^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh et al. ,	NDS 175,1 (2021)	19-May-2021

Parent: ^{223}Ra: E=0.0; $J^{\pi}=3/2^{+}$; $T_{1/2}$=11.4366 d *28*; Q(α)=5978.99 *21*; %α decay=100

^{223}Ra-J^{π}: From ^{223}Ra Adopted Levels in the ENSDF database (May 2001 update).

^{223}Ra-$T_{1/2}$: From weighted average of 11.4362 d *50* (2015Ko06, unweighted average of 11.4354 d *50* and 11.4370 d *50* by two different methods); 11.4358 d *28* (2015Co02); 11.447 d *6* (2015Be13, weighted average of 11.447 d *6* and 11.445 d *13* by two different methods); 11.444 d *46* (1987Mi10); 11.372 d *45* (1967JoZX), 11.4346 d *11* (1965Ki05, weighted average of 11.4347 d *11* and 11.4267 d *62* using two different methods. Uncertainty was increased by evaluators to 0.0033 d in the averaging procedure to reduce its weighting). Others: 11.22 d *5* (1959Ro51); 11.685 d *56* (1954Ha60, from the same laboratory as 1965Ki05). Weighted average of all the values is 11.4351 d *28*, but with reduced χ^2=6.4, indicating that the values from 1959Ro51 and 1954Ha60 are outliers. 2015Co02 recommended 11.4354 d *17* by taking power-moderated average of their value, and those from 2015Ko06 and 1965Ki05, while arguing that the value from 1987Mi10 could be affected by the presence of impurities produced in the reaction used for production of ^{223}Ra, and that the 1967JoZX value is from the same group as 1965Ki05. It should be, noted, however, that recommended value in 2015Co02 is dominated by the value from 1965Ki05 with the lowest quoted uncertainty of 0.0011 d. Note also that exclusion of values from 1987Mi10 and 1967JoZX does not affect the weighted averaged value adopted here.

^{223}Ra-Q(α): From 2021Wa16.

^{223}Ra-%α decay: %α=100 for ^{223}Ra α decay. ^{223}Ra also decays by ^{14}C cluster emission with a branching of 8.9×10^{-8}% *4* (from ^{223}Ra Adopted Levels in the ENSDF database (May 2001 update), where value is taken from measurement by 1995Ho11; no experimental data for ^{14}C decay mode available after the 2001 update in ENSDF).

2021Si11: measured absolute intensities of eight x rays (81-98 keV), and seven γ rays (122-445 keV) at LNMRI, Rio de Janeiro using HPGe detector, and source standardization using ionization chamber.

2019Ma02: measured absolute Iγ, independently at four laboratories: European Commission, Joint Research Centre (JRC), Belgium; CEA, LIST, LNE-LNHB, France; Cesky Metrologicky Institut, Czech Republic; and ENEA, Instituto Nazionale di Metrologia delle Radiazioni Ionizzanti, Italy. Absolute intensities of 22 γ rays were measured, and averaged values from four measurements were given. The γ-ray energies were taken from literature.

2015Co07: precise absolute and relative photon intensity measurements for 47 γ rays using two HPGe detectors at the National Physical Laboratory, UK. The γ-ray energies, placements and multipolarities were taken by authors from 2001 ENSDF evaluation published by 2001Br31.

2015Ko06: measured precise absolute photon intensities of 34 γ rays and precise half-life of ^{223}Ra decay using calibrated HPGe detectors at the Physikalisch-TechnischeBundesanstalt(PTB), Germany. The γ-ray energies were taken from the evaluation by the DDEP group.

2015Pi10: measured precise absolute photon intensities of seven γ rays using several HPGe detectors at the National Institute of Standards and Technology (NIST), USA. The γ-ray energies were taken from literature.

1998Sh02: measured Eγ, Iγ, Eα, $\alpha\gamma$ coin using hyperpure Ge detector for γ rays, and Si(Li) for α particles at Orsay, France. Deduced γ-ray multipolarities using conversion electron measurements from an unpublished thesis. Reinterpreted $\alpha\gamma(\theta)$ results from others.

1976Bl13: precise measurement of Eγ, Iγ, and x-ray intensities using Ge(Li) detector.

Previous Eγ measurements: 1972HeYM, 1970Da08, 1970Kr01, 1969Be67, 1968Br17, 1966Po02, 1957Pi31, 1957Pa07.

Previous Iγ measurements: 1972HeYM, 1970Da08, 1970Kr01, 1968Br17.

Eα, Iα measurements: 1970Da08, 1962Wa18, 1962Gi04, 1957Pi31. Most detailed and complete data are provided by 1962Wa18.

$\alpha\gamma(\theta)$ measurements: 1974Ri05, 1972HeYM, 1970Da08, 1970Kr01, 1969Be67, 1968Br37. 2016Jo02 (also 2014Jo03,2011Jo01) reanalyzed previous $\alpha\gamma(\theta)$ data, and deduced γ-mixing ratios and magnetic substate populations.

5607α(269γ)(linear polarization correlation) measurements: 1974Ri05, 1970CaZT.

γ(ce)(t), α(ce)(t) for level half-lives: 1974Ri05, 1974Ri01, 1970Kr01.

Note that 1970Kr01 and 1972HeYM used J=1/2 for ^{223}Ra g.s., which renders their analysis of $\alpha\gamma(\theta)$ data for γ-mixing ratios and level spins invalid, as the present adopted spin is 3/2 for ^{223}Ra g.s.

Measured relative Rn I(Kα_2 x ray)=215 *24*, Rn I(Kα_1 x ray)=364 *46*, Rn I(Kβ_1 x ray)=83 *9*, and Rn I(Kβ_2+ Kβ_1 x ray)=31 *4*, Rn I(Kβ_3 x ray)=43 *4*, Rn I(Kβ_5 x ray)=5.0 *6* (1976Bl13).

Total average radiation energy of 5968 keV *2* deduced by evaluators (using the RADLST program) agrees with Q(α)=5978.99 keV *21* (2021Wa16).

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

^{219}Rn Levels

^{219}Rn lies in a transitional region, with spherical, quadrupole, and possibly octupole deformations. Its structure has been interpreted in terms of the $g_{9/2}$ and $i_{11/2}$ mixed parity shell model configurations, which give rise to even- and odd-parity states. The ^{219}Rn states populated by α particle groups with low hindrance factors are associated to the ^{223}Ra ground state configuration (1998Sh02).

E(level)[†]	J^{π}[#]	$T_{1/2}$[‡]	Comments
0.0[@]	$5/2^+$	3.96 s *1*	$T_{1/2}$: from Adopted Levels.
4.413[@] *12*	$(9/2)^+$	15.4 ns *13*	$T_{1/2}$: from γ(ce)(t) (1974Ri05).
14.400[@] *10*	$(7/2)^+$	875 ps *30*	$T_{1/2}$: from γ(ce)(t) (1974Ri05).
126.726[&] *15*	$(11/2)^+$	402 ps *20*	$T_{1/2}$: from α(ce)(t) (1970Kr01).
158.631[&] *8*	$(7/2)^+$	42.3 ps *50*	$T_{1/2}$: other values: 40.2 ps *76* Doppler (1969BoZF); 17.7 ps *26* Doppler (1974Ri01).
269.475[&] *8*	$3/2^+$	14.2 ps *23*	$T_{1/2}$: other values: 27 ps *3* (1970Ko05,1970Ko34,1971Ko37); 11.5 ps *25* Doppler (1969BoZF); 4.4 ps *10* recoil-distance Doppler (1974Ri01).
338.276[&] *8*	$(5/2)^+$	6.1 ps *28*	$T_{1/2}$: other values: 8.1 ps *28* recoil-distance Doppler; 4.5 ps *8* Doppler (1969BoZF).
342.792 *24*	$(5/2,7/2)^-$		
376.19[&] *6*	$(9/2)^+$	6.9 ps *38*	$T_{1/2}$: other value: <170 ps (α)(ce)(t) (1970Kr01).
377.33 *6*	$(7/2,9/2)^-$		No evidence was found by 1998Sh02 for a previously reported level at 378.5 keV by 1992Br10, deexcited by a 251.6-keV γ ray. No α population, Iα<0.05, HF>600 (1998Sh02).
397.0 *4*			
445.037[&] *12*	$(5/2)^+$	6.2 ps *31*	$T_{1/2}$: other value: <170 ps α(ce)(t) (1970Kr01).
446.82 *3*	$(5/2)^-$		
490.88 *16*	$(5/2,7/2,9/2)^-$		Transition intensity balance gives −0.05% *4* α feeding.
514.42[&] *11*	$(9/2^+)$		
517.7? *10*			No α population. Iα<0.01, HF>600 (1998Sh02).
542.011[&] *16*	$(7/2^+)$		
594.08 *13*	$(7/2)^-$		
598.721[&] *24*	$(5/2,7/2,9/2)^+$		
623.70 *4*	$(5/2^+,7/2,9/2^+)$		
646.09 *13*	$(5/2^+,7/2)$		
672.5 *5*			
711.34 *11*	$(3/2^+$ to $9/2^+)$		
732.84 *13*	$(5/2^+,7/2)$		
≈748			
≈773			
≈800			
≈830			
≈851			
≈861			
≈873			

[†] Deduced from least-squares fit to Eγ data. Uncertainties of 362.0 and 371.6 γ rays from 376 level were increased by ≈5 times to ≈0.09 keV to obtain an acceptable least-squares fit. Reduced χ^2=1.05. Level energies above 733 keV are from Eα values.

[‡] From Doppler measurement (1976Li13), unless otherwise specified.

[#] Assignments for excited states in the Adopted Levels are based on ce and $\alpha\gamma(\theta)$ data in the α decay of ^{223}Ra.

[@] Configuration=$\nu g_{9/2}$.

[&] Configuration=$\nu i_{11/2}$.

