## Adopted Levels, Gammas

History

| Type | Author | Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | Balraj Singh, M. S. Basunia, Murray Martin et al. , | NDS 160, 405 (2019) | 30-Oct-2019 |

Q($\beta^-$)=−1842 *5*; S(n)=6512 *4*; S(p)=6466 *5*; Q($\alpha$)=7262.5 *19* 2017Wa10
S(2n)=11178 *6*, S(2p)=11143.0 *27* (2017Wa10).
Additional information 1.
Isotopic assignment: 1948St42.
2019An10: measured mass excess=5089 keV *54* as compared to 5217.2 keV *23* in 2017Wa10. Note that negative sign in 2019An10 is a misprint.
Theory references: consult NSR database (www.nndc.bnl.gov/nsr/) for 42 primary references for calculations of half-lives of radioactive decay modes, and 20 for nuclear structure.

### $^{218}$Rn Levels

Cross Reference (XREF) Flags

A $^{222}$Ra $\alpha$ decay (33.6 s)
B $^{232}$Th($^{136}$Xe,X$\gamma$)

| E(level)[†] | J$^\pi$[‡] | T$_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 0.0[#] | 0$^+$ | 33.75 ms *15* | AB | %$\alpha$=100<br>Evaluated rms charge radius=5.6540 fm *187* (2013An02).<br>Evaluated charge radius relative to $^{212}$Rn: $\delta\langle r^2\rangle(^{218}Rn,^{212}Rn)$=+0.7000 fm$^2$ *3* (2013An02).<br>T$_{1/2}$: From 2012Su11, delayed $\alpha\alpha$-coin method. Others: 39 ms *2* (1971Er02), 35 ms *1* (1963Di05), 30 ms *3* (1961Ru06), 19 ms (1948St42). |
| 324.320[#] *18* | 2$^+$ | <80 ps | AB | J$^\pi$: E2 324$\gamma$ to 0$^+$.<br>T$_{1/2}$: from ($\alpha$)(324$\gamma$)(t) in $^{222}$Ra $\alpha$ decay (1960Be25). |
| 653.18[#] *18* | (4$^+$) | | AB | J$^\pi$: 329$\gamma$ to 2$^+$, rotational band assignment in ($^{136}$Xe,X$\gamma$). |
| 796.911 *21* | (3$^-$) | | A | J$^\pi$: (E1) 473$\gamma$ to 2$^+$; $\gamma$ to (4$^+$). |
| 840.172[@] *18* | (3$^-$) | | AB | |
| 1014.3[#] *3* | (6$^+$) | | B | |
| 1026.1[@] *4* | (5$^-$) | | B | |
| 1327.9[@] *4* | (7$^-$) | | B | |
| 1392.9[#] *4* | (8$^+$) | | B | |
| 1694.3[@] *5* | (9$^-$) | | B | |
| 1775.2[#] *4* | (10$^+$) | | B | |
| 2070.9[@] *7* | (11$^-$) | | B | |
| 2168.9[#] *7* | (12$^+$) | | B | |
| 2457.9[@] *9* | (13$^-$) | | B | |
| 2576.6[#] *8* | (14$^+$) | | B | |
| 2853.0?[@] *10* | (15$^-$) | | B | |
| 3002.0[#] *10* | (16$^+$) | | B | |
| 3265.2?[@] *11* | (17$^-$) | | B | |
| 3437.5[#] *11* | (18$^+$) | | B | |
| 3683.2?[@] *13* | (19$^-$) | | B | |
| 3859.4[#] *12* | (20$^+$) | | B | |
| 4287.0[#] *13* | (22$^+$) | | B | |

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## Adopted Levels, Gammas (continued)

### $^{218}$Rn Levels (continued)

| E(level)[†] | Jπ[‡] | XREF |
|---|---|---|
| 4725.0[#] *14* | (24+) | B |
| 5167.8?[#] *15* | (26+) | B |

[†] From a least-squares fit to Eγ, by evaluators.
[‡] From probable band assignments (g.s. band and an octupole band) for levels above the first 2+ state.
[#] Band(A): g.s. band.
[@] Band(B): Octupole band. For 7− member, $D_0/Q_0$=0.000097 fm$^{-1}$ *8*, from the γ-ray branching ratio and rotational model, where $D_0$ and $Q_0$ are intrinsic electric dipole moment and quadrupole moment, respectively.

### γ($^{218}$Rn)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[†] | $E_f$ | $J_f^\pi$ | Mult. | α[@] | Comments |
|---|---|---|---|---|---|---|---|---|
| 324.320 | 2+ | 324.31[‡] *2* | 100 | 0.0 | 0+ | E2 | 0.1097 | B(E2)(W.u.)>23<br>Mult.: from ce data in $^{222}$Ra α decay. |
| 653.18 | (4+) | 328.9[‡] *2* | 100 | 324.320 | 2+ | [E2] | 0.1053 | |
| 796.911 | (3−) | 144.4[#] *5* | 2.8[#] *5* | 653.18 | (4+) | [E1] | 0.190 *4* | |
| | | 472.59[#] *1* | 100[#] *3* | 324.320 | 2+ | (E1) | | Mult.: from ce data in $^{222}$Ra α decay. |
| 840.172 | (3−) | 515.83[#] *3* | 51[#] *3* | 324.320 | 2+ | | | |
| | | 840.18[#] *2* | 100[#] *4* | 0.0 | 0+ | [E3] | | |
| 1014.3 | (6+) | 361.1 *2* | 100 | 653.18 | (4+) | | | |
| 1026.1 | (5−) | 186.3[&] *5* | | 840.172 | (3−) | | | |
| | | 372.7 *5* | | 653.18 | (4+) | | | |
| 1327.9 | (7−) | 302.0 *5* | 100 *15* | 1026.1 | (5−) | | | |
| | | 313.4 *5* | 52 *12* | 1014.3 | (6+) | | | |
| 1392.9 | (8+) | 378.6 *2* | 100 | 1014.3 | (6+) | | | |
| 1694.3 | (9−) | 301.4[&] *5* | | 1392.9 | (8+) | | | |
| | | 366.4 *5* | | 1327.9 | (7−) | | | |
| 1775.2 | (10+) | 382.3 *2* | 100 | 1392.9 | (8+) | | | |
| 2070.9 | (11−) | 376.6 *5* | 100 | 1694.3 | (9−) | | | |
| 2168.9 | (12+) | 393.7 *5* | 100 | 1775.2 | (10+) | | | |
| 2457.9 | (13−) | 387.0 *5* | 100 | 2070.9 | (11−) | | | |
| 2576.6 | (14+) | 407.7 *5* | 100 | 2168.9 | (12+) | | | |
| 2853.0? | (15−) | 395.1[&] *5* | | 2457.9 | (13−) | | | |
| 3002.0 | (16+) | 425.4 *5* | 100 | 2576.6 | (14+) | | | |
| 3265.2? | (17−) | 412.2[&] *5* | | 2853.0? | (15−) | | | |
| 3437.5 | (18+) | 435.5 *5* | 100 | 3002.0 | (16+) | | | |
| 3683.2? | (19−) | 418.0[&] *5* | | 3265.2? | (17−) | | | |
| 3859.4 | (20+) | 421.9 *5* | 100 | 3437.5 | (18+) | | | |
| 4287.0 | (22+) | 427.6 *5* | 100 | 3859.4 | (20+) | | | |
| 4725.0 | (24+) | 438.0 *5* | 100 | 4287.0 | (22+) | | | |
| 5167.8? | (26+) | 442.8[&] *5* | | 4725.0 | (24+) | | | |

[†] From $^{232}$Th($^{136}$Xe,Xγ), except where noted.
[‡] From $^{222}$Rn α decay.
[#] From $^{222}$Rn α decay only.
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation

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## Adopted Levels, Gammas (continued)

### $\gamma(^{218}Rn)$ (continued)

based on $\gamma$-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
& Placement of transition in the level scheme is uncertain.

