daughter}$($^{143}$Pm) | coincident $\gamma$-rays | $R_0$ (fm) | HF | |
|---|---|---|---|---|---|---|---|---|
| 2.987(5) | 2.906(5)*** | 0.0022(6)%** | $5/2^{+}$ | 0.0 | $5/2^{+}$ | —— | 1.5813(49) | $0.63^{+0.27}_{-0.17}$ |

* [1971Au09].
** [1962Si14].
*** 2.908(5) MeV [1967Go32], adjusted to 2.906(5) MeV in [1991Ry01].

**Table 4**
direct $\alpha$ emission from $^{151}$Tb, $J^{\pi} = 1/2^{+}$, $T_{1/2}$ = 17.609(14) h*, $BR_{\alpha}$ = 0.0095(15)%**.

| $E_{\alpha}$(c.m.) | $E_{\alpha}$(lab) | $I_{\alpha}$(rel) | $I_{\alpha}$(abs) | $J^{\pi}_{f}$ | $E_{daughter}$($^{147}$Eu) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|---|
| 3.268(5) | 3.181(5)*** | 0.1%*** | $9.5(15)\times10^{-6}$%** | $7/2^{+}$ | 0.2292 | 0.2292 | 1.5772(70) | 81 |
| 3.500(5) | 3.407(5)[@] | 100%*** | 90.0095(15)%** | $5/2^{+}$ | 0.0 | —— | 1.5772(70) | $6.3^{+1.8}_{-1.4}$ |

* [1984Gr15].
** [1974To07].
*** 3.183(5) MeV [1967Go32], adjusted to 3.181(5) MeV in [1991Ry01].
[@] 3.409(5) MeV [1967Go32], adjusted to 3.407(5) MeV in [1991Ry01].

**Table 5**
direct $\alpha$ emission from $^{175}$Ir, $J^{\pi} = (1/2^{+})$, $T_{1/2}$ = 8(1) s*, $BR_{\alpha}$ = 0.85(22)%**.

| $E_{\alpha}$(c.m.) | $E_{\alpha}$(lab) | $I_{\alpha}$(abs) | $J^{\pi}_{f}$ | $E_{daughter}$($^{171}$Re) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|
| 5.520(5) | 5.394(5)*** | 0.85(22)%** | | 0.1899(3) | 0.1899(3) | 1.550(19) | $3.3^{+2.7}_{-1.6}$ |

* [2004GoZZ].
** [1986Ke03].
*** Weighted average of 5.395(5) [2004GoZZ] and 5.393(5) MeV [1967Si02].
[@] [2018Ba33].

**Table 6**
direct $\alpha$ emission from $^{175m}$Ir, Ex = 169(7) keV*, $J^{\pi} = (9/2^{-})$, $T_{1/2}$ = 4.9(4) s**, $BR_{\alpha} = \approx 70\%$***.

| $E_{\alpha}$(c.m.) | $E_{\alpha}$(lab) | $I_{\alpha}$(abs) | $J^{\pi}_{f}$ | $E_{daughter}$($^{171}$ERe) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|
| 5.879(5) | 5.745(5)** | 0.85(22)%** | $(9/2^{-})$ 0.0 | —— | 1.550(19) | $\approx 1.0$ | |

* Excitation calculated as 169(7) keV, based on an unhindered $\alpha$-decay of the $^{175}$Ir isomer to the ground state of $^{171}$Re, and the $\alpha$-energy of the $^{175}$Ir ground state to an unhindered to the 189.8 keV in $^{171}$Re.
** [2004GoZZ].
*** Assuming an unhindered (HF =1.0) to the ground state of $^{171}$Re.
[@] [2018Ba33].