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

α radiations

Eα[†]	E(level)	Iα[†a]	HF[&]	Comments
≈5014.4	≈873	≈0.00044	≈125	
≈5025.5	≈861	≈0.00063	≈100	
≈5036.0	≈851	≈0.0004	≈190	
≈5056.0	≈830	≈0.0002	≈500	
≈5086.2	≈800	≈0.0003	≈500	
≈5112.4	≈773	≈0.0006	≈360	
≈5134.8	≈748	≈0.0017	≈180	
5151.8	732.84	0.020[@] *3*	19 *3*	Iα: other: 0.021 (measured by 1962Wa18).
5172.8	711.34	0.0201[@] *23*	25 *3*	Iα: other: 0.026 (measured by 1962Wa18).
5211.6	672.5	0.0022[@] *10*	3.8×10^2 *17*	Iα: other: 0.0053 (measured by 1962Wa18).
5236.3	646.09	0.041[@] *21*	28 *15*	Iα: other: 0.041 (measured by 1962Wa18).
5258.8	623.70	0.060[@] *7*	26 *3*	Iα: other: 0.042 (measured by 1962Wa18).
5282.8	598.721	0.135[@] *7*	16 *1*	Iα: other: 0.093 (measured by 1962Wa18).
5287.3 *10*	594.08	0.20[@] *5*	11 *3*	Eα: other values: 5287(?), 5290 (1957Pi31); 5288 *3* (1970Da08). Iα: other: 0.15 in 1977Ma31 evaluation from 0.13 (1962Wa18) and ≈0.16 (1970Da08), 0.3 (5287α?+5290α) (1957Pi31); 0.3 (1962Gi04).
5338.7 *10*	542.011	0.092[@] *8*	48 *5*	Eα: other values: 5337 (1957Pi31); 5339 *3* (1970Da08). Iα: measured values: ≈0.13 (1970Da08), 0.07 (1957Pi31); 0.10 (1962Wa18); 0.25 (5339α+5366α) (1962Gi04).
5365.6 *10*	514.42	≈0.13[#]	≈48	Eα: other values: 5363 (1957Pi31); 5367 (1970Da08). Iα: other values: 0.20 (1957Pi31); 0.108 (1962Wa18). Iα: 0.002 *22*, deduced by evaluators from γ-ray transition intensity balance.
5424	446.82	0.39[@] *5*	37 *5*	
5433.6 *5*	445.037	1.80[@] *3*	6.8 *7*	Eα: other values: 5432 (1957Pi31); 5435 *3* (1970Da08). Iα: other values: 2.27 *20* (1970Da08, combined for α transitions to 445.0 and 446.8 levels); 2.4 (1957Pi31); 2.5 (1962Gi04); 2.3 (1962Wa18).
5481.2	397.0	0.0010[@] *7*	2.7×10^4 *19*	Iα: other: ≈0.008 (measured by 1962Wa18).
5501.6 *10*	376.19	1.00[#] *15*	34 *6*	Eα: other values: 5500 (1957Pi31); 5501 *3* (1970Da08). Iα: other values: 0.86 (1957Pi31); 1.3 (1962Gi04); 0.8 (1962Wa18). Iα: 0.639 *20*, deduced by evaluators from γ-ray transition intensity balance.
5528	342.792	0.14[@] *4*	3.7×10^2 *11*	
5539.80[‡] *90*	338.276	8.9[‡] *2*	6.1 *2*	Eα: other values: 5537 (1957Pi31); 5537.1 (1961Ry02); 5540.0 *9* (1971Gr17); Iα: other values: 10.3 (1957Pi31); 10.2 (1962Gi04); 9.1 (1962Wa18); 9.16 *30* (1970Da08). Iα: 9.39 *8*, deduced by evaluators from γ-ray transition intensity balance.
5606.73[‡] *30*	269.475	25.0[‡] *5*	4.9 *1*	Eα: other values: 5605 (1957Pi31); 5605.3 (1961Ry02); 5607.1 (1962Wa18); 5606 *3* (1970Da08); 5607.34 *30* (1971Gr17). Iα: other values: 23.6 (1957Pi31); 25.7 (1962Gi04); 26 (1962Wa18); 24.2 *4* (1970Da08). Iα: 24.1 *3*, deduced by evaluators from γ-ray transition intensity balance.
5716.23[‡] *29*	158.631	51.2[‡] *13*	8.6 *2*	Eα: other values: 5715 (1957Pi31); 5714.3 (1961Ry02); 5716.1 (1962Wa18); 5715 *3* (1970Da08); 5716.16 *29* (1971Gr17). Iα: other values: 50.4 (1957Pi31); 48.0 (1962Gi04); 53.7 (1962Wa18); 52.5 *8* (1970Da08). Iα: 51.1 *7*, deduced by evaluators from γ-ray transition intensity balance.
5747.0[‡] *4*	126.726	8.9[‡] *2*	71 *2*	Eα: other values: 5745 *2* (1957Pi31); 5745.5 (1961Ry02); 5745.4 (1962Wa18); 5747 (1970Da08); 5747.2 *4* (1971Gr17). Iα: other values: 10.5 (1957Pi31); 10.2 (1962Gi04); 9.1 (1962Wa18); 9.50 *58* (1970Da08). Iα: 10.61 *17*, deduced by evaluators from γ-ray transition intensity balance.
5857.5 *10*	14.400	0.31[#] *4*	7.1×10^3 *10*	Eα: other values: 5856 (1957Pi31); 5857 (1970Da08).

Continued on next page (footnotes at end of table)

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

α radiations (continued)

Eα[†]	E(level)	Iα[†a]	HF[&]	Comments
				Iα: other values: 0.3 (1957Pi31); 0.32 (1962Wa18). Other: 0.0 *20* from γ transition intensity balance.
5871.3[‡] *10*	0.0	1.0[‡] *2*	2.6×10^3 *5*	Eα: other values: 5870 *2* (1957Pi31); 5871 *3* (1970Da08); 5869.5 *17* (1964Wa19). Iα: 0.96 (1957Pi31); 1.5 (1962Gi04); 0.87 (1962Wa18); 0.85 *4* (1970Da08). Other: 1.0 *21* from γ transition intensity balance.

[†] From 1962Wa18 (data using magnetic spectrometer), unless otherwise specified. Original energies of 1962Wa18 have been increased by 2 keV because of changes in the calibration energies, as recommended by 1991Ry01. Uncertainties are from estimates in 1977Ma31 evaluation. Additional α-particle energies of 1957Pi31 and 1970Da08 given in comments also have been increased by 3 keV because of changes in the calibration energies. Evaluators have renormalized intensities (Iα) to add to 100%.

[‡] Value recommended by 1991Ry01.

[#] From 1970Da08, semiconductor detector.

[@] Deduced by evaluators from γ-transition intensity balance.

[&] The nuclear radius parameter $r_0(^{219}Rn)=1.5457$ *10* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides from 2020Si16.

[a] Absolute intensity per 100 decays.

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

γ(^{219}Rn)

Iγ normalization: From weighted average of absolute Iγ(154.2γ)=5.83 *8* (2021Si11), 6.02 *3* (2015Co07), 6.08 *6* (2015Pi10), 6.03 *5* (2015Ko06), 6.04 *35* (1972HeYM). Other absolute Iγ(154.2γ): 6.43 *23* (2019Ma02), 5.4 *4* (1976Bl13), 5.58 *11* (1970Kr01), 5.23 *52* (1970Da08), 5.4 *4* (1968Br17); not used in averaging as these are either less precise or seemingly discrepant. Weighted average of all the values is 6.00 *4*, but reduced χ^2=3.5 is higher than critical χ^2=1.9.

I(γ+ce) normalization: Same value as γ-normalization factor.

Following γ rays with Eγ, Iγ reported by different authors have not been confirmed in later studies such as by 1972HeYM, 1998Sh02 and 2015Co07. With the reported intensities in previous studies these should not have escaped detection in more recent experiments, thus these have been omitted: 63.2 *5*, 0.40 *11* (1968Br17, Iγ uncertain); ≈64, 4.4 (1966Po02); 136.1 *2*, 0.20 *2* (1970Kr01); 143.1 *8*, no Iγ (1957Pi31, ce data); 193.0 *10*, ≈0.07 (1970Da08); 219.0 *8*, 0.10 *4* (1968Br17); 236.0 *6*, ≈0.07 (1968Br17); 293.8 *2*, 0.48 (1970Kr01, this γ was assigned to ^{219}Rn α decay by 1976Bl13); 346.8 *3*, ≈1.3 (1970Da08, uncertain assignment); 393.0, <0.08 (1970Kr01) and 393.5 *5*, 0.081 *29* (1970Da08); 439.3 *4*, 0.59 *10* (1970Kr01), 439.02 *6*, 0.39 *3* (1976Bl13) and 440.8 *2* (1957Pi31, ce data); 465.2 *1*, 0.029 *7* (1968Br17); 481.6 *5*, 0.15 *4* (1970Kr01).

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[@]	α[c]	$I_{(\gamma+ce)}$ [b]	Comments
4.413 *12*		4.413	(9/2)$^+$	0.0	5/2$^+$	(E2)		2.41×10^6 *5*	933 *24*	N1/N2=0.36 *4*; N1/N3=0.32 *4* (1974Ri05) N1/N2=1.4 *5*; N1/N3=1.0 *3* (1972HeYM) α(M)=1.195×10^5 *24*; α(N)=1.87×10^6 *4*; α(O)=3.74×10^5 *8*; α(P)=4.01×10^4 *8* E_γ: from level energy. Measured values are Eγ=4.1 *1* (1998Sh02), 4.4 (1972HeYM, ce data). $I_{(\gamma+ce)}$: deduced by evaluators from transition intensity balance, assuming no direct α feeding to this level. Mult.,δ: M1+E2, δ=0.062 *3* from ce data (1974Ri05). 1972HeYM also claim dominant M1 from N-subshell ratios. BriccMixing also gives dominant M1, but is also consistent with E2(+M3) with δ=0.0121 *13*. 1998Sh02 argue that ce data for N1 shell in 1974Ri05 is not independent of tails of peaks for N2 and N3 shells, and that the data could be consistent with pure E2 also. Evaluators consider the multipolarity assignment as tentative.
9.987 *16*	0.28 *3*	14.400	(7/2)$^+$	4.413	(9/2)$^+$	M1+E2	0.048 *4*	9.2×10^2 *7*	255 *23*	M1/M2=2.12 *14*; M1/M3=2.40 *25*; N1/N2=1.89 *26*; N1/N3=3.56 *71*(1974Ri05) M1/M2=2.1 *3*; M3/M2=1.05 *30* (1972HeYM) α(M)=7.0×10^2 *5*; α(N)=182 *13*; α(O)=38 *3*; α(P)=5.0 *3* E_γ: from level-energy difference. Measured values are Eγ=10.1 *1* (1998Sh02), 10.0 (1972HeYM, ce data). I_γ: deduced by evaluators from γ-ray transition intensity balance of 421 *5* relative units at 14.4 level, and Iγ(10.0γ)/Iγ(14.4γ)=0.85 *9* from measured ce intensities