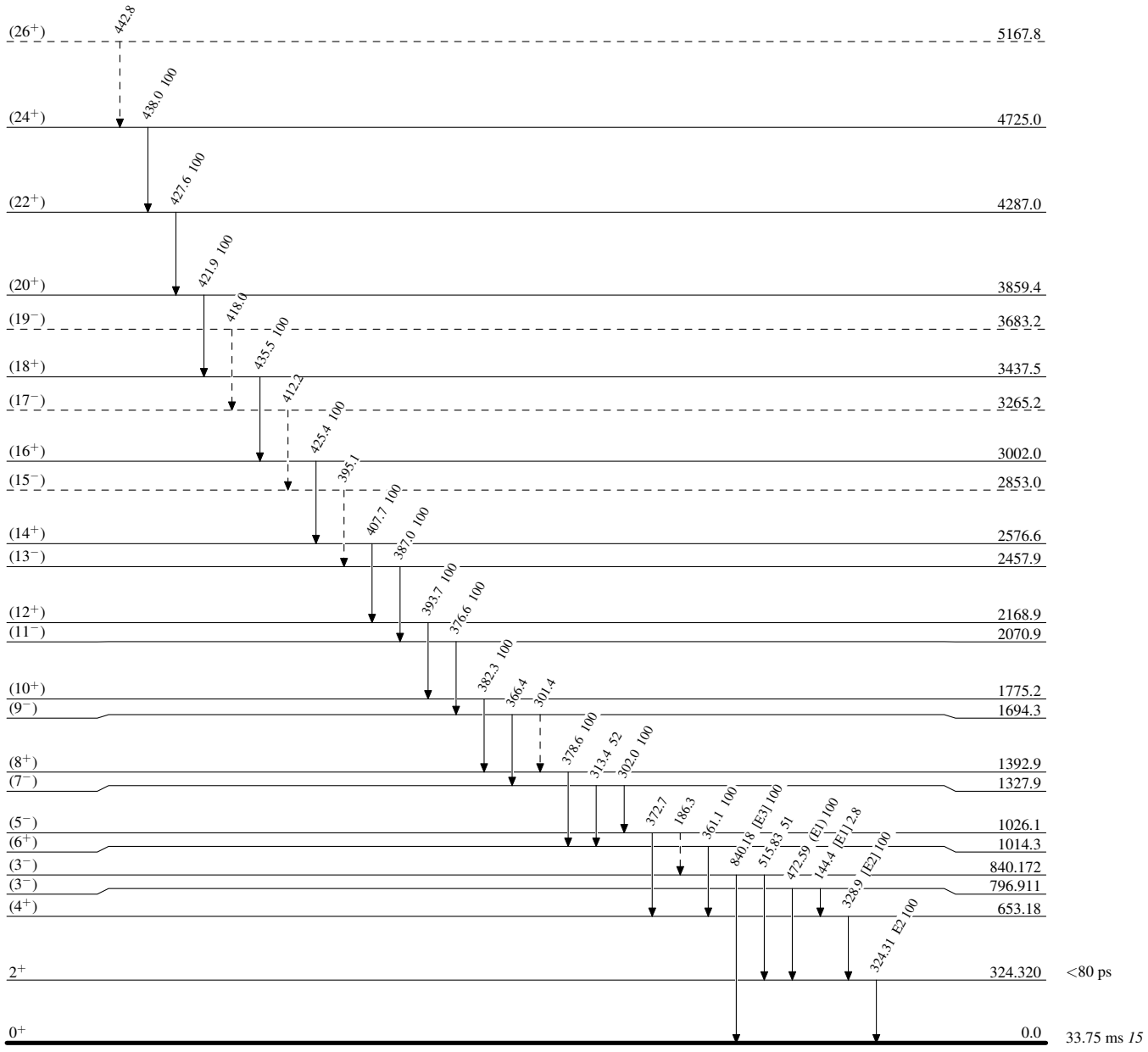
## Adopted Levels, Gammas

Legend

### Level Scheme

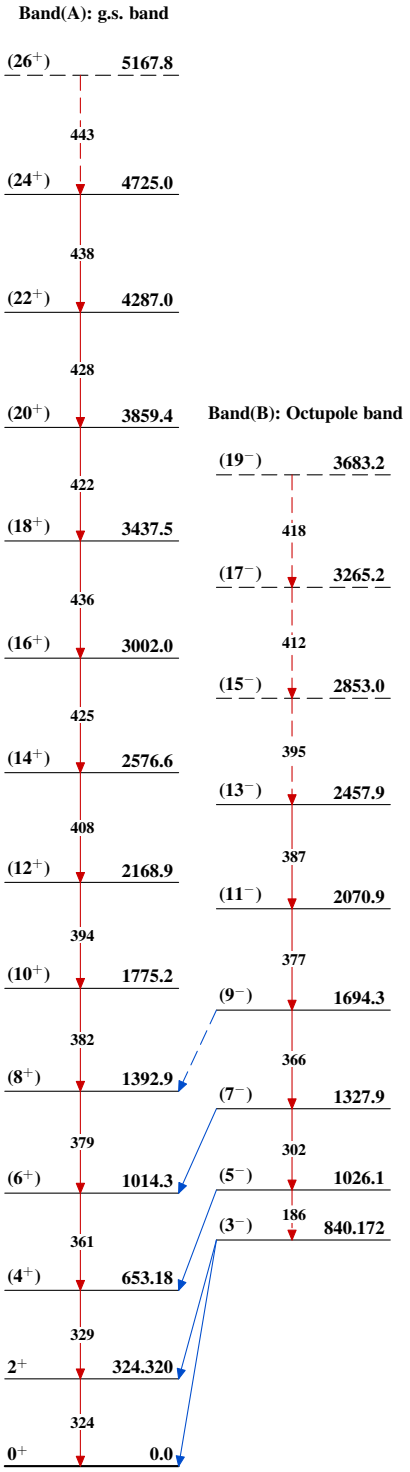
Intensities: Relative photon branching from each level

$\gamma$ Decay (Uncertain)




$^{218}_{86}Rn_{132}$

## Adopted Levels, Gammas




$^{218}_{86}Rn_{132}$

## Adopted Levels, Gammas

| History | | | |
|---|---|---|---|
| Type | Author | Citation | Literature Cutoff Date |
| Full Evaluation | E. Browne, J. K. Tuli | NDS 112,1115 (2011) | 31-Oct-2010 |

Q($\beta^-$)=−870 *4*; S(n)=6288.6 *23*; S(p)=7073 *4*; Q($\alpha$)=6404.66 *10* 2012Wa38
Note: Current evaluation has used the following Q record −869 4 *6288.6 23* 7073 4 *6404.6710* 2009AuZZ,2003Au03.
Additional information 1.
Historic Note: This isotope was originally called Thoron with symbol Tn.

Mass measurements: Penning-trap mass spectrometer (2009Ne03); Schottky mass spectrometry (2005LiZZ).
$\gamma$-ray linear polarization following $\alpha$ decay (2005JoZY).
Calculations, compilations, systematics:
$^{14}$C decay rate: 1986De32.
Cluster model for $\alpha$ decay, Geiger-Nuttall plot: 1991Bu05.
$\alpha$ decay: 2006StZX, 2003Da24, 1997Al22, 1996Wi27, 1992De44.
Effect of octupole and $2^6$ pole deformation on binding energies: 1986Ch23.
Equilibrium deformation energy: 1988So08, 1984Na22.
$K^\pi=0^+$ and $K^\pi=0^-$ bands: 1980Sh07.
Levels, $\beta(\lambda)$ ratios: 1995De13.
n-p interaction energy: 1990Mo11.
Quasibands in even-even nuclei: 1984Sa37.
Single-particle levels: 1984So09.
Spontaneous emission of heavy ions: 1986Po06.
Super- and hyper-deformed configurations: 1995We02.

### $^{220}$Rn Levels

Cross Reference (XREF) Flags

- A $^{220}$At $\beta^-$ decay
- B $^{232}$Th($^{136}$Xe,X$\gamma$)
- C $^{224}$Ra $\alpha$ decay

| E(level)† | J$^\pi$ | T$_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 0‡ | 0$^+$ | 55.6 s *1* | ABC | %$\alpha$=100<br>T$_{1/2}$: from 1966Hu20 (value is rounded off from 55.61 s *4*). Others: 55.3 s *3* (1963Gi07), 56.3 s *2* (1961Ro14), 51.5 s *10* (1955Sc81), 61 s $^{+10}_{-8}$ (2003Da24). |
| 240.986‡ *6* | 2$^+$ | 0.146 ns *5* | ABC | J$^\pi$: E2 $\gamma$ ray to 0$^+$.<br>T$_{1/2}$: from $\alpha\gamma$(t) (1960Be25) (weighted average of 0.150 ns *10* and 0.145 ns *5*). |
| 533.68‡ *10* | 4$^+$ | | ABC | J$^\pi$: $\alpha\gamma(\theta)$ from 0$^+$ parent ($^{224}$Ra $\alpha$ decay). |
| 645.44# *9* | 1$^-$ | | ABC | J$^\pi$: $\alpha\gamma(\theta)$ from 0$^+$ parent ($^{224}$Ra $\alpha$ decay). |
| 663.03# *10* | (3$^-$) | | ABC | J$^\pi$: probable member of $K^\pi=0^-$ band. For energy and $\alpha$ hindrance factor systematics see 1981Pe09. |
| 851.9# *4* | (5$^-$) | | B | |
| 873.88‡ *22* | (6$^+$) | | B | |
| 1128.2# *4* | (7$^-$) | | B | |
| 1244.3‡ *3* | (8$^+$) | | B | |
| 1462.1# *5* | (9$^-$) | | B | |
| 1631.1‡ *4* | (10$^+$) | | B | |
| 1834.0# *7* | (11$^-$) | | B | |

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## Adopted Levels, Gammas (continued)

### $^{220}$Rn Levels (continued)

| E(level)† | Jπ | XREF | E(level)† | Jπ | XREF | E(level)† | Jπ | XREF |
|---|---|---|---|---|---|---|---|---|
| 2033.9‡ *7* | (12+) | B | 2887.0‡ *10* | (16+) | B | 3763.9‡ *12* | (20+) | B |
| 2227.1# *9* | (13−) | B | 3068.6# *11* | (17−) | B | 3961.5?# *13* | (21−) | B |
| 2452.7‡ *8* | (14+) | B | 3325.3‡ *11* | (18+) | B | | | |
| 2638.3# *10* | (15−) | B | 3509.8# *12* | (19−) | B | | | |

† Deduced by evaluators from least-squares fit to adopted γ-ray energies.
‡ Band(A): g.s. $K^\pi=0^+$ rotational band.
# Band(B): $K^\pi=0^-$ γ vibrational band.