**Table 7**
direct $\alpha$ emission from $^{179}$Au*, $J^{\pi} = 1/2^{+}$, $T_{1/2}$ = 7.3(3) s, $BR_{\alpha}$ = 22.0(9)%**.

| $E_{\alpha}$(c.m.) | $E_{\alpha}$(lab) | $I_{\alpha}$(rel) | $I_{\alpha}$(abs) | $J^{\pi}_{f}$ | $E_{daughter}$($^{175}$Ir) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|---|
| 5.72810 | 5.600(10) | 0.36(1)% | 0.078(4)% | | 0.2603(7) | 0.0261, 0.2342 | 1.5516(28) | 38(4) |
| 5.835(15) | 5.705(15) | <0.16(7)% | <0.036(16)% | | 0.1460(7) | 0.0261, 0.1199 | 1.5516(28) | $>270^{+23}_{-9}$ |
| 5.849(10) | 5.718(10) | <0.98(31)% | < 0.22(7)% | | 0.1319(4) | 0.0261, 0.1053, 0.1319 | 1.5516(28) | $>51^{+28}_{-15}$ |
| 5.982(4) | 5.848(4) | 100 | 22.0(9)% | $(1/2^{+})$ | 0.0 | —— | 1.5516(28) | 1.85(17) |

* All values from [2021Ha32], except where noted.
** [1986Ke03].

**Table 8**
direct $\alpha$ emission from $^{183m}$Tl*, Ex = 628.7(3) keV, $J^\pi$ = (9/2$^-$), $T_{1/2}$ = 53.3(3) ms, $BR_\alpha$ = 1.45(42)%.

| $E_\alpha$(c.m.) | $E_\alpha$(lab) | $I_\alpha$(rel) | $I_\alpha$(abs) | $J^\pi_f$ | $E_{daughter}$($^{179}$Au) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|---|
| 6.193(15) | 6.058(15) | 1.6(3)% | 0.024(8)% | (9/2$^-$) | 0.407(17) | 0.0271, 0.0624, 0.0895, 0.2798 | 1.5108(76) | $6^{+4}_{-2}$ |
| 6.475(9) | 6.333(9) | 100(2)% | 1.45(42)% | (9/2$^-$) | 0.127(17) | 0.0271, 0.0624, 0.0895 | 1.5108(76) | $1.3^{+0.7}_{-0.4}$ |
| 6.602(15) | 6.458(15) | 1.13 (31)% | 0.016(7)% | (1/2$^+$) | 0.0 | —— | 1.5108(76) | $350^{+250}_{-120}$ |

* All values from [2022Ve01], except where noted.

**Table 9**
direct $\alpha$ emission from $^{187}$Bi*, $J^\pi$ = (1/2$^+$), $T_{1/2}$ = 38(2) ms**, $BR_\alpha$ = ≈100%.

| $E_\alpha$(c.m.) | $E_\alpha$(lab) | $I_\alpha$(rel) | $I_\alpha$(abs) | $J^\pi_f$ | $E_{daughter}$($^{183}$Tl) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|---|
| 7.156(5) | 7.000(5) | 100(5)% | 88(4)% | (9/2$^-$) | 0.625(7) | | 1.4864(88) | $0.43^{+0.10}_{-0.08}$ |
| 7.506(15) | 7.342(15) | 3.4(8)% | 3.0(7)% | (3/2$^+$) | 0.273(1) | 0.273 | 1.4864(88) | $170^{+70}_{-50}$ |
| 7.782(5) | 7.612 (5) | 10.2(7)% | 9.0(5)% | (1/2$^+$) | 0.0 | —— | 1.4864(88) | $390^{+80}_{-70}$ |

* All values from [2006An11], except where noted.
** Weighted average of 40(2) ms [2006An11] and 32(3) ms [1999Ba45].

**Table 10**
direct $\alpha$ emission from $^{187m}$Bi*, Ex = 112(11) keV, $J^\pi$ = (9/2$^-$), $T_{1/2}$ = 370(20) $\mu$s, $BR_\alpha$ = 100%.

| $E_\alpha$(c.m.) | $E_\alpha$(lab) | $I_\alpha$(abs) | $J^\pi_f$ | $E_{daughter}$($^{183}$Tl) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|
| 7.894(10) | 7.721(10) | 100% | (1/2$^+$) | 0.0 | —— | 1.4864(88) | $0.72^{+0.16}_{-0.13}$ |

* All values from [2006An11], except where noted.