$^{219}_{86}Rn_{133}$-5

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡] [b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	$I_{(\gamma+ce)}$ [b]	Comments
										(1974Ri05), and theoretical α for assigned multipolarities.
14.400 *10*	0.33 *3*	14.400	$(7/2)^+$	0.0	$5/2^+$	M1+E2	0.112 *4*	511 *25*	166 *23*	Mult.: from ce data. M1/M2=0.98 *2*; M1/M3=0.86 *9*; N1/N2=1.11 *16*; N1/N3=1.40 *20* (1974Ri05) M1/M2=1.0 *2*; M3/M2=0.8 *3* (1972HeYM) α(M)=387 *19*; α(N)=100 *5*; α(O)=20.8 *10*; α(P)=2.54 *11* E_γ: from level energy. Measured values are Eγ=14.4 *1* (1998Sh02), 14.4 (1972HeYM). I_γ: deduced by evaluators from γ-ray transition intensity balance at 14.4 level, and Iγ(10.0γ)/Iγ(14.4γ)=0.85 *9* from measured ce intensities and theoretical α (1974Ri05).
31.98 *3*	0.0018 *4*	158.631	$(7/2)^+$	126.726	$(11/2)^+$	E2		1.98×10^3		M2/M1>17; M3/M2=1.0 *1* (1970Kr01); L1/M=3.7 (1957Pi31) α(L)=1465 *22*; α(M)=391 *6* α(N)=101.4 *15*; α(O)=20.3 *3*; α(P)=2.21 *4* Eγ=31.9 *1* (1998Sh02), 31.992 *30* (1976Bl13), 31.6 *2* (1970Kr01), 31.2 (1957Pi31). I_γ: from 1970Kr01. Other: 0.0024 (1998Sh02). Iγ=0.0102 *11* (1976Bl13) is too large to be consistent with 52% α feeding to the 158 level. Measured Iγ(per 100 decays of ^{223}Ra): 0.055 *6* (1976Bl13), 0.00010 *2* (1970Kr01). Mult.: >80% E2 or δ(E2/M1)>2 from ce data (1970Kr01). E2 listed by 1998Sh02 from ce data.
34.5 *2*		377.33	$(7/2,9/2)^-$	342.792	$(5/2,7/2)^-$	[M1+E2]		7.1×10^2 *65*		Eγ=34.5 *2* (1998Sh02), 33.6 *5* (1968Br17). Iγ=1.9 *6* (1968Br17, uncertain Iγ). No intensity given by 1998Sh02.
69.5[&] *1*	0.12[&] *5*	446.82	$(5/2)^-$	377.33	$(7/2,9/2)^-$	(M1) [a]		7.36		α(L)=5.60 *9*; α(M)=1.330 *20* α(N)=0.347 *5*; α(O)=0.0759 *11*; α(P)=0.01108 *17* Other: Eγ=(68), Iγ=5.5 (1957Pi31); probably belongs to another activity.

$^{219}_{86}Rn_{133}$-6

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[@]	α[c]	Comments
70.9[&d]	0.061[&] *20*	517.7?		446.82	$(5/2)^-$	[D,E2]		21 *20*	Other: Eγ≈72, Iγ=7.8 (1966Po02), probably belongs to another activity.
102.2[&] *2*	0.015[&] *7*	445.037	$(5/2)^+$	342.792	$(5/2,7/2)^-$	[E1]		0.44	
103.2[&] *2*	0.10[&] *5*	594.08	$(7/2)^-$	490.88	$(5/2,7/2,9/2)^-$	(M1+E2)[a]		9.6 *24*	α(K)=5.0 *47*; α(L)=3.5 *17*; α(M)=0.90 *49* α(N)=0.24 *13*; α(O)=0.048 *25*; α(P)=0.0058 *23*
104.23 *8*	0.198 *10*	446.82	$(5/2)^-$	342.792	$(5/2,7/2)^-$	(M1+E2)[a]		9.3 *24*	α(K)=4.9 *46*; α(L)=3.3 *16*; α(M)=0.87 *46* α(N)=0.23 *12*; α(O)=0.046 *23*; α(P)=0.0056 *22* Eγ=104.0 *2* (1998Sh02), 104.254 *66* (1976Bl13), 103.7 *4* (1972HeYM), 103.7 *3* (1968Br17). Iγ from 2015Co07. Others: 0.34 *5* (1998Sh02), 0.35 *6* (1976Bl13), 0.28 *17* (1972HeYM), 0.26 4 (1968Br17), all seem high as compared to most precise value in 2015Co07. Measured Iγ(per 100 decays of ^{223}Ra): 0.0119 *6* (2015Co07), 0.018 *2* (1976Bl13), 0.017 *10* (1972HeYM), 0.014 *2* (1968Br17).
106.78 *3*	0.381 *18*	445.037	$(5/2)^+$	338.276	$(5/2)^+$	M1(+E2)	<0.5	10.4 *5*	α(L1)exp=1.45 *30* (1970Kr01) α(K)=7.9 *9*; α(L)=1.9 *3*; α(M)=0.46 *8* α(N)=0.120 *21*; α(O)=0.026 *4*; α(P)=0.0036 *4* Eγ=106.7 *1* (1998Sh02), 106.783 *32* (1976Bl13), 106.5 *3* (1972HeYM), 106.8 *2* (1970Kr01), 106.8 *2* (1970Da08), 106.6 *3* (1968Br17). I_γ: weighted average of Iγ=0.354 *18* (2015Co07), 0.42 *3* (1998Sh02), 0.41 *6* (1976Bl13), 0.43 *14* (1972HeYM), 0.42 *11* (1970Da08), 0.34 *7* (1970Kr01), 0.43 *8* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0213 *11* (2015Co07), 0.021 *2* (1976Bl13), 0.026 *8* (1972HeYM), 0.019 *4* (1970Kr01), 0.022 *6* (1970Da08), 0.023 *4* (1968Br17). Mult.: M1 listed by 1998Sh02 from ce data.
108.5[&] *2*	0.10[&] *5*	446.82	$(5/2)^-$	338.276	$(5/2)^+$	[E1]		0.38	
110.856 *10*	0.868 *21*	269.475	$3/2^+$	158.631	$(7/2)^+$	E2		5.36	L2/L1=20 *8*; L3/L1=14 *6*; L3/L2=0.70 *10* (1970Kr01) L1/L2=0.07 *5*; L1/L3=0.10 *6* (1970Da08) α(K)=0.363 *5*; α(L)=3.69 *6*; α(M)=0.994 *14* α(N)=0.259 *4*; α(O)=0.0522 *8*; α(P)=0.00581 *9* Eγ=110.8 *1* (1998Sh02), 110.857 *10* (1976Bl13), 110.8 *3* (1972HeYM), 110.9 *1* (1970Kr01), 110.8 *1* (1970Da08), 110.8 *2* (1968Br17). I_γ: weighted average of Iγ=0.850 *17* (2015Co07), 0.93 *6*

$^{219}_{86}Rn_{133}$-7

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
									(2015Ko06), 1.02 *8* (1998Sh02), 1.05 *15* (1976Bl13), 1.08 *15* (1970Da08), 0.81 *7* (1970Kr01), 1.04 *17* (1968Br17). Other: 0.47 *20* (1972HeYM) seems discrepant. Measured Iγ(per 100 decays of ^{223}Ra): 0.0512 *10* (2015Co07), 0.056 *6* (2015Ko06), 0.053 *5* (1976Bl13), 0.029 *12* (1972HeYM), 0.045 *4* (1970Kr01), 0.056 *6* (1970Da08), 0.056 *8* (1968Br17). 5607α(111γ)(θ): A_2=+0.99 *46*, A_4=−0.64 *39* (1970Kr01).
112.6[&d]		711.34	(3/2$^+$ to 9/2$^+$)	598.721	(5/2,7/2,9/2)$^+$	[D,E2]		5.0 *45*	
114.7[&] *2*	0.17[&] *7*	490.88	(5/2,7/2,9/2)$^-$	376.19	(9/2)$^+$	[E1]		0.334	Other: Eγ=114.5 *5*, Iγ=0.15 *8* (relative), 0.009 *5* (per 100 decays) (1972HeYM).
122.319 *10*	21.67 *11*	126.726	(11/2)$^+$	4.413	(9/2)$^+$	M1+E2	−0.127 *15*	7.34	L1/L2=7.68 *40*; L1/L3=37 *7* (1970Da08) L2/L1=0.128 *7*; L3/L1<0.035 (1970Kr01) α(K)exp≈3.6; K/L1=4.2; L2/L3=0.21; L3/L1=0.07 (1957Pi31) α(K)=5.88 *9*; α(L)=1.107 *17*; α(M)=0.264 *4* α(N)=0.0689 *11*; α(O)=0.01503 *23*; α(P)=0.00218 *4* Eγ=122.32 *7* (1998Sh02), 122.319 *10* (1976Bl13), 122.3 *1* (1972HeYM), 122.4 *2* (1970Kr01), 122.3 *1* (1970Da08), 122.3 *2* (1968Br17), 122 (1966Po02), 122.2 (1957Pi31). I_γ: weighted average of Iγ=21.0 *6* (2021Si11), 21.6 *12* (2019Ma02), 21.79 *11* (2015Co07), 21.63 *27* (2015Ko06), 21.38 *27* (2015Pi10), 21.2 *6* (1998Sh02), 20 *3* (1976Bl13), 19.6 *15* (1972HeYM), 21.3 *6* (1970Kr01), 21 *4* (1968Br17). Other: 26 *4* (1970Da08). Measured Iγ(per 100 decays of ^{223}Ra): 1.226 *36* (2021Si11), 1.39 *6* (2019Ma02), 1.312 *6* (2015Co07), 1.304 *12* (2015Ko06), 1.30 *1* (2015Pi10), 1.01 *11* (1976Bl13), 1.19 *5* (1972HeYM), 1.19 *2* (1970Kr01), 1.33 *13* (1970Da08), 1.15 *15* (1968Br17). δ: 2016Jo02 deduced δ(Q/D)=−0.126 *11* from analysis of αγ(θ), and recommended δ=−0.128 *9* as an averaged value. Evaluators obtain δ=0.127 *15* using BrIccMixing code. Pure M1 listed by 1998Sh02 from ce data. 5747α(122γ)(θ): A_2=+0.043 *25*, A_4=−0.044 *37* (1970Kr01); deduced δ=−0.130 *20*, assuming 5/2