### γ($^{220}$Rn)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$† | $I_\gamma$† | $E_f$ | $J_f^\pi$ | Mult.† | α# | Comments |
|---|---|---|---|---|---|---|---|---|
| 240.986 | 2+ | 240.986‡ *6* | 100‡ | 0 | 0+ | E2 | 0.276 | B(E2)(W.u.)=47.6 *17* |
| 533.68 | 4+ | 292.70‡ *10* | 100‡ | 240.986 | 2+ | (E2) | 0.1487 | |
| 645.44 | 1− | 404.2‡ *2* | 41‡ *10* | 240.986 | 2+ | | | |
| | | 645.50‡ *10* | 100‡ *17* | 0 | 0+ | | | |
| 663.03 | (3−) | 422.04‡ *10* | 100‡ | 240.986 | 2+ | | | |
| 851.9 | (5−) | 188.8 *5* | 25 *8* | 663.03 | (3−) | E2 | 0.644 *11* | ce(K)/(γ+ce)=0.1125 *17*; ce(L)/(γ+ce)=0.206 *4*; ce(M)/(γ+ce)=0.0552 *11*; ce(N+)/(γ+ce)=0.0176 *4* ce(N)/(γ+ce)=0.0144 *3*; ce(O)/(γ+ce)=0.00292 *6*; ce(P)/(γ+ce)=0.000335 *7* |
| | | 318.3 *5* | 100 *15* | 533.68 | 4+ | E1 | 0.0291 | ce(K)/(γ+ce)=0.0229 *4*; ce(L)/(γ+ce)=0.00405 *6*; ce(M)/(γ+ce)=0.000958 *14*; ce(N+)/(γ+ce)=0.000308 *5* ce(N)/(γ+ce)=0.000248 *4*; ce(O)/(γ+ce)=$5.31\times10^{-5}$ *8*; ce(P)/(γ+ce)=$7.34\times10^{-6}$ *11* |
| 873.88 | (6+) | 340.2 *2* | 100 | 533.68 | 4+ | E2 | 0.0956 | ce(K)/(γ+ce)=0.0480 *7*; ce(L)/(γ+ce)=0.0292 *4*; ce(M)/(γ+ce)=0.00762 *11*; ce(N+)/(γ+ce)=0.00245 *4* ce(N)/(γ+ce)=0.00199 *3*; ce(O)/(γ+ce)=0.000410 *6*; ce(P)/(γ+ce)=$5.00\times10^{-5}$ *8* |
| 1128.2 | (7−) | 254.3 *5* | 41 *10* | 873.88 | (6+) | E1 | 0.0487 | ce(K)/(γ+ce)=0.0375 *6*; ce(L)/(γ+ce)=0.00680 *10*; ce(M)/(γ+ce)=0.001613 *24*; ce(N+)/(γ+ce)=0.000518 *8* ce(N)/(γ+ce)=0.000417 *7*; ce(O)/(γ+ce)=$8.89\times10^{-5}$ *14*; ce(P)/(γ+ce)=$1.215\times10^{-5}$ *18* |
| | | 276.2 *5* | 100 *2* | 851.9 | (5−) | E2 | 0.178 *3* | ce(K)/(γ+ce)=0.0700 *10*; ce(L)/(γ+ce)=0.0600 *9*; ce(M)/(γ+ce)=0.01583 *25*; ce(N+)/(γ+ce)=0.00507 *8* ce(N)/(γ+ce)=0.00412 *7*; ce(O)/(γ+ce)=0.000847 *14*; ce(P)/(γ+ce)=0.0001006 *16* |
| 1244.3 | (8+) | 370.4 *2* | 100 | 873.88 | (6+) | E2 | 0.0755 | ce(K)/(γ+ce)=0.0408 *6*; ce(L)/(γ+ce)=0.0219 |

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**Adopted Levels, Gammas (continued)**

$\gamma(^{220}Rn)$ (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[†] | $E_f$ | $J_f^\pi$ | Mult.[†] | $\alpha$[#] | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | *3*; ce(M)/(γ+ce)=0.00568 *8*; ce(N+)/(γ+ce)=0.00183 *3* ce(N)/(γ+ce)=0.001480 *21*; ce(O)/(γ+ce)=0.000307 *5*; ce(P)/(γ+ce)=3.78×10$^{-5}$ *6* |
| 1462.1 | (9$^-$) | 217.9 *5* | 14 *4* | 1244.3 | (8$^+$) | E1 | 0.0701 | ce(K)/(γ+ce)=0.0527 *8*; ce(L)/(γ+ce)=0.00977 *15*; ce(M)/(γ+ce)=0.00232 *4*; ce(N+)/(γ+ce)=0.000743 *12* ce(N)/(γ+ce)=0.000598 *9*; ce(O)/(γ+ce)=0.0001273 *20*; ce(P)/(γ+ce)=1.72×10$^{-5}$ *3* |
| | | 333.9 *5* | 100 *15* | 1128.2 | (7$^-$) | E2 | 0.1008 | ce(K)/(γ+ce)=0.0497 *7*; ce(L)/(γ+ce)=0.0312 *5*; ce(M)/(γ+ce)=0.00814 *13*; ce(N+)/(γ+ce)=0.00261 *4* ce(N)/(γ+ce)=0.00212 *4*; ce(O)/(γ+ce)=0.000438 *7*; ce(P)/(γ+ce)=5.32×10$^{-5}$ *8* |
| 1631.1 | (10$^+$) | 386.8 *2* | 100 | 1244.3 | (8$^+$) | E2 | 0.0671 | ce(K)/(γ+ce)=0.0375 *5*; ce(L)/(γ+ce)=0.0190 *3*; ce(M)/(γ+ce)=0.00490 *7*; ce(N+)/(γ+ce)=0.001575 *23* ce(N)/(γ+ce)=0.001277 *18*; ce(O)/(γ+ce)=0.000265 *4*; ce(P)/(γ+ce)=3.29×10$^{-5}$ *5* |
| 1834.0 | (11$^-$) | 371.9 *5* | 100 | 1462.1 | (9$^-$) | E2 | 0.0746 | ce(K)/(γ+ce)=0.0404 *6*; ce(L)/(γ+ce)=0.0216 *4*; ce(M)/(γ+ce)=0.00561 *9*; ce(N+)/(γ+ce)=0.00180 *3* ce(N)/(γ+ce)=0.001460 *22*; ce(O)/(γ+ce)=0.000303 *5*; ce(P)/(γ+ce)=3.73×10$^{-5}$ *6* |
| 2033.9 | (12$^+$) | 402.8 *5* | 100 | 1631.1 | (10$^+$) | E2 | 0.0603 | ce(K)/(γ+ce)=0.0347 *5*; ce(L)/(γ+ce)=0.01657 *24*; ce(M)/(γ+ce)=0.00428 *7*; ce(N+)/(γ+ce)=0.001374 *21* ce(N)/(γ+ce)=0.001114 *17*; ce(O)/(γ+ce)=0.000232 *4*; ce(P)/(γ+ce)=2.89×10$^{-5}$ *5* |
| 2227.1 | (13$^-$) | 393.1 *5* | 100 | 1834.0 | (11$^-$) | E2 | 0.0643 | ce(K)/(γ+ce)=0.0363 *5*; ce(L)/(γ+ce)=0.0180 *3*; ce(M)/(γ+ce)=0.00464 *7*; ce(N+)/(γ+ce)=0.001492 *22* ce(N)/(γ+ce)=0.001209 *18*; ce(O)/(γ+ce)=0.000251 *4*; ce(P)/(γ+ce)=3.12×10$^{-5}$ *5* |
| 2452.7 | (14$^+$) | 418.8 *5* | 100 | 2033.9 | (12$^+$) | E2 | 0.0545 | ce(K)/(γ+ce)=0.0321 *5*; ce(L)/(γ+ce)=0.01459 *21*; ce(M)/(γ+ce)=0.00376 *6*; ce(N+)/(γ+ce)=0.001207 *18* ce(N)/(γ+ce)=0.000978 *15*; ce(O)/(γ+ce)=0.000204 *3*; ce(P)/(γ+ce)=2.55×10$^{-5}$ *4* |
| 2638.3 | (15$^-$) | 411.2 *5* | 100 | 2227.1 | (13$^-$) | E2 | 0.0572 | ce(K)/(γ+ce)=0.0333 *5*; ce(L)/(γ+ce)=0.01549 *23*; ce(M)/(γ+ce)=0.00399 *6*; ce(N+)/(γ+ce)=0.001283 *19* ce(N)/(γ+ce)=0.001039 *16*; ce(O)/(γ+ce)=0.000216 *4*; ce(P)/(γ+ce)=2.71×10$^{-5}$ *4* |
| 2887.0 | (16$^+$) | 434.3 *5* | 100 | 2452.7 | (14$^+$) | E2 | 0.0497 | ce(K)/(γ+ce)=0.0300 *5*; ce(L)/(γ+ce)=0.01298 *19*; ce(M)/(γ+ce)=0.00333 *5*; ce(N+)/(γ+ce)=0.001071 *16* ce(N)/(γ+ce)=0.000867 *13*; ce(O)/(γ+ce)=0.000181 *3*; ce(P)/(γ+ce)=2.28×10$^{-5}$ *4* |
| 3068.6 | (17$^-$) | 430.3 *5* | 100 | 2638.3 | (15$^-$) | E2 | 0.0509 | ce(K)/(γ+ce)=0.0305 *5*; ce(L)/(γ+ce)=0.01337 *20*; ce(M)/(γ+ce)=0.00343 *5*; ce(N+)/(γ+ce)=0.001104 *16* ce(N)/(γ+ce)=0.000894 *13*; ce(O)/(γ+ce)=0.000186 *3*; ce(P)/(γ+ce)=2.35×10$^{-5}$ *4* |
| 3325.3 | (18$^+$) | 438.3 *5* | | 2887.0 | (16$^+$) | | | |