**Table 11**
direct $\alpha$ emission from $^{191}$At*, $J^\pi$ = (1/2$^+$), $T_{1/2}$ = $1.7^{+11}_{-5}$ ms, $BR_\alpha$ = 100%.

| $E_\alpha$(c.m.) | $E_\alpha$(lab) | $I_\alpha$(abs) | $J^\pi_f$ | $E_{daughter}$($^{187}$Bi) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|
| 7.714(11) | 7.552(11) | 100% | (1/2$^+$) | 0.112(20) | | 1.522(12) | 0.41(29) |

* All values from [2003Ke08].

**Table 12**
direct $\alpha$ emission from $^{191m}$At*, Ex = 50(30) keV, $J^\pi$ = (7/2$^-$), $T_{1/2}$ = $2.1^{+4}_{-3}$ ms, $BR_\alpha$ = 100%.

| $E_\alpha$(c.m.) | $E_\alpha$(lab) | $I_\alpha$(rel) | $I_\alpha$(abs) | $J^\pi_f$ | $E_{daughter}$($^{187}$Bi) | coincident $\gamma$-rays | $R_0$ (fm) | HF |
|---|---|---|---|---|---|---|---|---|
| 7.817(15) | 7.653(15) | 100(2)% | 98(2)% | (7/2$^-$) | 0.063(10) | 0.063(10) | 1.522(12) | $1.1^{+0.4}_{-0.3}$ |
| 7.880(15) | 7.715(15) | 2(2)% | 2(2)% | (9/2$^-$) | 0.0 | —— | 1.522(12) | 1200(1100) |

* All values from [2003Ke08].

## References used in the Tables


[1] **1953Ra02** J. O. Rasmussen, Jr., S. G. Thompson, A. Ghiorso, Phys. Rev. **89**, 33 (1953).

[2] **1960Ma47** R. D. Macfarlane, UCRL-9566, p. 46 (1960).

[3] **1960To05** K. S. Toth, J. O. Rasmussen, Nuclear Phys. **16**, 474 (1960). https://doi.org/10.1016/S0029-5582(60)81008-5

[4] **1962Si14** A. Siivola, Ann. Acad. Sci. Fennicae, Ser. A VI, No. —bf109 (1962).

[5] **1963Pa21** I. M. H. Pagden, R. Jakeways, F. C. Flack, Nucl. Phys. **48**, 555 (1963). https://doi.org/10.1016/0029-5582(63)90222-0

[6] **1964Ma19** R. D. Macfarlane, D. W. Seegmiller, Nucl. Phys. **53**, 449 (1964). https://doi.org/10.1016/0029-5582(64)90624-8

[7] **1964To04** K. S. Toth, T. H. Handley, E. Newman, I. R. Williams, Phys. Rev. **136**, B1233 (1964). https://doi.org/10.1103/PhysRev. 136. B1233

[8] **1965Si07** A. Siivola, UCRL-11828, p. 25 (1965).

[9] **1966Ch22** V. G. Chumin, Z. T. Zhelev, K. Y. Gromov, Program and Theses, Proc. 16th All-Union Conf. Nucl. Spectroscopy and Struct. of at. Nuclei, Moscow, p. 35 (1966).

[10] **1967Ch28** V. G. Chumin, Z. T. Zhelev, K. Y. Gromov, B. Makhmudov, Izv. Akad. Nauk SSSR, Ser. Fiz. **31**, 146 (1967); Bull. Acad. Sci. USSR, Phys. Ser. **31**, 138 (1968).

[11] **1967Ch32** V. G. Chumin, Z. Zhelev, K. Y. Gromov, B. Makhmudov, Intern. Nucl. Phys. Conf. , Gatlinburg, Tenn. (1966); R. L. Becker, C. D. Goodman, P. H. Stelson, A. Zucker, Eds. , Academic Press, New York, p. 922 (1967).