$^{219}_{86}Rn_{133}$-8

$\gamma(^{219}Rn)$ (continued)

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[@]	α[c]	Comments
									→ 7/2 transition. 5747$\alpha(122\gamma)(\theta)$: A_2=−0.046 *25*, A_4=−0.015 *30* (1972HeYM).
131.6 *2*	0.09 *5*	646.09	(5/2$^+$,7/2)	514.42	(9/2$^+$)	[D,E2]		3.1 *29*	Eγ=131.7 *2* (1998Sh02), 131.2 *5* (1972HeYM). Iγ=0.10 *5* (1998Sh02); 0.08 *5* (relative), 0.005 *3* (per 100 decays) (1972HeYM).
138.3[&] *3*	0.044[&] *18*	514.42	(9/2$^+$)	376.19	(9/2)$^+$	[M1+E2]		3.7 *16*	
144.235 *10*	57.7 *3*	158.631	(7/2)$^+$	14.400	(7/2)$^+$	M1+E2	−0.121 *17*	4.59	L1/L2=8.20 *26*; L1/L3=48 *7*; K/L=5.53 *20* (1970Da08) L2/L1=0.126 *5*; L3/L1=0.0157 *25* (1970Kr01) K/L1=3.7; L1/L2=8.8; L1/L3=25 (1957Pi31) α(K)=3.69 *6*; α(L)=0.684 *10*; α(M)=0.1630 *24* α(N)=0.0425 *7*; α(O)=0.00928 *14*; α(P)=0.001347 *19* Eγ=144.23 *3* (1998Sh02), 144.235 *10* (1976Bl13), 144.2 *1* (1972HeYM), 144.3 *2* (1970Kr01), 144.19 *4* (1970Da08), 144.2 *2* (1968Br17), 144 (1966Po02), 144.2 (1957Pi31). Iγ=56.9 *10* (2021Si11), 57.7 *31* (2019Ma02), 57.8 *3* (2015Co07), 57.5 *6* (2015Ko06), 57.7 *8* (2015Pi10), 57.3 *19* (1998Sh02), 57 *8* (1976Bl13), 62 *6* (1972HeYM), 61 *9* (1970Da08), 57.9 *17* (1970Kr01), 57 *7* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 3.32 *6* (2021Si11), 3.71 *15* (2019Ma02), 3.481 *16* (2015Co07), 3.469 *20* (2015Ko06), 3.51 *3* (2015Pi10), 2.90 *30* (1976Bl13), 3.72 *25* (1972HeYM), 3.24 *7* (1970Kr01), 3.13 *32* (1970Da08), 3.1 *3* (1968Br17). δ: 2016Jo02 deduced δ(Q/D)=−0.11 *3* from analysis of $\alpha\gamma(\theta)$ data, and recommended δ=−0.12 *1*, combined with results of ce data. Evaluators obtain 0.121 *17* using BrIccMixing code. 1998Sh02 cited δ=0.12 *2* from ce data. 5716$\alpha(144\gamma)(\theta)$: A_2=+0.380 *25*, A_4=+0.037 *30* (1970Kr01); deduced δ=−0.068 *22*, assuming 5/2 → 5/2 transition. 5716$\alpha(144\gamma)(\theta)$: A_2=+0.322 *42*, A_4=−0.074 *50* (1970Da08). 5716$\alpha(144\gamma)(\theta)$: A_2=+0.37 *4* (1998Sh02), implies negative δ. 5716$\alpha(144\gamma)(\theta)$: A_2=+0.364 *16*, A_4=−0.018 *18* (1972HeYM).
147.2[&] *3*	0.10[&] *5*	594.08	(7/2)$^-$	446.82	(5/2)$^-$	[M1+E2]		3.0 *14*	
154.208 *10*	100.0 *8*	158.631	(7/2)$^+$	4.413	(9/2)$^+$	M1		3.83 *6*	L2/L1=0.114 *3* (1970Kr01); L1/L2=8.80 *40*; K/L=5.85 *20*

$^{219}_{86}Rn_{133}$-9

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

$\gamma(^{219}Rn)$ (continued)

E_γ [†]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
									(1970Da08) K/L1=4.3 (1957Pi31) α(K)=3.09 *5*; α(L)=0.560 *8*; α(M)=0.1331 *19* α(N)=0.0347 *5*; α(O)=0.00759 *11*; α(P)=0.001108 *16* Eγ=154.20 *3* (1998Sh02), 154.209 *10* (1976Bl13), 154.2 *1* (1972HeYM), 154.3 *2* (1970Kr01), 154.18 *3* (1970Da08), 154.30 *15* (1968Br17), 154 (1966Po02), 154.1 (1957Pi31). Iγ=100.0 *14* (2021Si11), 100.0 *36* (2019Ma02), 100 (2015Co07), 100.0 *8* (2015Ko06), 100.0 *10* (2015Pi10), 100.0 *24* (1998Sh02), 100 *10* (1976Bl13), 100 *6* (1972HeYM), 100 *10* (1970Da08), 100.0 *20* (1970Kr01), 100 *7* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 5.83 *8* (2021Si11), 6.43 *23* (2019Ma02), 6.02 *3* (2015Co07), 6.03 *5* (2015Ko06), 6.08 *6* (2015Pi10), 5.03 *51* (1976Bl13), 6.04 *35* (1972HeYM), 5.58 *11* (1970Kr01), 5.23 *52* (1970Da08), 5.4 *4* (1968Br17). Mult.,δ: 2016Jo02 deduced δ(Q/D)=−0.0150 *75* from analysis of $\alpha\gamma(\theta)$ data, consistent with pure M1. BrIccMixing gives 0.015 *13*. 1998Sh02 cited δ(E2/M1)=0.08 *6* from ce data. 5716α(154γ)(θ): A_2=−0.094 *10*, A_4=−0.054 *15* (1970Kr01); deduced δ=−0.033 *7*, assuming 5/2 → 7/2 transition. 5716α(154γ)(θ): A_2=−0.099 *29*, A_4=+0.008 *33* (1970Da08). 5716α(154γ)(θ): A_2=−0.07 *2* (1998Sh02), implies negative δ. 5716α(154γ)(θ): A_2=−0.111 *10*, A_4=−0.019 *15* (1972HeYM).
158.635 *10*	12.26 *6*	158.631	(7/2)$^+$	0.0	5/2$^+$	M1+E2	−0.20 *3*	3.45 *6*	α(K)exp=2.96 *12* (1970Kr01); K/L=5.32 *33*; L1/L2=6.8 *13* (1970Da08) K/L1=5.7 (1957Pi31) α(K)=2.76 *5*; α(L)=0.525 *8*; α(M)=0.1255 *20* α(N)=0.0327 *5*; α(O)=0.00713 *11*; α(P)=0.001028 *15* Eγ=158.65 *5* (1998Sh02), 158.634 *10* (1976Bl13), 158.6 *1* (1972HeYM), 158.7 *2* (1970Kr01), 158.62 *4* (1970Da08), 158.7 *2* (1968Br17), 158 (1966Po02), 158.6 (1957Pi31). I_γ: weighted average of Iγ=12.4 *6* (2019Ma02), 12.27 *6* (2015Co07), 12.22 *17* (2015Ko06), 12.2 *4* (1998Sh02), 12.1 *17* (1976Bl13), 11.9 *11* (1972HeYM), 12.2 *4* (1970Kr01). Others: 14.7 *22* (1970Da08), 13.0 *16* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.795 *30* (2019Ma02), 0.749 *4* (2015Co07), 0.737 *8* (2015Ko06), 0.612 *60* (1976Bl13), 0.72 *5* (1972HeYM), 0.683 *14* (1970Kr01), 0.76 *8* (1970Da08), 0.70 *7* (1968Br17). δ: 2016Jo02 deduced δ(Q/D)=−0.205 *18* from analysis of $\alpha\gamma(\theta)$ data, and recommended an averaged value of δ=−0.205 *18*, consistent with result from ce data. BrIccMixing code gives 0.20 *3*. 1998Sh02 cited δ=0.23 *4*. 5716α(159γ)(θ): A_2=+0.11 *3* (1998Sh02), implies negative δ. 5716α(159γ)(θ): A_2=+0.053 *30*, A_4=−0.026 *35* (1972HeYM).