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## Adopted Levels, Gammas (continued)

### $\gamma(^{220}Rn)$ (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[†] | $E_f$ | $J_f^\pi$ | Mult.[†] | $\alpha$[#] | Comments |
|---|---|---|---|---|---|---|---|---|
| 3509.8 | $(19^-)$ | 441.2 *5* | 100 | 3068.6 | $(17^-)$ | E2 | 0.0478 | ce(K)/($\gamma$+ce)=0.0291 *4*; ce(L)/($\gamma$+ce)=0.01234 *18*; ce(M)/($\gamma$+ce)=0.00316 *5*; ce(N+)/($\gamma$+ce)=0.001018 *15* ce(N)/($\gamma$+ce)=0.000824 *12*; ce(O)/($\gamma$+ce)=0.0001720 *25*; ce(P)/($\gamma$+ce)=2.17×10$^{-5}$ *4* |
| 3763.9 | $(20^+)$ | 438.6 *5* | | 3325.3 | $(18^+)$ | | | |
| 3961.5? | $(21^-)$ | 451.7 *5* | | 3509.8 | $(19^-)$ | | | |

† From $^{232}$Th($^{136}$Xe,X$\gamma$), unless otherwise specified.

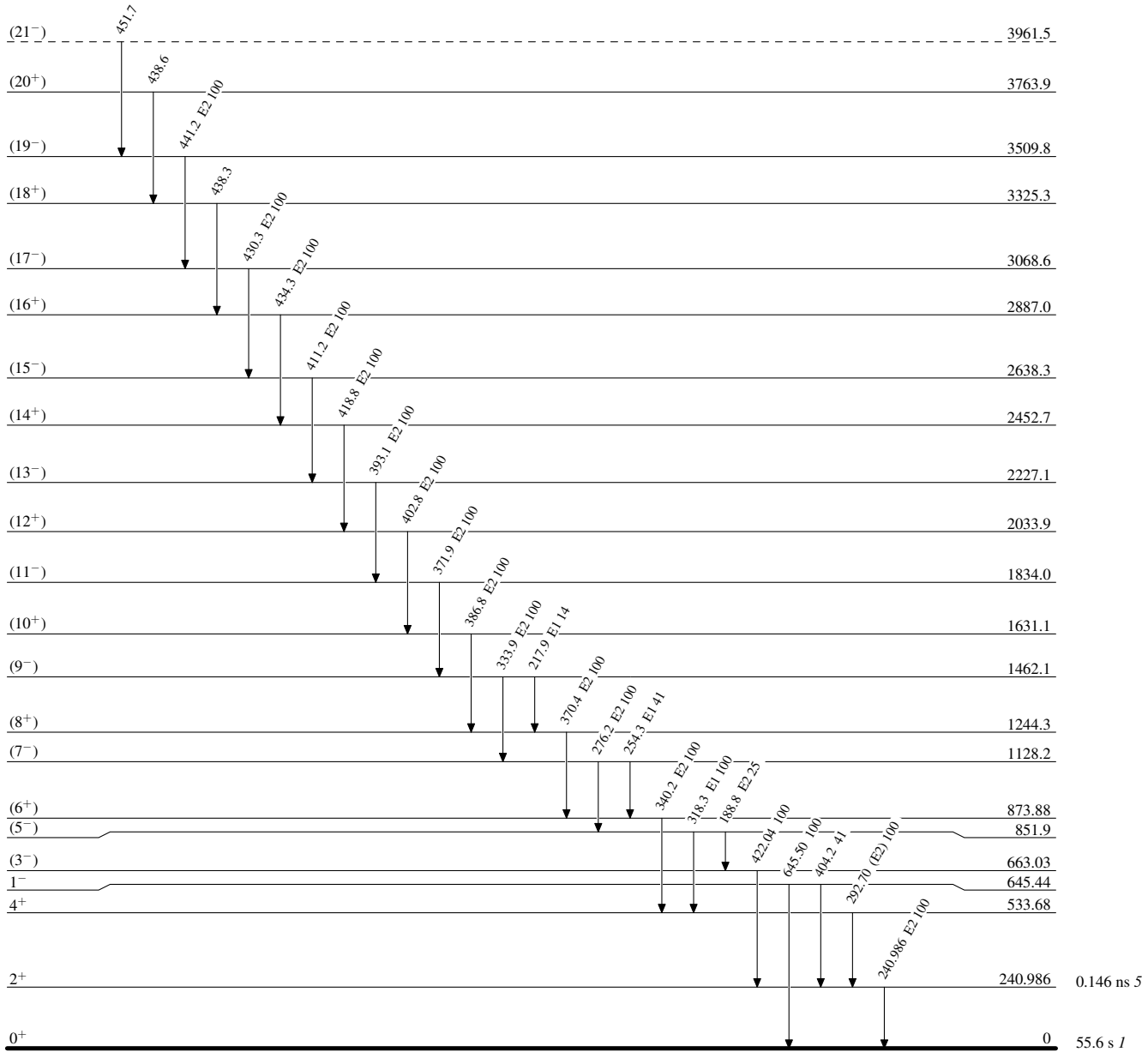
‡ From $^{224}$Ra $\alpha$ decay.

# Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on $\gamma$-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

## Adopted Levels, Gammas

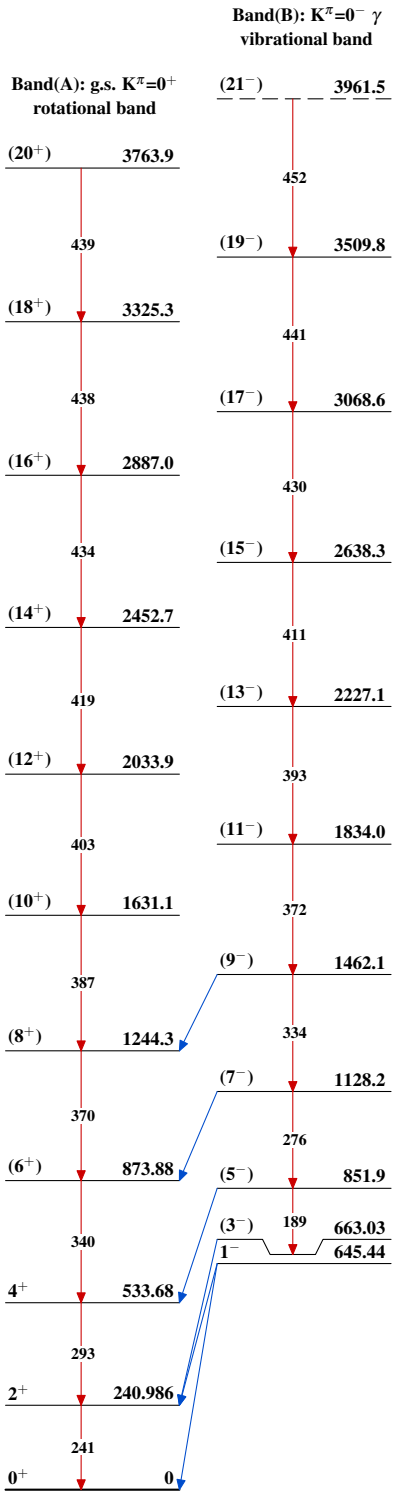
### Level Scheme

Intensities: Relative photon branching from each level




$^{220}_{86}Rn_{134}$

## Adopted Levels, Gammas




$^{220}_{86}Rn_{134}$

## Adopted Levels, Gammas

| History | | | |
|---|---|---|---|
| Type | Author | Citation | Literature Cutoff Date |
| Full Evaluation | Balraj Singh, M. S. Basunia, Jun Chen et al. , | NDS 192,315 (2023) | 25-Sep-2023 |

Q($\beta^-$)=−6 *8*; S(n)=6171 *6*; S(p)=7700 *14*; Q($\alpha$)=5590.4 *3* 2021Wa16
S(2n)=10382.7 *19*, S(2p)=13469 *18* (2021Wa16).

Dataset by Balraj Singh, S. Basunia, and IAEA-ICTP workshop participants: B.M.S. Amro, S. Basu, S. Das, A. Karmakar, and S.S. Nayak.

$^{222}$Rn is a naturally occuring radioactive isotope, emitted from the $\alpha$ decay of $^{226}$Ra, a long-lived activity produced in the decay chain of $^{238}$U, first identified by 1899Cu01, just three years after the discovery of radioactivity, followed by the first measurement of half-life of $^{222}$Rn decay by 1902Cu01.

Mass measurement: 2010Li02: Schottky mass spectrometry.

Theoretical nuclear structure calculations:

2021Va08: calculated levels, $J^\pi$, yrast positive- and negative-parity states, B(E1), B(E2), B(E3), B(M1), magnetic dipole and electric quadrupole moments using the *spdf*-IBM-2 interacting boson model.