[12] **1967Go32** N. A. Golovkov, K. Y. Gromov, N. A. Lebedev, B. Makhmudov, A. S. Rudnev, V. G. Chumin, Izv. Akad. Nauk SSSR, Ser. Fiz. **31**, 1618 (1967); Bull. Acad. Sci. USSR, Phys. Ser. **31**, 1657 (1968).

[13] **1967Ko09** J. Kormicki, H. Niewodniczanski, Z. Stachura, K. Zuber, A. Budziak, Nucl. Phys. A**100**, 297 (1967). https://doi.org/10.1016/0375-9474(67)90410-1

[14] **1967Si02** A. Siivola, Nucl. Phys. A**92**, 475 (1967). https://doi.org/10.1016/0375-9474(67)90230-8

[15] **1968De01** A. G. Demin, T. Fenyes, I. Mahunka, V. G. Subbotin, L. Tron, Nucl. Phys. A**106**, 337 (1968). https://doi.org/10.1016/0375-9474(67)90878-0

[16] **1968Li08** H. Liskien, Nucl. Phys. A**118**, 379 (1968). https://doi.org/10.1016/0375-9474(68)90344-8

[17] **1968Si01** A. Siivola, Nucl. Phys. A**109**, 231 (1968). https://doi.org/10.1016/0375-9474(68)90571-X

[18] **1969To04** K. S. Toth, Nucl. Phys. A133, 222 (1969). https://doi.org/10.1016/0375-9474(69)90461-8

[19] **1970ToZV** K. S. Toth, REPT ORNL-4534, P35 7/29/71.

[20] **1971Av09** M. P. Avotina, A. V. Zolotavin, Prop. At. Nucl. No. 11, Izdatelstvo Nauk SSSR, Leningrad (1971)

[21] **1972To07** J. P. Torres, P. Paris, D. Lecouturier, P. Kilcher, Nucl. Phys. A**189**, 609 (1972). https://doi.org/10.1016/0375-9474(72)90317-X

[22] **1974To07** K. S. Toth, C. R. Bingham, W. -D. Schmidt-Ott, Phys. Rev. C**10**, 2550 (1974). https://doi.org/10.1103/PhysRevC. 10.2550

[23] **1975ToZT** K. S. Toth, C. R. Bingham, W. -D. Schmidt-Ott, ORNL-5025, p. 56 (1975).

[24] **1980Da09** H. Dautet, G. Bischoff, J. M. D'Auria, B. D. Pate, Can. J. Phys. **58**, 891 (1980). https://doi.org/10.1139/p80-122

[25] **1980De01** J. De Kam, F. van Geffen, M. van der Velde, Nucl. Phys. A**333**, 443 (1980). https://doi.org/10.1016/0375-9474(80)90109-8

[26] **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. **91**B, 46 (1980). https://doi.org/10.1016/0370-2693(80)90659-0

[27] **1982By03** A. A. Bykov, V. D. Vitman, Yu. V. Naumov, S. Yu. Orlov, V. K. Tarasov, Izv. Akad. Nauk SSSR, Ser. Fiz. **46**, 2230 (1982); Bull. Acad. Sci. USSR, Phys. Ser. **46**, No. 11, 166 (1982).

[28] **1983Ge08** W. Gelletly, Nucl. Instrum. Methods **211**, 89 (1983). https://doi.org/10. 1016/0167-5087(83)90559-8

[29] **1984Gr15** K. E. Gregorich, K. J. Moody, G. T. Seaborg, Radiochim. Acta **35**, 1 (1984). https://doi.org/10.1524/ract.1984.35.1.1

[30] **1984ScZQ** J. Schneider GSI-84-3 (thesis) (1984).

[31] **1986Ke03** J. G. Keller, K. -H. Schmidt, F. P. Hessberger, G. Munzenberg, W. Reisdorf, H. -G. Clerc, C. -C. Sahm, Nucl. Phys. A**452**, 173 (1986). https://doi.org/10.1016/0375-9474(86)90514-2

[32] **1987Ru05** E. Runte, F. Meissner, V. Freystein, T. Hild, H. Salewski, W. -D. Schmidt-Ott, R. Michaelsen, Z. Phys. A**328**, 373 (1987).