$^{219}_{86}Rn_{133}$-10

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

$\gamma(^{219}Rn)$ (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
165.8 *2*	0.069 *24*	542.011	$(7/2^+)$	376.19	$(9/2)^+$	[M1+E2]		2.1 *11*	Eγ=165.9 *2* (1998Sh02), 165.5 *5* (1972HeYM). Iγ=0.058 *24* (2019Ma02), 0.10 *5* (1998Sh02), 0.08 *5* (1972HeYM). Measured Iγ(per 100 decays of ^{223}Ra): 0.0037 *15* (2019Ma02), 0.005 *3* (1972HeYM).
175.6 *2*	0.2621 *17*	445.037	$(5/2)^+$	269.475	$3/2^+$	[M1+E2]		1.7 *9*	Eγ=175.5 *2* (1998Sh02), 175.5 *4* (1972HeYM), 175.7 *2* (1970Kr01), 176.0 *3* (1970Da08). I_γ: weighted average of Iγ=0.2620 *17* (2015Co07), 0.284 *35* (2015Ko06), 0.34 *7* (1998Sh02), 0.34 *9* (1972HeYM), 0.24 *7* (1970Kr01). Doublet in 1970Da08 and 1968Br17. Measured Iγ(per 100 decays of ^{223}Ra): 0.01578 *10* (2015Co07), 0.0171 *21* (2015Ko06), 0.021 *5* (1972HeYM), 0.014 *4* (1970Kr01), 0.043 *6* (1970Da08, for 176+177), 0.03 *1* (1968Br17, for doublet).
177.3 *1*	0.710 *18*	446.82	$(5/2)^-$	269.475	$3/2^+$	[E1]		0.115	Eγ=177.3 *1* (1998Sh02), 177.4 *3* (1972HeYM), 177.4 *2* (1970Kr01), 177.3 *3* (1970Da08), 176.8 *4* (1968Br17). Iγ=0.86 *6* (2019Ma02), 0.708 *13* (2015Co07), 0.63 *4* (2015Ko06), 0.83 *8* (1998Sh02), 0.79 *14* (1972HeYM), 0.83 *8* (1970Kr01). Doublet in 1970Da08 and 1968Br17. Measured Iγ(per 100 decays of ^{223}Ra): 0.055 *3* (2019Ma02), 0.0426 *8* (2015Co07), 0.0381 *23* (2015Ko06), 0.047 *8* (1972HeYM), 0.046 *4* (1970Kr01), 0.043 *6* (1970Da08, doublet), 0.03 *1* (1968Br17, possible doublet).
179.54 *6*	2.673 *18*	338.276	$(5/2)^+$	158.631	$(7/2)^+$	M1+E2	0.53 *8*	2.12 *10*	α(K)exp=1.43 *20*; L2/L1=0.283 *56*; L3/L1=0.129 *32* (1970Kr01) K/L2=4.2 (1957Pi31) α(K)=1.62 *10*; α(L)=0.376 *6*; α(M)=0.0922 *19* α(N)=0.0240 *5*; α(O)=0.00516 *9*; α(P)=0.000711 *11* Eγ=179.6 *1* (1998Sh02), 179.518 *55* (1976Bl13), 179.7 *2* (1972HeYM), 179.7 *2* (1970Kr01), 179.6 *3* (1970Da08), 179.6 *3* (1968Br17), 180 (1966Po02), 179.8 (1957Pi31). I_γ: weighted average of Iγ=2.50 *21* (2019Ma02), 2.678 *18* (2015Co07), 2.54 *10* (2015Ko06), 2.68 *25* (1998Sh02), 2.7 *4* (1976Bl13), 2.6 *4* (1972HeYM), 2.9 *5* (1970Da08), 2.6 *7* (1970Kr01), 2.8 *8* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.161 *12* (2019Ma02), 0.1613 *10* (2015Co07), 0.153 *6* (2015Ko06), 0.136 *14* (1976Bl13), 0.158 *20* (1972HeYM), 0.146 *4* (1970Kr01), 0.150 *18* (1970Da08), 0.15 *4* (1968Br17). α(K)exp: not completely separated from Auger lines (1970Kr01). Additional information 2. 5540α(179γ)(θ): A_2=+0.17 *7*, A_4=−0.14 *6* (1970Kr01).
199.3 *3*	0.049 *24*	646.09	$(5/2^+,7/2)$	446.82	$(5/2)^-$	[D,E2]		1.0 *9*	Eγ=199.3 *3* (1998Sh02), 199.4 *5* (1972HeYM).

$^{219}_{86}Rn_{133}$-11

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [c]	Comments
								Iγ=0.049 *24* (1998Sh02), 0.050 *33* (relative), 0.003 *2* (per 100 decays) (1972HeYM).
221.32 *24*	0.497 *16*	598.721	(5/2,7/2,9/2)$^+$	377.33	(7/2,9/2)$^-$	(E1) [a]	0.0675	α(K)=0.0543 *8*; α(L)=0.01005 *15*; α(M)=0.00239 *4* α(N)=0.000616 *9*; α(O)=0.0001311 *19*; α(P)=1.78×10^{-5} *3* Eγ=221.4 *1* (1998Sh02), 220.6 *3* (1972HeYM), 221.4 *2* (1970Kr01), 221.5 *3* (1968Br17). Iγ=0.47 *3* (2019Ma02), 0.504 *16* (2015Co07), 0.46 *4* (2015Ko06), 0.63 *10* (1998Sh02), 0.56 *10* (1972HeYM), 0.54 *10* (1970Kr01), 0.65 *19* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0304 *19* (2019Ma02), 0.0304 *10* (2015Co07), 0.0279 *24* (2015Ko06), 0.034 *5* (1972HeYM), 0.030 *6* (1970Kr01), 0.035 *10* (1968Br17).
246.2[&] *3*	0.16 *5*	623.70	(5/2$^+$,7/2,9/2$^+$)	377.33	(7/2,9/2)$^-$	[D,E2]	0.54 *49*	Eγ from 1998Sh02. Other: 245.2 *3* (1972HeYM). Iγ=0.17 *5* (1998Sh02); 0.15 *5* (relative), 0.009 *3* (per 100 decays) (1972HeYM).
249.3 *1*	0.622 *14*	376.19	(9/2)$^+$	126.726	(11/2)$^+$	(M1+E2) [a]	0.62 *38*	α(K)=0.45 *36*; α(L)=0.125 *20*; α(M)=0.031 *4* α(N)=0.0081 *9*; α(O)=0.00173 *23*; α(P)=0.00023 *6* Eγ=249.3 *1* (1998Sh02), 249.4 *3* (1972HeYM), 249.3 *5* (1968Br17). I_γ: weighted average of Iγ=0.622 *14* (2015Co07), 0.60 *10* (2015Ko06), 0.68 *17* (1998Sh02), 0.7 *3* (1972HeYM), 0.67 *19* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0375 *9* (2015Co07), 0.036 *6* (2015Ko06), 0.040 *18* (1972HeYM), 0.036 *10* (1968Br17).
251.6 *3*	1.057 *20*	594.08	(7/2)$^-$	342.792	(5/2,7/2)$^-$	(M1+E2) [a]	0.60 *37*	α(K)=0.44 *35*; α(L)=0.122 *20*; α(M)=0.030 *4* α(N)=0.0079 *9*; α(O)=0.00168 *24*; α(P)=0.00022 *6* Eγ=251.2 *2* (1998Sh02), 251.78 *13* (1976Bl13), 251.8 *3* (1972HeYM), 252.0 (1970Kr01), 251.7 *6* (1970Da08), 251.9 *2* (1968Br17). Iγ=1.062 *19* (2015Co07), 1.05 *7* (2015Ko06), 0.73 *24* (1998Sh02), 1.24 *23* (1976Bl13), 1.1 *4* (1972HeYM), 1.1 *4* (1970Da08), 0.66 *17* (1970Kr01), 1.3 *3* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0640 *11* (2015Co07), 0.063 *4* (2015Ko06), 0.063 *9* (1976Bl13), 0.035 *15* (1972HeYM), 0.037 *10* (1970Kr01), 0.057 *20* (1970Da08), 0.068 *15* (1968Br17).
255.2 *2*	0.831 *21*	269.475	3/2$^+$	14.400	(7/2)$^+$	[E2]	0.229	Eγ=255.1 *2* (1998Sh02), 255.3 *2* (1976Bl13), 255.0 *5* (1972HeYM), 256 (1970Kr01), 255.0 *6* (1970Da08), 255.2 *3* (1968Br17).

$^{219}_{86}Rn_{133}$-12

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
									I_γ: weighted average of Iγ=0.829 *21* (2015Co07), 0.73 *11* (2015Ko06), 0.93 *12* (1998Sh02), 0.87 *21* (1976Bl13), 1.0 *4* (1970Da08), 1.1 *3* (1968Br17). Other: 0.54 *16* (1972HeYM). Measured Iγ(per 100 decays of ^{223}Ra): 0.0499 *13* (2015Co07), 0.044 *4* (2015Ko06), 0.044 *9* (1976Bl13), 0.032 *10* (1972HeYM), ≈0.04 (1970Kr01), 0.05 *2* (1970Da08), 0.060 *15* (1968Br17).
255.7 *3*	0.09 *5*	594.08	$(7/2)^-$	338.276	$(5/2)^+$	[E1]		0.048	Eγ=255.7 *3* (1998Sh02), 255.6 *5* (1972HeYM). Iγ=0.10 *5* (1998Sh02); 0.08 *5* (relative), 0.005 *3* (per 100 decays) (1972HeYM).
260.4 *3*	0.11 *5*	598.721	$(5/2,7/2,9/2)^+$	338.276	$(5/2)^+$	[M1+E2]		0.5 *4*	Eγ=260.4 *3* (1998Sh02), 260.5 *5* (1972HeYM). Iγ=0.12 *5* (1998Sh02); 0.10 *5* (relative), 0.006 *3* (per 100 decays) (1972HeYM).
269.463 *10*	221.0 *11*	269.475	$3/2^+$	0.0	$5/2^+$	M1+E2	−0.149 *10*	0.789 *12*	K/L1=6.26 *21*; L2/L1=0.125 *30* (1972HeYM) L2/L1=0.11 *5*; L3/L1<0.01 (1970Kr01) K/L=5.50 *12*; L1/L2=8.14 *31* (1970Da08) α(K)exp=0.95; K/L1=4.8; L1/L2=19 (1957Pi31) α(K)=0.637 *9*; α(L)=0.1157 *17*; α(M)=0.0275 *4* α(N)=0.00716 *10*; α(O)=0.001566 *22*; α(P)=0.000228 *4* Eγ=269.47 *3* (1998Sh02), 269.462 *10* (1976Bl13), 269.4 *1* (1972HeYM), 269.6 *2* (1970Kr01), 269.41 *3* (1970Da08), 271.0 (1968Br17), 270 (1966Po02), 269.6 (1957Pi31). I_γ: weighted average of Iγ=219 *11* (2019Ma02), 221.9 *11* (2015Co07), 218.2 *30* (2015Ko06), 217.8 *29* (2015Pi10). Others: 240.5 *26* (2021Si11), 244 *8* (1998Sh02), 260 *30* (1976Bl13), 225 *16* (1972HeYM), 260 *40* (1970Da08), 243 *7* (1970Kr01), 260 *40* (1968Br17); all appear to be systematically higher as compared to the more recent measurements, although, except for value in 2021Si11, others agree within the uncertainties. Weighted average of all the values is 224.1 *23*, but with reduced χ^2=6.9, as compared to critical χ^2=1.9. NRM weighted average of all the data is 222.1 *16*, with reduced χ^2=2.8, where uncertainty in 2021Si11 gets adjusted to 7.1 from 2.6. Measured Iγ(per 100 decays of ^{223}Ra): 14.02 *15* (2021Si11), 14.1 *5* (2019Ma02), 13.37 *7* (2015Co07), 13.16 *15* (2015Ko06), 13.24 *12* (2015Pi10), 13.41 *50* (1976Bl13), 13.6 *6* (1972HeYM), 13.6 *3* (1970Kr01), 13.6 *10* (1970Da08), 14.0 *15* (1968Br17).