2020Ca18: calculated deformation parameters $\beta_2$, $\beta_3$, octupole deformation energies, proton quadrupole $Q_{20}$ and octupole $Q_{30}$ moments for octupole-deformed nuclei using Skyrme energy density functional, and covariant energy density functional models.

2019Zh50: calculated empirical proton-neutron interaction, B(E2), B(E3), binding energy, total energy in ($\beta_2$,$\beta_3$) plane, neutron and proton single-particle levels using the covariant density functional theory and the quadrupole-octupole collective Hamiltonian.

2018Yo12: calculated E(first $4^+$)/E(first $2^+$) ratio, energy of the first $3^-$ state using shell model with one-octupole-phonon representing collective octupole vibration across the magic core.

2017Xi15: calculated levels, $J^\pi$, B(E1), B(E2), B(E3), electric dipole moment, deformation energy surface in ($\beta_2$,$\beta_3$) plane, reflection-asymmetric states using microscopic quadrupole-octupole collective Hamiltonian (QOCH), based on based on relativistic energy density functional.

2014De43, 2013De12: calculated energy levels, $J^\pi$, deformation parameters, B(E2), $T_{1/2}$ using coherent state model (CSM).

2013Ro30: calculated level energies of $1^-$ states, B(E1), B(E3) using two-dimensional generator coordinate method (GCM) for quadrupole-octupole coupling with Gogny forces.

2005Za02, 2001Za04: calculated levels, $J^\pi$, transition rates, octupole excitations using interacting boson model.

1998Ra05: calculated high-spin levels, $J^\pi$, $K^\pi=0^-$ band using phenomenological model.

1994Li05: calculated total energy surface vs $\alpha_{20}$, $\alpha_{32}$ deformations, fourfold degenerate levels using the results of realistic total nuclear energy calculations.

1987Ro08: calculated single-particle states, pairing energies, octupole deformation, dipole vs octupole moments, B(E1)/B(E2) using constrained HF plus BCS method.

1983Ro14: calculated potential equilibrium deformation, deformation energies, static quadrupole and hexadecapole moments using density-dependent shell correction method.

1982Le19: calculated potential energy minima, octupole separation energy, and intrinsic reflection symmetry breaking using deformed shell-model.

1981Gy03: calculated potential energy, quadrupole and octupole equilibrium deformations using macroscopic-microscopic method.

1981Pe09: analyzed levels, $J^\pi$, strong Coriolis coupling effects for rotational bands based on one-phonon octupole vibrational states.

1980Sh07: analyzed levels, $J^\pi$, inverse moments of inertia; deduced structural relation of $K^\pi=0^+$ and $K^\pi=0^-$ bands.

Other theoretical calculations: 14 primary references for structure, and 76 primary references for decay characteristics are in the NSR database, and listed in this dataset as 'document' records.

Additional information 1.

## $^{222}$Rn Levels

The $K^\pi=0^+$ g.s. band and the $K^\pi=0^-$ band at 600.66 keV have been interpreted as octupole parity-doublet bands. However, 2022Sp01 and 2020Bu20 in their Coulomb excitation study do not support stable octupole deformation in the ground state of $^{222}$Rn.

### Cross Reference (XREF) Flags

| | |
|---|---|
| A | $^{226}$Ra $\alpha$ decay (1603 y) |
| B | $^{232}$Th($^{136}$Xe,X$\gamma$) |
| C | Coulomb excitation |

| E(level)[†] | Jπ[‡] | $T_{1/2}$[#] | XREF | Comments |
|---|---|---|---|---|
| 0.0[@] | $0^+$ | 3.8222 d *9* | ABC | %α=100<br>With Q(β⁻)=−6 *8* (2021Wa16), no β⁻ decay is expected.<br>Evaluated rms charge radius $<r^2>^{1/2}$=5.692 fm *20* (2013An02).<br>Evaluated δ$<r^2>$($^{222}$Rn−$^{212}$Rn)=+1.1236 fm$^2$ *4* (2013An02).<br>Additional information 2.<br>$T_{1/2}$: weighted average of 3.82146 d *85* (2015Be07, from decay curve for integral γ-ray spectrum from 6 keV onwards, weighted average of four measurements: 3.82157 d *32* for 1301 h, 3.82134 d *30* for 1462 h, 3.82169 d *32* for 1185 h, and 3.82124 d *35* for 1357 h; statistical uncertainty of 0.00016 d and systematic uncertainty of 0.00004 d in 2015Be07 combined in quadrature, and total uncertainty increased to 0.00085, to have a maximum relative weight of 50%); 3.8195 d *30* (2004Sc04, ionization chamber, reanalysis of 2004Sc04 data by 2018Po01 gave 3.825 d *5*); 3.8224 d *18* (1995Co34, 4π αβ liquid scintillation counter, average of six measurements); 3.82351 d *170* (1972Bu33, decay curve for integral γ-ray spectrum measured over 40 half-lives, average of two measurements, quoted uncertainty of 0.00034 increased to 0.00170 as in 1990Ho28 evaluation); 3.83 d *3* (1958Sh69, calorimetry); 3.82290 d *170* (1956Ma64, ionization chamber, average of three measurements, quoted uncertainty of 0.00027 increased to 0.00170 as in 1990Ho28); 3.825 d *5* (1956Ro31, calorimetry, quoted uncertainty of 0.004 increased to 0.005 as in 1990Ho28); 3.825 d *6* (1955To07,1951To25, ionization chamber, average of two measurements, quoted uncertainty of 0.005 increased to 0.006 as in 1990Ho28); 3.823 d *3* (1924Cu01, ionization chamber, average of four measurements, quoted uncertainty of 0.002 increased to 0.003 as in 1990Ho28); 3.825 d *4* (1923Bo01, ionization chamber, average of four measurements). Other: 3.81474 d *14* from 1994Se21 (indirect $T_{1/2}$ deduced in the measurement of efficiency of Lucas scintillation cell by depositing a known quantity of $^{222}$Rn and following the decay and ingrowth of Rn and its daughters for a total of 7014 data points, and fitting these data points using several parameters; $T_{1/2}$ value is quoted very precisely, but disagrees by many standard deviations from the other precise and direct measurements). Other nominal recent value=3.81 d *12* (2018Ap01). Measurements prior to 1923, cited from compilations in 1995Co34 and 1995Co35: 3.811 d (1921Bo01); 3.847 d (1913RuZZ); 3.85 d (1910Cu02); 3.747 d (1907Ru04); 3.863 d (1905Sa01); 3.896 d (1904Bu01); 3.71 d (1903Ru05); 3.987 d (1902Cu01).<br>2005Tr01: measured lower limits for half-lives for double β decay modes of $^{222}$Rn: $T_{1/2}$>2.8 y for 0νββ and >0.11 y for 2νββ. |
| 186.211[@] *13* | $2^+$ | 0.32 ns *2* | ABC | μ=+0.92 *14* (1970Or02,2020StZV)<br>Q=−1.4 *+5−6*<br>μ: measurement of g=0.45 *7* by αγ(θ,H) (1970Or02), integral perturbed angular correlation method.<br>Q: deduced by evaluators from diagonal E2 matrix element ($186,2^+ \rightarrow 186,2^+$)=−1.8 *+6−9* in Coulomb excitation (2022Sp01).<br>Jπ: E2 γ to $0^+$.<br>$T_{1/2}$: αγ(t) (1960Be25). Other measurement: 0.31 ns (1961Fo08). |
| 448.48[@] *6* | $4^+$ | 52.5 ps *+44−23* | ABC | (α)(262γ)(θ) data of 1989Po03 rule out J of 0, 1, 2 and 3; population of natural-parity state in α decay from $0^+$ parent. |
| 600.74[&] *4* | $1^-$ | 0.7 ps *+11−5* | ABC | Jπ: γ to g.s.; the (α)(601γ)(θ) and (α)(415γ)(θ) data rule out 2; population of natural-parity state in α decay from $0^+$ parent. |
| 635.57[&] *9* | $3^-$ | ≈0.4 ns | ABC | (α)(449γ)(θ) data of 1989Po03 rules out 0, 1, 2 and 4; population of natural-parity state in α decay from $0^+$ parent. |
| 768.08[@] *21* | $(6^+)$ | 15.9 ps *+18−11* | BC | Jπ: γ to $4^+$; level is Coulomb excited as g.s. band member. |
| 797.4[&] *5* | $(5^-)$ | | BC | Jπ: gamma to $4^+$; possible γ to $3^-$; band member. |
| 867.0 *7* | $(0^+)$ | | C | Jπ: gammas to $2^+$ and $1^-$; possible bandhead of β band (2022Sp01). |
| 867.1[a] *7* | $(2^+)$ | | C | Jπ: γ to $0^+$; possible bandhead of γ band. |

Continued on next page (footnotes at end of table)