[33] **1987To09** K. S. Toth, D. M. Moltz, F. Blonnigen, F. T. Avignone III, Phys. Rev. C**35**, 2330 (1987). https://doi.org/10.1103/PhysRevC.35.2330

[34] **1992BoZO** V. A. Bolshakov, A. G. Dernyatin, K. A. Mezilev, Yu. N. Novikov, A. V. Popov, Yu. Ya. Sergeev, V. I. Tikhonov, V. A. Sergienko, G. V. Veselov, Contrib. 6th Intern. Conf. on Nuclei Far from Stability + 9th Intern. Conf. on Atomic Masses and Fundamental Constants, Bernkastel-Kues, Germany, PE50 (1992).

[35] **1992HeZV** W. Heller, R. Binder, H. Bruchertseifer, U. Becker, F. Haberberger, G. Herrmann, J. V. Kratz, M. Mendel, A.

Nahler, M. Pense-Maskow, N. Trautmann, N. Wiehl, W. Bruchle, E. Jager, M. Schadel, B. Schausten, J. Alstad, G. Skarnemark, R. Dressler, S. Fischer, A. Ross, B. Eichler, S. Hubener, Univ. Mainz, 1991 Ann. Rept., p. 28 (1992).

[36] **1992Sc16** W. -D. Schmidt-Ott, H. Salewski, F. Meissner, U. Bosch-Wicke, P. Koschel, V. Kunze, R. Michaelsen, Nucl. Phys. A**545**, 646 (1992). https://doi.org/10.1016/0375-9474(92)90297-W

[37] **1996Pa01** R. D. Page, P. J. Wood, R. A. Cunningham, T. Davinson, N. J. Davis, A. N. James, K. Livingston, P. J. Sellin, A. C. Shotter, Phys. Rev. C**53**, 660 (1996). https://doi.org/10.1103/PhysRevC.53.660

[38] **1998DaZR** C. N. Davids, L. T. Brown, L. F. Conticchio, D. Seweryniak, J. C. Batchelder, K. S. Toth, C. R. Bingham, R. J. Irvine, W. B. Walters, J. Wauters, E. F. Zganjar, J. L. Wood, C. De Coster, B. Decroix, K. Heyde, ANL-98/24 (Physics Division Ann. Rept. , 1997), p. 15 (1998).

[39] **1999Ba45** J. C. Batchelder, K. S. Toth, C. R. Bingham, L. T. Brown, L. F. Conticchio, C. N. Davids, R. J. Irvine, D. Seweryniak, W. B. Walters, J. Wauters, E. F. Zganjar, J. L. Wood, C. De Coster, B. Decroix, K. Heyde, Eur. Phys. J. A **5**, 49 (1999). https://doi.org/10.1007/s100500050255

[40] **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

[41] **2004GoZZ** J. T. M. Goon, Thesis, University of Tennessee, Knoxville (2004).

[42] **2004Ra28** P. M. Raddon, D. G. Jenkins, C. D. O'Leary, A. J. Simons, R. Wadsworth, A. N. Andreyev, R. D. Page, M. P. Carpenter, F. G. Kondev, T. Enqvist, P. T. Greenlees, P. M. Jones, R. Julin, S. Juutinen, H. Kettunen, M. Leino, A. -P. Leppanen, P. Nieminen, J. Pakarinen, P. Rahkila, J. Uusitalo, D. T. Joss, Phys. Rev. C **70**, 064308 (2004). https://doi.org/10.1103/PhysRevC.70.064308

[43] **2005Ke10** H. Kettunen, T. Enqvist, K. Eskola, T. Grahn, P. T. Greenlees, K. Helariutta, P. Jones, R. Julin, S. Juutinen, H. Kankaanpaa, A. Keenan, H. Koivisto, P. Kuusiniemi, M. Leino, A. -P. Leppanen, M. Muikku, P. Nieminen, J. Pakarinen, P. Rahkila, J. Uusitalo, Eur. Phys. J. A **25**, Supplement **1**, 181 (2005). https://doi.org/10.1140/epjad/i2005-06-114-1