$^{219}_{86}Rn_{133}$-13

γ(^{219}Rn) (continued)

E_γ †	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult. #	δ @	α c	$I_{(\gamma+ce)}$ b	Comments
										δ: 2016Jo02 deduced δ(Q/D)=−0.149 *4* from analysis of αγ(θ) data, and recommended the same value for δ. BrIccMixing code gives 0.149 *10*. M1 listed by 1998Sh02 from ce data. Additional information 1. 5607α(269γ)(θ): A_2=+0.180 *4*, A_4=−0.009 *6* (1974Ri05). 5607α(269γ)(lin pol)(θ): B_2=+0.019 *7*, B_4=0.0007 *22* (1974Ri05). 5607α(269γ)(θ): A_2=+0.181 *17*, A_4=+0.007 *22* (1970Kr01); deduced δ=−0.140 *12*, assuming 3/2 → 3/2 transition. 5607α(269γ)(lin pol)(θ): B_2=+0.023 *7*, B_4=−0.0023 *27* (cited by 1974Ri05 from 1970CaZT). 5607α(269γ)(θ): A_2=+0.195 *45*, A_4=+0.005 *48* (1970Da08). 5607α(269γ)(θ): A_2=+0.184 *12*, A_4=−0.012 *15* (1972HeYM). 5607α(269γ)(θ): A_2=+0.18 (1957Pi31).
270.3& *4*	0.012& *7*	397.0		126.726	$(11/2)^+$	[D,E2]		0.42 *38*		
286.0& *4*	0.020& *10*	732.84	$(5/2^+,7/2)$	446.82	$(5/2)^-$	[D,E2]		0.36 *32*		
288.18 *3*	2.47 *4*	446.82	$(5/2)^-$	158.631	$(7/2)^+$	E1		0.0364		α(K)exp=0.023 *15* (1970Kr01) α(K)=0.0295 *5*; α(L)=0.00527 *8*; α(M)=0.001249 *18* α(N)=0.000323 *5*; α(O)=6.91×10^{-5} *10*; α(P)=9.50×10^{-6} *14* Eγ=288.1 *1* (1998Sh02), 288.183 *27* (1976Bl13), 288.1 *2* (1972HeYM), 288.3 *2* (1970Kr01), 288.4 *3* (1970Da08), 287.8 *3* (1968Br17), 288 *1* (1966Po02). Iγ=1.96 *12* (2019Ma02), 2.488 *27* (2015Co07), 2.42 *7* (2015Ko06), 2.1 *4* (1972HeYM). NRM weighted average taken, where uncertainty in 2019Ma02 gets adjusted to 0.23. Others: 2.80 *10* (1998Sh02), 2.8 *4* (1976Bl13), 2.8 *5* (1970Da08), 2.82 *13* (1970Kr01), 3.0 *5* (1968Br17), all seem high as compared to some recent values. Weighted average of all the values is 2.49 *5* with reduced χ^2=4.9 as compared to critical χ^2=1.9. NRM weighted average of all the values is 2.50 *4*, with reduced χ^2=2.9, and uncertainty in 2019Ma02 adjusted to 0.21. Measured Iγ(per 100 decays of ^{223}Ra): 0.126 *6* (2019Ma02), 0.1498 *16* (2015Co07), 0.146 *4* (2015Ko06), 0.144 *7* (1976Bl13), 0.127 *18*

$^{219}_{86}Rn_{133}$-14

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[@]	α[c]	Comments
									(1972HeYM), 0.158 *7* (1970Kr01), 0.147 *16* (1970Da08), 0.16 *2* (1968Br17). Mult.: from ce data (1970Kr01). E1 listed by 1998Sh02 from ce data.
323.871 *10*	60.5 *3*	338.276	(5/2)$^+$	14.400	(7/2)$^+$	M1(+E2)	−0.04 *5*	0.484 *8*	L2/L1<0.15; L3/L1<0.03 (1970Kr01) K/L=5.74 *24*; L1/L2=8.3 *10* (1970Da08); (L1+L2)/L3=33 *3* (1974Ri05) K/L1=4.0; L1/L3=1.9 (1957Pi31) α(K)=0.392 *6*; α(L)=0.0700 *10*; α(M)=0.01661 *24* α(N)=0.00433 *7*; α(O)=0.000947 *14*; α(P)=0.0001383 *20* Eγ=323.90 *5* (1998Sh02), 323.870 *10* (1976Bl13), 323.9 *1* (1972HeYM), 324.1 *2* (1970Kr01), 323.88 *5* (1970Da08), 323.90 *15* (1968Br17), 324 (1966Po02), 323.9 (1957Pi31). I_γ: weighted average of Iγ=59.9 *34* (2019Ma02), 60.7 *3* (2015Co07), 60.7 *6* (2015Ko06), 59.7 *6* (2015Pi10), 60 *5* (1972HeYM). Others: 65.4 *10* (2021Si11), 70.0 *21* (1998Sh02), 71 *8* (1976Bl13), 70 *10* (1970Da08), 71.5 *20* (1970Kr01), 69 *9* (1968Br17); all seem systematically higher than some of the recent measurements and 1972HeYM. Weighted average of all the values is 61.1 *6* with reduced χ^2=7.4 as compared to critical χ^2=1.8. NRM weighted average is 60.7 *4* with reduced χ^2=2.7, where uncertainties in 2021Si11, 1998Sh02 and 1970Kr01 get adjusted upward by a factor of ≈2. Measured Iγ(per 100 decays of ^{223}Ra): 3.81 *6* (2021Si11), 3.85 *17* (2019Ma02), 3.655 *18* (2015Co07), 3.661 *21* (2015Ko06), 3.63 *2* (2015Pi10), 3.60 *18* (1976Bl13), 3.65 *15* (1972HeYM), 4.00 *8* (1970Kr01), 3.60 *36* (1970Da08), 3.7 *4* (1968Br17). δ: 2016Jo02 deduced δ(Q/D)=−0.035 *49* from analysis of $\alpha\gamma(\theta)$ data, and recommended pure M1. BrIccMixing gives δ=0.38 *4*, but with large reduced χ^2 of 14. M1+E2 listed by 1998Sh02 from ce data. 5540α(324γ)(θ): A_2=−0.040 *13*, A_4=−0.021 *20* (1974Ri05). 5540α(324γ)(θ): A_2=−0.033 *15*, A_4=−0.020 *20* (1970Kr01); deduced δ=−0.058 *14*, assuming 3/2 → 5/2 transition. 5540α(324γ)(θ): A_2=+0.007 *12*, A_4=−0.036 *30* (1972HeYM).
328.38 *3*	3.36 *3*	342.792	(5/2,7/2)$^-$	14.400	(7/2)$^+$	E1		0.0271	α(K)=0.0220 *3*; α(L)=0.00387 *6*; α(M)=0.000916 *13* α(N)=0.000237 *4*; α(O)=5.08×10^{-5} *8*; α(P)=7.04×10^{-6} *10* α(K)exp=0.03 *2* (1970Kr01) Eγ=328.4 *1* (1998Sh02), 328.381 *29* (1976Bl13), 328.5 *1* (1972HeYM), 328.7 *2* (1970Kr01), 328.5 *1* (1970Da08), 328.30 *15* (1968Br17). I_γ: weighted average of Iγ=3.36 *3* (2015Co07), 3.28 *7* (2015Ko06), 3.7 *12* (1998Sh02), 3.7 *5* (1976Bl13), 2.7 *5*

$^{219}_{86}Rn_{133}$-15

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
									(1972HeYM), 3.1 *7* (1970Da08), 3.70 *18* (1970Kr01), 3.7 *5* (1968Br17). Small contribution (2.2%) from ^{211}Po and ^{207}Tl decays. Measured Iγ(per 100 decays of ^{223}Ra): 0.2021 *16* (2015Co07, some contribution from ^{211}Po and ^{207}Tl decays), 0.198 *4* (2015Ko06), 0.188 *11* (1976Bl13), 0.161 *25* (1972HeYM), 0.207 *10* (1970Kr01), 0.162 *32* (1970Da08), 0.20 *2* (1968Br17).
334.01 *6*	1.255 *9*	338.276	(5/2)$^+$	4.413	(9/2)$^+$	(E2)		0.1007	Mult.: E1 listed by 1998Sh02 from ce data. α(K)exp=0.08 *5* (1970Kr01) α(K)=0.0546 *8*; α(L)=0.0343 *5*; α(M)=0.00895 *13* α(N)=0.00233 *4*; α(O)=0.000481 *7*; α(P)=5.85×10^{-5} *9* Eγ=333.9 *1* (1998Sh02), 334.039 *56* (1976Bl13), 333.9 *1* (1972HeYM), 334.4 *2* (1970Kr01), 333.8 *1* (1970Da08), 333.9 *2* (1968Br17). I_γ: weighted average of Iγ=1.255 *9* (2015Co07), 1.24 *5* (2015Ko06). Others: 1.78 *11* (1998Sh02), 1.45 *25* (1976Bl13), 1.6 *3* (1972HeYM), 2.4 *6* (1970Da08), 1.85 *15* (1970Kr01), 1.6 *3* (1968Br17); all appear to be systematically higher than the recent measurements. Weighted average of all the values is 1.261 *22* with reduced χ^2=6.4 as compared to critical χ^2=2.0. NRM weighted average is 1.257 *15* with reduced χ^2=2.8, where uncertainty in 1998Sh02 gets adjusted upward to 0.21 and that in 1970Kr01 to 0.24. Measured Iγ(per 100 decays of ^{223}Ra): 0.0756 *6* (2015Co07), 0.0750 *29* (2015Ko06), 0.073 *10* (1976Bl13), 0.094 *15* (1972HeYM), 0.103 *8* (1970Kr01), 0.124 *24* (1970Da08), 0.086 *13* (1968Br17).
338.282 *10*	43.20 *21*	338.276	(5/2)$^+$	0.0	5/2$^+$	M1+E2	−0.23 *5*	0.413 *10*	Mult.: α(K)exp gives E2(+M1), δ>3.2, also consistent with E1. E2 listed by 1998Sh02 from ce data. α(K)exp=0.367 *24* (1970Kr01); K/L=5.11 *41*; L1/L2=8.8 *18* (1970Da08) K/L1=3.2 (1957Pi31) α(K)=0.333 *9*; α(L)=0.0607 *11*; α(M)=0.01444 *25* α(N)=0.00376 *7*; α(O)=0.000822 *15*; α(P)=0.0001195 *23* Eγ=338.32 *5* (1998Sh02), 338.280 *10* (1976Bl13), 338.3 *1* (1972HeYM), 338.6 *2* (1970Kr01), 338.3 *1* (1970Da08), 338.3 *1* (1968Br17), 338 (1966Po02), 338.0 (1957Pi31). I_γ: weighted average of Iγ=42.9 *19* (2019Ma02), 43.25 *21* (2015Co07), 43.4 *4* (2015Ko06), 42.6 *5* (2015Pi10), 43 *3* (1972HeYM). Others: 48.9 *9* (2021Si11), 49.8 *16* (1998Sh02), 49 *6* (1976Bl13), 50 *8* (1970Da08), 51 *12* (1970Kr01), 50 *6* (1968Br17); all appear to be systematically higher than some of the recent