## Adopted Levels, Gammas (continued)

### $^{222}$Rn Levels (continued)

| E(level)[†] | J$^{\pi}$[‡] | T$_{1/2}$[#] | XREF | Comments |
|---|---|---|---|---|
| 959.2[a] *10* | (3$^+$) | | C | J$^{\pi}$: gamma to 2$^+$; possible band member. |
| 1048.7[&] *5* | (7$^-$) | | BC | J$^{\pi}$: gamma to (6$^+$); possible $\gamma$ to (5$^-$); band member. |
| 1111.5[a] *10* | (4$^+$) | | C | J$^{\pi}$: $\gamma$ to 4$^+$; possible band member. |
| 1127.7[@] *3* | (8$^+$) | 7.3 ps *+11−16* | BC | J$^{\pi}$: $\gamma$ to (6$^+$); band member. |
| 1356.5[&] *5* | (9$^-$) | 7 ps *+9−5* | BC | J$^{\pi}$: gammas to (7$^-$) and (8$^+$); band member.<br>T$_{1/2}$: 67 ps *+126−57* deduced from B(E2) value in Coulomb excitation.<br>D$_0$/Q$_0$=0.00191 b$_{1/2}$ *35* (1999Co02).<br>Average D$_0$=0.010 eb$^{1/2}$ *2* (1999Co02) for J=9 and 11 states. |
| 1512.5[@] *4* | (10$^+$) | 7.8 ps *+51−12* | BC | J$^{\pi}$: $\gamma$ to (8$^+$); band member. |
| 1707.8[&] *5* | (11$^-$) | | B | J$^{\pi}$: gammas to (9$^-$) and (10$^+$); band member.<br>D$_0$/Q$_0$=0.00273 b$_{1/2}$ *63* (1999Co02).<br>Average D$_0$=0.010 eb$^{1/2}$ *2* (1999Co02) for J=9 and 11 states. |
| 1912.9?[@] *6* | (12$^+$) | | B | J$^{\pi}$: possible $\gamma$ to (10$^+$); band member. |
| 2088.7[&] *7* | (13$^-$) | | B | J$^{\pi}$: gammas to (11$^-$) and (12$^+$); band member. |
| 2316.7?[@] *8* | (14$^+$) | | B | J$^{\pi}$: possible $\gamma$ to (12$^+$); band member. |
| 2485.0?[&] *9* | (15$^-$) | | B | J$^{\pi}$: possible $\gamma$ to (13$^-$); band member. |
| 2727.2?[@] *10* | (16$^+$) | | B | J$^{\pi}$: possible $\gamma$ to (14$^+$); band member. |
| 2881.6?[&] *10* | (17$^-$) | | B | J$^{\pi}$: possible $\gamma$ to (15$^-$); band member. |
| 3285.6?[&] *12* | (19$^-$) | | B | J$^{\pi}$: possible $\gamma$ to (17$^-$); band member. |
| 3695.8?[&] *13* | (21$^-$) | | B | J$^{\pi}$: possible $\gamma$ to (19$^-$); band member. |

[†] From least-squares fit to E$\gamma$ data.
[‡] From band assignments in $^{232}$Th($^{136}$Xe,X$\gamma$) for levels above 635 keV.
[#] For levels above 186 keV, half-lives deduced by evaluators from E2 matrix elements measured (2022Sp01) in Coulomb excitation.
[@] Band(A): $K^{\pi}=0^+$ g.s. band.
[&] Band(B): $K^{\pi}=0^-$ octupole vibrational band.
[a] Band(C): Possible $\gamma$ band.

## Adopted Levels, Gammas (continued)

### $\gamma(^{222}Rn)$

B(E2)(W.u.) and B(E1)(W.u.) values are from Coulomb excitation, deduced by evaluators from measured transition matrix elements, with exceptions noted.

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[†] | $E_f$ | $J_f^\pi$ | Mult. | $\alpha$[‡] | $I_{(\gamma+ce)}$ | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 186.211 | $2^+$ | 186.211 *13* | 100 | 0.0 | $0^+$ | E2 | 0.677 *9* | | B(E2)(W.u.)=58 *4* |
| 448.48 | $4^+$ | 262.27 *5* | 100 | 186.211 | $2^+$ | [E2] | 0.2087 *30* | | B(E2)(W.u.)=90 *+4−7* |
| 600.74 | $1^-$ | 414.60 *5* | 60 | 186.211 | $2^+$ | [E1] | 0.01628 *23* | | B(E1)(W.u.)=0.0014 *+23−9*<br>B(E1)(W.u.) from $T_{1/2}$ and $\gamma$ branching, 20% uncertainty assumed in the $\gamma$ branching ratio. |
| | | 600.66 *5* | 100 | 0.0 | $0^+$ | [E1] | 0.00762 *11* | | B(E1)(W.u.)=$7\times10^{-4}$ *+21−4* |
| 635.57 | $3^-$ | (34.81 *16*) | ≈0.032 | 600.74 | $1^-$ | [E2] | $1.30\times10^3$ *4* | ≈42 | B(E2)(W.u.)=80 *+32−27* |
| | | 187.10[@] *20* | | 448.48 | $4^+$ | [E1] | 0.1011 *14* | | |
| | | 449.37 *10* | ≈100 | 186.211 | $2^+$ | [E1] | 0.0137 *2* | ≈100 | B(E1)(W.u.)≈$4\times10^{-6}$<br>B(E1)(W.u.) from $T_{1/2}$. |
| 768.08 | $(6^+)$ | 319.6 *2* | 100 | 448.48 | $4^+$ | [E2] | 0.1144 *16* | | B(E2)(W.u.)=120 *+9−12* |
| 797.4 | $(5^-)$ | 163.0[@] *5* | | 635.57 | $3^-$ | [E2] | 1.116 *21* | | B(E2)(W.u.)=4.6 *+12−17* |
| | | 348.9 *5* | | 448.48 | $4^+$ | | | | |
| 867.0 | $(0^+)$ | 266 *2* | | 600.74 | $1^-$ | [E1] | 0.0438 *10* | | B(E1)(W.u.)=$1.4\times10^{-3}$ *+11−8* |
| | | 681[#] | | 186.211 | $2^+$ | [E2] | 0.0176 *3* | | B(E2)(W.u.)=13 *4*<br>Iγ(681γ)/Iγ(266γ)=1.9 *+38−12*, deduced by evaluators from B(E2)(W.u.)/B(E1)(W.u.) ratio. |
| 867.1 | $(2^+)$ | 681[#] | | 186.211 | $2^+$ | [E2+M1] | 0.042 *25* | | B(E2)(W.u.)=6.8 *42* |
| | | 867 | | 0.0 | $0^+$ | [E2] | 0.0107 *2* | | B(E2)(W.u.)=1.5 *+4−5*<br>Iγ(867γ)/Iγ(681γ)=0.7 *+6−4*, deduced by evaluators from B(E2)(W.u.) ratio, assuming pure E2 for 681. |
| 959.2 | $(3^+)$ | 773 | | 186.211 | $2^+$ | [E2+M1] | 0.031 *17* | | B(E2)(W.u.)=26 *+14−17* |
| 1048.7 | $(7^-)$ | 251.4[@] *5* | | 797.4 | $(5^-)$ | [E2] | 0.240 *4* | | B(E2)(W.u.)=$26\times10^1$ *+12−10* |
| | | 280.6 *5* | 100 *28* | 768.08 | $(6^+)$ | [E1] | 0.0387 *6* | | |
| 1111.5 | $(4^+)$ | 663 | | 448.48 | $4^+$ | [E2+M1] | 0.04 *3* | | B(E2)(W.u.)=11.5 *+39−45* |
| 1127.7 | $(8^+)$ | 359.6 *2* | 100 | 768.08 | $(6^+)$ | [E2] | 0.0819 *12* | | B(E2)(W.u.)=149 *+42−19* |
| 1356.5 | $(9^-)$ | 228.8 *5* | 74 *42* | 1127.7 | $(8^+)$ | [E1] | 0.0624 *9* | | |
| | | 307.7 *5* | 100 *42* | 1048.7 | $(7^-)$ | [E2] | 0.1279 *19* | | B(E2)(W.u.)=$20\times10^1$ *+19−8* |
| 1512.5 | $(10^+)$ | 384.9 *2* | 100 | 1127.7 | $(8^+)$ | [E2] | 0.0680 *10* | | B(E2)(W.u.)=100 *+26−39* |
| 1707.8 | $(11^-)$ | 195.4 *5* | 48 *31* | 1512.5 | $(10^+)$ | [E1] | 0.0910 *14* | | |
| | | 351.2 *5* | 100 *31* | 1356.5 | $(9^-)$ | [E2] | 0.0874 *13* | | |
| 1912.9? | $(12^+)$ | 400.4[@] *5* | | 1512.5 | $(10^+)$ | | | | |
| 2088.7 | $(13^-)$ | 175.6[@] *5* | | 1912.9? | $(12^+)$ | | | | |
| | | 380.9 *5* | 100 *53* | 1707.8 | $(11^-)$ | [E2] | 0.0700 *10* | | |





$^{222}_{86}Rn_{136}$-4

## Adopted Levels, Gammas (continued)

### $\gamma(^{222}Rn)$ (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$ † | $E_f$ | $J_f^\pi$ |
|---|---|---|---|---|
| 2316.7? | $(14^+)$ | 403.8@ *5* | 1912.9? | $(12^+)$ |
| 2485.0? | $(15^-)$ | 396.3@ *5* | 2088.7 | $(13^-)$ |
| 2727.2? | $(16^+)$ | 410.5@ *5* | 2316.7? | $(14^+)$ |
| 2881.6? | $(17^-)$ | 396.6@ *5* | 2485.0? | $(15^-)$ |
| 3285.6? | $(19^-)$ | 404.0@ *5* | 2881.6? | $(17^-)$ |
| 3695.8? | $(21^-)$ | 410.2@ *5* | 3285.6? | $(19^-)$ |

† From $^{226}$Ra $\alpha$ decay for levels up to 636 keV. For higher levels, values are from $^{232}$Th($^{136}$Xe,X$\gamma$).