[44] **2005Su03** Y. Suzuki, H. Matsumura, Prog. Theor. Phys. (Kyoto) **113**, 87 (2005). https://doi.org/10.1143/PTP. 113. 87

[45] **2006An11** A. N. Andreyev, S. Antalic, D. Ackermann, S. Franchoo, F. P. Hessberger, S. Hofmann, M. Huyse, I. Kojouharov, B. Kindler, P. Kuusiniemi, S. R. Lesher, B. Lommel, R. Mann, G. Munzenberg, K. Nishio, R. D. Page, J. J. Ressler, B. Streicher, S. Saro, B. Sulignano, P. Van Duppen, D. Wiseman, R. Wyss, Phys. Rev. C **73**, 044324 (2006). https://doi.org/10.1103/PhysRevC.73.044324

[46] **2011Ve01** M. Venhart, A. N. Andreyev, J. L. Wood, S. Antalic, L. Bianco, P. T. Greenlees, U. Jakobsson, P. Jones, R. Julin, S. Juutinen, S. Ketelhut, M. Leino, M. Nyman, R. D. Page, P. Peura, P. Rahkila, J. Saren, C. Scholey, J. Sorri, J. Thomson, J. Uusitalo, Phys. Lett. B **695**, 82 (2011). https://doi.org/10.1016/j. physletb. 2010.10.055

[47] **2021Ha32** R. D. Harding, A. N. Andreyev, A. E. Barzakh, J. G. Cubiss, P. Van Duppen, M. Al Monthery, N. A. Althubiti, B. Andel, S. Antalic, T. E. Cocolios, T. Day Goodacre, K. Dockx, G. J. Farooq-Smith, D. V. Fedorov, V. N. Fedosseev, D. A. Fink, L. P. Gaffney, L. Ghys, J. D. Johnson, D. T. Joss, M. Huyse, N. Imai, K. M. Lynch, B. A. Marsh, Y. Martinez Palenzuela, P. L. Molkanov, G. G. O'Neill, R. D. Page, R. E. Rossel, S. Rothe, M. D. Seliverstov, S. Sels, C. Van Beveren, E. Verstraelen, Phys. Rev. C **104**, 024326 (2021). https://doi.org/10.1103/PhysRevC.104.024326

[48] **2021Ha32** R. D. Harding, A. N. Andreyev, A. E. Barzakh, J. G. Cubiss, P. Van Duppen, M. Al Monthery, N. A. Althubiti, B. Andel, S. Antalic, T. E. Cocolios, T. Day Goodacre, K. Dockx, G. J. Farooq-Smith, D. V. Fedorov, V. N. Fedosseev, D. A. Fink, L. P. Gaffney, L. Ghys, J. D. Johnson, D. T. Joss, M. Huyse, N. Imai, K. M. Lynch, B. A. Marsh, Y. Martinez Palenzuela, P. L. Molkanov, G. G. O'Neill, R. D. Page, R. E. Rossel, S. Rothe, M. D. Seliverstov, S. Sels, C. Van Beveren, E. Verstraelen, Phys. Rev. C **104**, 024326 (2021). https://doi.org/10.1103/PhysRevC.104.024326

[49] **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

[50] **2022Ve01** M. Venhart, A. N. Andreyev, J. G. Cubiss, J. L. Wood, A. E. Barzakh, C. Van Beveren, T. E. Cocolios, R. P. de Groote, D. V. Fedorov, V. N. Fedosseev, R. Ferrer, D. A. Fink, L. Ghys, M. Huyse, U. Koster, J. Lane, V. Liberati, K. M. Lynch, B. A. Marsh, P. L. Molkanov, T. J. Procter, E. Rapisarda, K. Sandhu, M. D. Seliverstov, A. M. Sjodin, P. Van Duppen, M. Veselsky, Phys. Rev. C **105**, 034338 (2022). https://doi.org/10.1103/PhysRevC. 105. 034338