$^{219}_{86}Rn_{133}$-16

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [c]	Comments
								measurements and 1972HeYM. Weighted average of all the values is 43.5 *4* with reduced χ^2=5.9 as compared to critical χ^2=1.8. NRM weighted average is 43.3 *3* with reduced χ^2=1.9, where uncertainty in 2021Si11 gets adjusted to 2.1 and that in 1998Sh02 to 2.5. Measured Iγ(per 100 decays of ^{223}Ra): 2.85 *5* (2021Si11), 2.76 *10* (2019Ma02), 2.605 *13* (2015Co07), 2.614 *13* (2015Ko06), 2.59 *2* (2015Pi10), 2.48 *12* (1976Bl13), 2.61 *10* (1972HeYM), 2.88 *7* (1970Kr01), 2.59 *27* (1970Da08), 2.70 *25* (1968Br17). δ: 2016Jo02 deduced δ(Q/D)=−0.235 *30* from analysis of $\alpha\gamma(\theta)$, and recommended the same δ value. BrIccMixing gives 0.23 *5*. M1+E2 listed by 1998Sh02 from ce data. 5540α(338γ)(θ): A_2=+0.177 *11*, A_4=+0.028 *17* (1974Ri05). 5540α(338γ)(θ): A_2=+0.183 *19*, A_4=−0.025 *28* (1970Kr01); deduced δ=−0.138 *15*, assuming 3/2 → 3/2 transition. 5540α(338γ)(θ): A_2=+0.206 *18*, A_4=−0.040 *30* (1972HeYM).
342.87 *4*	2.90 *7*	342.792	$(5/2,7/2)^-$	0.0	$5/2^+$	(E1)	0.0246	α(K)exp≤0.12 (1970Kr01) α(K)=0.0200 *3*; α(L)=0.00350 *5*; α(M)=0.000828 *12* α(N)=0.000214 *3*; α(O)=4.60×10^{-5} *7*; α(P)=6.38×10^{-6} *9* Eγ=342.80 *7* (1998Sh02), 342.898 *44* (1976Bl13), 342.9 *1* (1972HeYM), 342.3 (1970Kr01), 342.9 *1* (1970Da08), 342.8 *2* (1968Br17). I_γ: from 2015Ko06. Evaluators assume that 2015Ko06 have corrected the contribution (18%) from ^{211}Pb decay. Others: 3.25 *4* (2015Co07), 3.9 *3* (1998Sh02), 3.9 *5* (1976Bl13), 1.6 *4* (1972HeYM), 3.9 *11* (1970Da08), 4.14 *23* (1970Kr01), 3.7 *5* (1968Br17). About 18% of the intensity could belong to the decay of ^{211}Pb. Measured Iγ(per 100 decays of ^{223}Ra): 0.1958 *21* (2015Co07, some contribution from ^{211}Pb decay), 0.175 *4* (2015Ko06), 0.200 *16* (1976Bl13), 0.097 *22* (1972HeYM), 0.231 *12* (1970Kr01), 0.21 *6* (1970Da08), 0.20 *2* (1968Br17). Mult.: E1 or E2 from ce data (1970Kr01). E1 listed by 1998Sh02 from ce data.
355.5[&] *2*	0.073[&] *24*	732.84	$(5/2^+,7/2)$	377.33	$(7/2,9/2)^-$	[D,E2]	0.20 *18*	
355.7[&] *2*	0.049[&] *24*	514.42	$(9/2^+)$	158.631	$(7/2)^+$	[M1+E2]	0.23 *15*	Iγ=0.132 *11* (2019Ma02), 0.206 *25* (2015Co07), 0.049 *24* (1998Sh02). Doublet in 1998Sh02, other component has Iγ=0.073 *24*. 2019Ma02 and 2015Co07 report a single line. Iγ is adopted from 1998Sh02, based on the split intensity in this work. Measured Iγ(per 100 decays of ^{223}Ra): 0.0085 *7* (2019Ma02), 0.0124 *15* (2015Co07).
362.052 *17*	0.439 *33*	376.19	$(9/2)^+$	14.400	$(7/2)^+$	[M1+E2]	0.22 *14*	Eγ=361.7 *1* (1998Sh02), 362.062 *17* (1976Bl13), 361.3 *2* (1972HeYM), 361.7 *3* (1970Kr01), 361.5 *3* (1970Da08), 361.6 *5*

$^{219}_{86}Rn_{133}$-17

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [@]	α [c]	Comments
									(1968Br17), 362 (1966Po02). Uncertainty increased to 0.085 keV for least-squares fit. I_γ: weighted average of Iγ=0.435 *33* (2015Ko06), 0.49 *12* (1998Sh02). Others: 0.566 *12* (2015Co07, assigned to ^{211}Pb decay), 0.74 *15* (1968Br17), 0.80 *10* (1976Bl13), 0.53 *14* (1972HeYM), 0.96 *21* (1970Da08), 0.82 *9* (1970Kr01). The 362+363 doublet is separated only in 2015Ko06, 1998Sh02 and 1968Br17. Measured Iγ(per 100 decays of ^{223}Ra): 0.0341 *7* (2015Co07, assigned to ^{211}Bi decay), 0.0262 *20* (2015Ko06), 0.040 *3* (1976Bl13), 0.032 *8* (1972HeYM), 0.046 *5* (1970Kr01), 0.05 *1* (1970Da08), 0.04 *1* (1968Br17).
362.9 *2*	0.309 *15*	377.33	$(7/2,9/2)^-$	14.400	$(7/2)^+$	[E1]		0.022	I_γ: weighted average of Iγ=0.319 *15* (2015Co07), 0.292 *22* (2015Ko06), 0.27 *12* (1998Sh02). Other: 0.74 *15* (1968Br17). In other studies, 362-363 doublet is not separated. See also Iγ comment for 362.05γ. Measured Iγ(per 100 decays of ^{223}Ra): 0.0192 *9* (2015Co07), 0.0176 *13* (2015Ko06), 0.04 *1* (1968Br17, for doublet).
368.56 *12*	0.223 *6*	711.34	$(3/2^+$ to $9/2^+)$	342.792	$(5/2,7/2)^-$	[D,E2]		0.18 *16*	Eγ=368.5 *1* (1998Sh02), 368.8 *2* (1972HeYM), 369.5 (1968Br17). I_γ: weighted average of Iγ=0.223 *5* (2015Co07), 0.25 *4* (2015Ko06). Others: 0.15 *7* (1998Sh02), 0.13 *6* (1972HeYM), ≈0.37 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0134 *4* (2015Co07), 0.0152 *25* (2015Ko06), 0.008 *4* (1972HeYM), ≈0.02 (1968Br17).
371.676 *15*	7.22 *5*	376.19	$(9/2)^+$	4.413	$(9/2)^+$	M1(+E2)	<0.15	0.330 *6*	α(K)exp=0.292 *23* (1970Kr01) α(K)=0.267 *5*; α(L)=0.0478 *8*; α(M)=0.01134 *17* α(N)=0.00295 *5*; α(O)=0.000646 *10*; α(P)=9.43×10^{-5} *15* Eγ=371.7 *1* (1998Sh02), 371.675 *15* (1976Bl13), 371.9 *1* (1972HeYM), 372.0 *3* (1970Kr01), 371.5 *3* (1970Da08), 371.7 *2* (1968Br17), 371 (1966Po02), 371.1 (1957Pi31). Uncertainty increased to 0.075 keV for least-squares fit. I_γ: weighted average of Iγ=7.1 *4* (2019Ma02), 7.22 *5* (2015Co07), 8.3 *10* (1976Bl13). Others: 8.3 *7* (2015Ko06), 8.5 *4* (1998Sh02), 9.5 *11* (1972HeYM), 10.5 *19* (1970Da08), 8.66 *24* (1970Kr01), 10.2 *13*

$^{219}_{86}Rn_{133}$-18

γ(^{219}Rn) (continued)