‡ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on $\gamma$-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

# Multiply placed.

@ Placement of transition in the level scheme is uncertain.





$^{222}_{86}Rn_{136}$-5

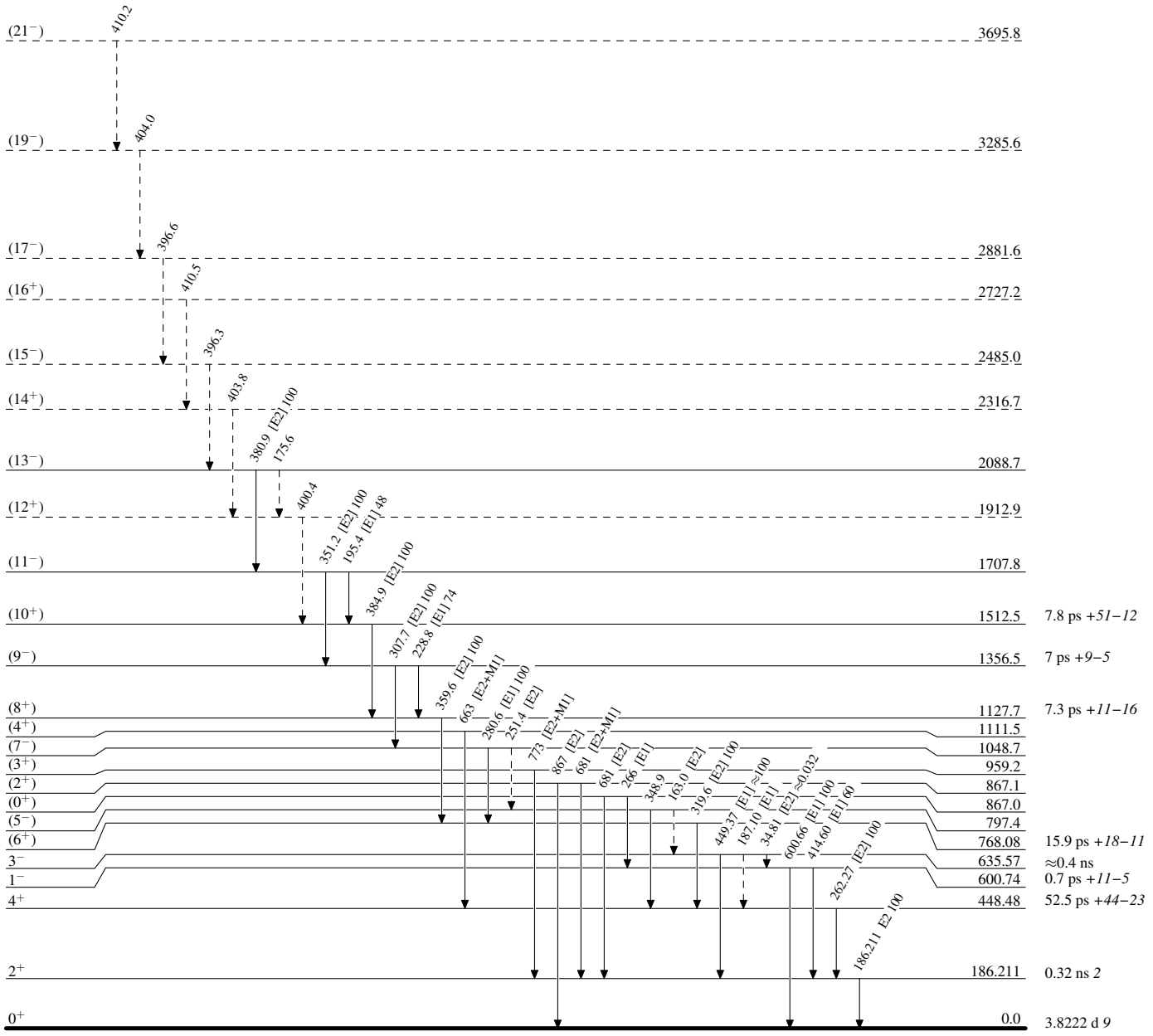
## Adopted Levels, Gammas

Legend

### Level Scheme

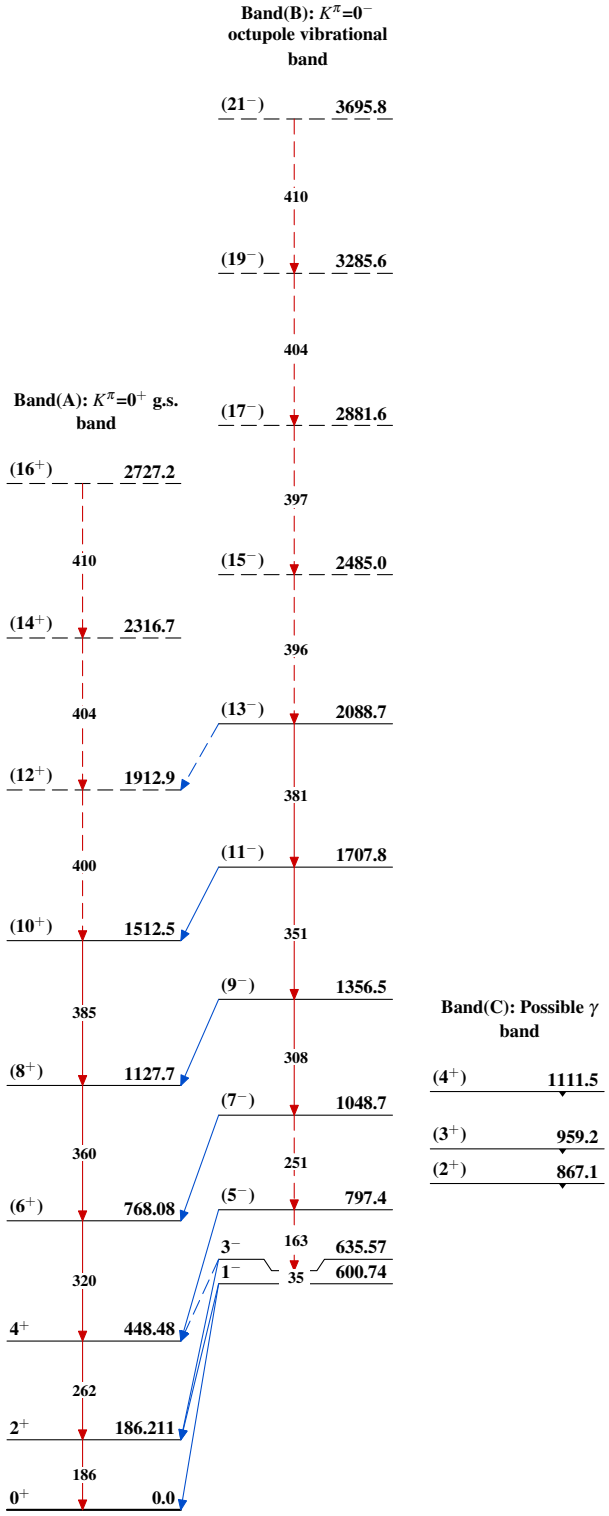
Intensities: Relative photon branching from each level

$\gamma$ Decay (Uncertain)




$^{222}_{86}Rn_{136}$

## Adopted Levels, Gammas




$^{222}_{86}Rn_{136}$

## Adopted Levels, Gammas

| History | | | |
|---|---|---|---|
| Type | Author | Citation | Literature Cutoff Date |
| Full Evaluation | Balraj Singh, Sukhjeet Singh | ENSDF | 08-Mar-2022 |

Q($\beta^-$)=696 *15*; S(n)=6016 *13*; S(p)=8272 *17*; Q($\alpha$)=4757 *20* 2021Wa16
S(2n)=10069 *10*, S(2p)=14620 *40* (2021Wa16).
1961Be28 (also 1961Po06): $^{224}$Rn produced and identified in $^{232}$Th(p,X),E=230 MeV, followed by chemical separation; but half-life of 4.9 h reported in this work is in disagreement with later measurements.
1964Bu02: $^{224}$Rn produced and identified in $^{232}$Th(p,X),E=660 MeV; measured half-life.
Mass measurements:
2012Ch19 (also 2008ChZI): precise mass measurement by Schottky Mass Spectrometry.
2009Ne03: measured mass using ISOLTRAP mass spectrometer.
Additional information 1.

Theoretical calculations: 22 references extracted from the NSR database are listed in document records.

### $^{224}$Rn Levels

Cross Reference (XREF) Flags

A $^{120}$Sn($^{224}$Rn,$^{224}$Rn′$\gamma$)

| E(level)† | J$^\pi$‡ | $T_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 0# | $0^+$ | 107 min *3* | A | %$\beta^-$=100<br>$T_{1/2}$: from 1973AfZY. Other: 114 min *6* (1964Bu02). Weighted average of the two results is 108 min *3*. 2012Gu11 (also 2011GuZY) investigated temperature dependence on half-life, but no difference was detected; measured values are not listed in this paper. |
| 135.6# *5* | $(2^+)$ | | A | |
| 357.6# *6* | $(4^+)$ | | A | |
| 641.4# *8* | $(6^+)$ | | A | |
| 650.6@ *8* | $(3^-)$ | | A | |
| 790.8@ *8* | $(5^-)$ | | A | |
| 969.2# *9* | $(8^+)$ | | A | |
| 1006.4@ *10* | $(7^-)$ | | A | |
| 1277.2@ *10* | $(9^-)$ | | A | |
| 1327.8# *10* | $(10^+)$ | | A | |
| 1588.3@ *13* | $(11^-)$ | | A | |
| 1706.8# *11* | $(12^+)$ | | A | |
| 2098.7?# *13* | $(14^+)$ | | A | |

† From $^{120}$Sn($^{224}$Rn,$^{224}$Rn′$\gamma$).
‡ As proposed by 2020Bu20 in $^{120}$Sn($^{224}$Rn,$^{224}$Rn′$\gamma$), based on population of levels in an even-even nucleus in Coulomb excitation process with expected E2 excitations, and band associations. Evaluators assign $J^\pi$ values for excited states in parentheses as supporting arguments, in terms of transition multipolarities from angular distributions or correlations, linear polarizations, or conversion electron measurements are not yet available.
# Band(A): g.s. band.
@ Band(B): Octupole band based on $(3^-)$.

## Adopted Levels, Gammas (continued)

### $\gamma(^{224}Rn)$

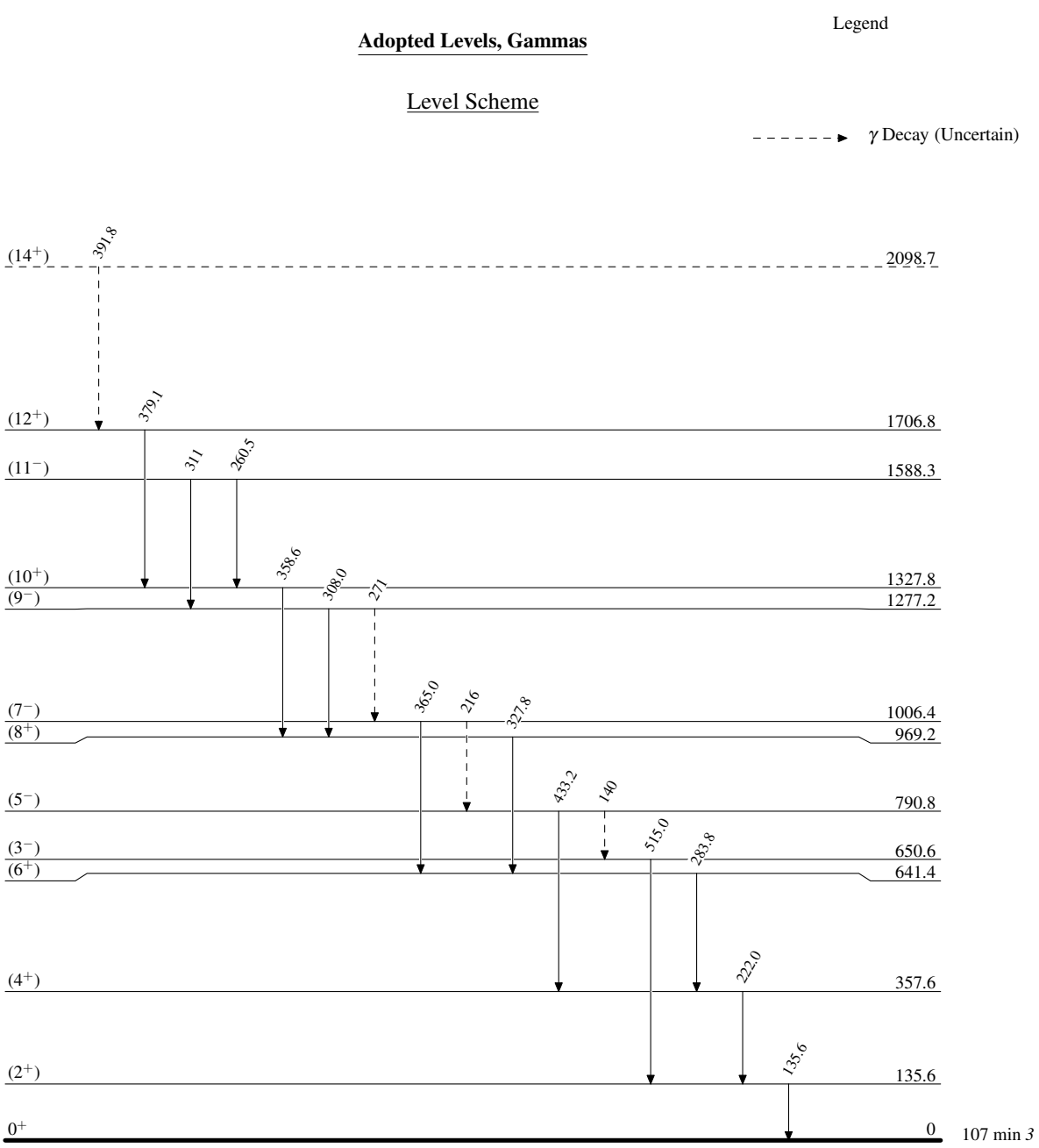
| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $E_f$ | $J_f^\pi$ | $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $E_f$ | $J_f^\pi$ |
|---|---|---|---|---|---|---|---|---|---|
| 135.6 | $(2^+)$ | 135.6 *5* | 0 | $0^+$ | 1006.4 | $(7^-)$ | 365.0 *5* | 641.4 | $(6^+)$ |
| 357.6 | $(4^+)$ | 222.0 *5* | 135.6 | $(2^+)$ | 1277.2 | $(9^-)$ | 271[‡] | 1006.4 | $(7^-)$ |
| 641.4 | $(6^+)$ | 283.8 *5* | 357.6 | $(4^+)$ | | | 308.0 *5* | 969.2 | $(8^+)$ |
| 650.6 | $(3^-)$ | 515.0 *6* | 135.6 | $(2^+)$ | 1327.8 | $(10^+)$ | 358.6 *5* | 969.2 | $(8^+)$ |
| 790.8 | $(5^-)$ | 140[‡] | 650.6 | $(3^-)$ | 1588.3 | $(11^-)$ | 260.5 *8* | 1327.8 | $(10^+)$ |
| | | 433.2 *5* | 357.6 | $(4^+)$ | | | 311 | 1277.2 | $(9^-)$ |
| 969.2 | $(8^+)$ | 327.8 *5* | 641.4 | $(6^+)$ | 1706.8 | $(12^+)$ | 379.1 *5* | 1327.8 | $(10^+)$ |
| 1006.4 | $(7^-)$ | 216[‡] | 790.8 | $(5^-)$ | 2098.7? | $(14^+)$ | 391.8[‡] *6* | 1706.8 | $(12^+)$ |

[†] From $^{120}Sn(^{224}Rn,^{224}Rn'\gamma)$.

[‡] Placement of transition in the level scheme is uncertain.

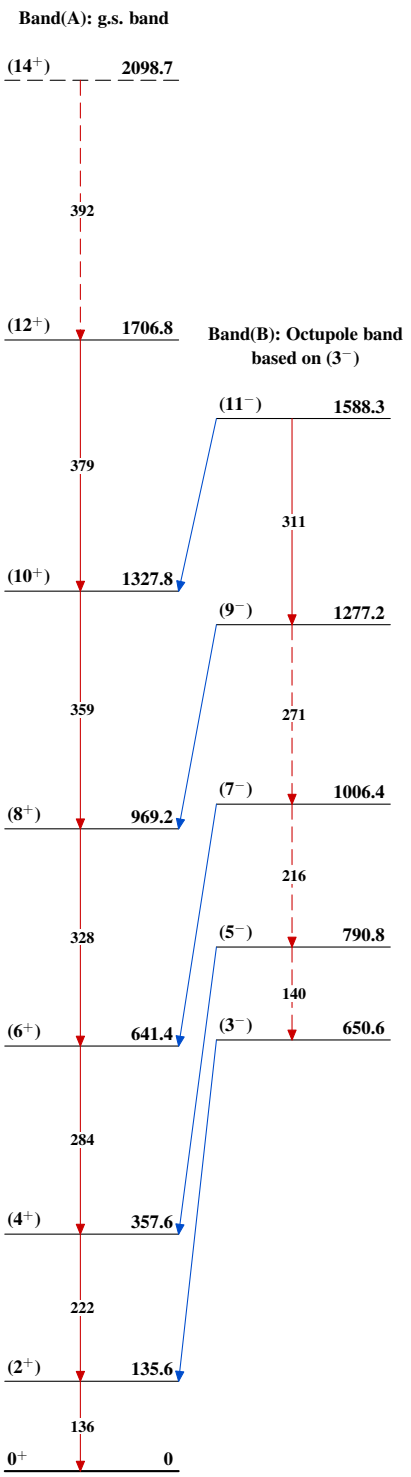
**Adopted Levels, Gammas**

Level Scheme




$^{224}_{86}Rn_{138}$

## Adopted Levels, Gammas




$^{224}_{86}Rn_{138}$