E_γ †	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult. #	α c	Comments
								(1968Br17); all seem systematically high. Weighted average of all the values is 7.31 *13* with reduced χ^2=7.3 as compared to critical χ^2=2.0. Measured Iγ(per 100 decays of ^{223}Ra): 0.457 *18* (2019Ma02), 0.435 *3* (2015Co07), 0.50 *4* (2015Ko06), 0.57 *5* (1972HeYM), 0.484 *10* (1970Kr01), 0.54 *8* (1970Da08), 0.55 *5* (1968Br17). Mult.: M1+E2 listed by 1998Sh02 from ce data. 5502α(338γ)(θ): A_2=+0.292 *27*, A_4=−0.003 *38* (1970Kr01). α(K)=0.01667 *24*; α(L)=0.00289 *4*; α(M)=0.000682 *10* α(N)=0.0001765 *25*; α(O)=3.80×10^{-5} *6*; α(P)=5.29×10^{-6} *8*
372.9 *1*	1.38 *30*	377.33	(7/2,9/2)$^-$	4.413	(9/2)$^+$	(E1) a	0.0205	Eγ=372.9 *1* (1998Sh02), 372.881 *61* (1976Bl13), 373.3 (1970Kr01), 373.0 *4* (1968Br17, uncertain). Iγ: unweighted average of Iγ=1.882 *22* (2015Co07), 0.85 *7* (2015Ko06), 0.88 *9* (1998Sh02, no uncertainty stated by authors, 10% uncertainty assumed by evaluators), 1.9 *3* (1976Bl13). Others: ≈0.90 (1970Kr01), ≈1.8 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.1133 *13* (2015Co07), 0.051 *4* (2015Ko06), 0.098 *11* (1976Bl13), <0.08 (1972HeYM), ≈0.05 (1970Kr01), ≈0.1 (1968Br17).
376.1 *2*	0.092 *5*	376.19	(9/2)$^+$	0.0	5/2$^+$	[E2]	0.072	Eγ=376.1 *2* (1998Sh02), 376.0 *3* (1970Da08), 376.0 (1970Kr01), 377.0 *6* (1968Br17, tentative assignment). Iγ: weighted average of Iγ=0.092 *5* (2015Co07), 0.093 *10* (2015Ko06). Others: 0.22 *7* (1998Sh02), <0.08 (1972HeYM), ≈0.23 *8* (1970Da08), <0.18 (1970Kr01), ≈0.13 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0056 *4* (2015Co07), 0.0056 *6* (2015Ko06), <0.005 (1972HeYM), <0.01 (1970Kr01), 0.012 *4* (1970Da08), ≈0.007 (1968Br17).
382.8 *5*	0.031 *8*	542.011	(7/2$^+$)	158.631	(7/2)$^+$	[M1+E2]	0.19 *12*	Eγ=383.0 *5* (1972HeYM), 382.5 *5* (1970Da08), 383.0 *6* (1968Br17, uncertain assignment). This γ is not reported by 1998Sh02. Iγ: from Iγ=0.038 *9* (2015Co07), with subtraction of 18% contribution from ^{219}Rn decay. Others: 0.07 *5* (1972HeYM), 0.29 *11* (1970Da08), ≈0.04 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0023 *6* (2015Co07), 0.004 *3* (1972HeYM), 0.015 *5* (1970Da08), ≈0.006 (1968Br17).
387.7 *2*	0.086 *11*	514.42	(9/2$^+$)	126.726	(11/2)$^+$	[M1+E2]	0.18 *12*	Eγ=387.6 *2* (1998Sh02), 388.0 *5* (1972HeYM). Iγ: from 2015Co07, authors incorrectly mention contribution from ^{219}Rn decay, should be for 383γ instead. Others: 0.27 *10* (1998Sh02), 0.23 *9* (1972HeYM), ≈0.074 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0052 *7* (2015Co07), 0.014 *5* (1972HeYM), ≈0.004 (1968Br17).
390.1 *2*	0.087 *10*	732.84	(5/2$^+$,7/2)	342.792	(5/2,7/2)$^-$	[D,E2]	0.16 *14*	Eγ=390.0 *2* (1998Sh02), 391.0 *8* (1972HeYM), 390.0 *6* (1968Br17). Other: 393.5 *5* (1970Da08).

$^{219}_{86}Rn_{133}$-19

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

$\gamma(^{219}Rn)$ (continued)

E_γ[†]	I_γ[‡][b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[c]	Comments
								I_γ: weighted average of Iγ=0.088 *11* (2015Co07), 0.12 *5* (1998Sh02), 0.05 *4* (1972HeYM). Others: 0.21 *8* (1970Da08 for a 393.5γ), ≈0.13 (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0053 *7* (2015Co07), 0.003 *2* (1972HeYM), 0.011 *4* (1970Da08 for a 393.5γ), ≈0.007 (1968Br17).
430.6 *3*	0.389 *9*	445.037	$(5/2)^+$	14.400	$(7/2)^+$	[M1+E2]	0.14 *9*	Eγ=430.6 *3* (1998Sh02), 430.5 *5* (1972HeYM). I_γ: weighted average of Iγ=0.34 *4* (2015Co07), 0.393 *9* (2015Ko06), 0.34 *10* (1998Sh02), 0.32 *9* (1972HeYM). There could be ≈28% contribution from a γ in ^{211}Pb decay, which may or may not have been considered in the quoted intensities. Measured Iγ(per 100 decays of ^{223}Ra): 0.0206 *19* (2015Co07, mixed with line from ^{211}Pb decay), 0.0237 *5* (2015Ko06), 0.019 *5* (1972HeYM).
432.12 *11*	0.519 *23*	446.82	$(5/2)^-$	14.400	$(7/2)^+$	[E1]	0.015	Eγ=432.4 *3* (1998Sh02), 432.08 *11* (1976Bl13), 432.6 *2* (1972HeYM), 432.4 (1970Kr01), 432.0 *6* (1970Da08), 431.8 *2* (1968Br17). Iγ=0.493 *23* (2015Co07), 0.50 *5* (2015Ko06), 0.61 *5* (1998Sh02), 0.49 *9* (1976Bl13), 0.54 *14* (1972HeYM), 0.63 *10* (1970Kr01), 0.62 *9* (1968Br17). Other: ≈0.57 (1970Da08). Measured Iγ(per 100 decays of ^{223}Ra): 0.0297 *14* (2015Co07), 0.0299 *28* (2015Ko06), 0.025 *4* (1976Bl13), 0.033 *8* (1972HeYM), 0.036 *5* (1970Kr01), ≈0.03 (1970Da08), 0.034 *4* (1968Br17).
445.033 *12*	20.24 *10*	445.037	$(5/2)^+$	0.0	$5/2^+$	M1	0.205	α(K)exp=0.194 *19* (1970Kr01) α(K)=0.1661 *24*; α(L)=0.0295 *5*; α(M)=0.00698 *10* α(N)=0.00182 *3*; α(O)=0.000398 *6*; α(P)=5.82×10^{-5} *9* Eγ=445.06 *5* (1998Sh02), 445.031 *12* (1976Bl13), 444.9 *1* (1972HeYM), 445.5 (1970Kr01), 444.92 *7* (1970Da08), 445.0 *1* (1968Br17), 446 (1966Po02), 445.5 (1957Pi31). I_γ: weighted average of Iγ=22.1 *14* (2021Si11), 19.9 *11* (2019Ma02), 20.22 *10* (2015Co07), 20.27 *22* (2015Ko06), 20.02 *23* (2015Pi10), 22.7 *9* (1998Sh02), 22 *3* (1976Bl13), 20.7 *20* (1972HeYM), 25 *4* (1970Da08), 22.5 *20* (1968Br17). Iγ=26.8 *20* (1970Kr01) seems discrepant. Measured Iγ(per 100 decays of ^{223}Ra): 1.29 *8* (2021Si11), 1.28 *5* (2019Ma02), 1.218 *6* (2015Co07), 1.222 *6* (2015Ko06), 1.217 *8* (2015Pi10), 1.14 *5* (1976Bl13), 1.25 *10* (1972HeYM), 1.50 *11* (1970Kr01), 1.27 *13* (1970Da08), 1.22 *5* (1968Br17). Mult.: from ce data (1970Kr01). M1 listed by 1998Sh02 from ce data. 5434α(338γ)(θ): A_2=+0.106 *20*, A_4=−0.001 *30* (1970Kr01); deduced δ=−0.188 *14*, assuming 3/2 → 3/2 transition and +0.247 *12* for 5/2 → 3/2.
487.5 *2*	0.109 *11*	646.09	$(5/2^+,7/2)$	158.631	$(7/2)^+$	[D,E2]	0.08 *7*	Eγ=487.4 *2* (1998Sh02), 488.0 *8* (1972HeYM), 487.6 *5* (1970Kr01),

$^{219}_{86}Rn_{133}$-20

$\gamma(^{219}Rn)$ (continued)

E_γ [†]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [c]	Comments
								488.0 *5* (1970Da08), 487.0 *5* (1968Br17). I_γ: NRM weighted average of Iγ=0.100 *9* (2019Ma02), 0.137 *5* (2015Co07), 0.100 *25* (2015Ko06), where uncertainty in 2015Co07 gets adjusted to 0.15. Others: 0.195 *25* (1998Sh02), 0.18 *9* (1972HeYM), 0.24 *7* (1970Kr01), 0.18 *4* (1968Br17), ≈0.29 (1970Da08), all seem high. Measured Iγ(per 100 decays of ^{223}Ra): 0.0064 *6* (2019Ma02), 0.0083 *3* (2015Co07), 0.0060 *15* (2015Ko06), 0.011 *6* (1972HeYM), 0.013 *6* (1970Kr01), ≈0.015 (1970Da08), 0.010 *2* (1968Br17).
[x]490.8[&] *3*	0.029[&] *12*							
500.0[&] *4*	0.023 *8*	514.42	(9/2$^+$)	14.400	(7/2)$^+$	[M1+E2]	0.09 *6*	I_γ: weighted average of Iγ=0.022 *8* (2015Co07), 0.024 *10* (1998Sh02). Iγ(per 100 decays of ^{223}Ra): 0.0013 *5* (2015Co07).
510.0[&] *4*	0.007[&] *5*	514.42	(9/2$^+$)	4.413	(9/2)$^+$	[E2]	0.034	
[x]523.2[&] *4*	0.029 *9*							I_γ: weighted average of Iγ=0.034 *9* (2015Co07), 0.024 *10* (1998Sh02). Iγ(per 100 decays of ^{223}Ra): 0.0021 *6* (2015Co07).
527.611 *13*	1.097 *13*	542.011	(7/2$^+$)	14.400	(7/2)$^+$	[M1+E2]	0.08 *5*	Eγ=527.6 *1* (1998Sh02), 527.611 *13* (1976Bl13), 527.0 *6* (1972HeYM), 527.5 *5* (1970Kr01), 527.0 *7* (1970Da08), 527.4 *3* (1968Br17). I_γ: weighted average of Iγ=1.09 *6* (2019Ma02), 1.094 *13* (2015Co07), 1.06 *4* (2015Ko06), 1.24 *8* (1998Sh02), 1.08 *13* (1976Bl13), 1.1 *3* (1972HeYM), 1.3 *3* (1970Da08), 1.31 *12* (1970Kr01), 1.30 *16* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.070 *4* (2019Ma02), 0.0659 *8* (2015Co07), 0.0637 *23* (2015Ko06), 0.055 *3* (1976Bl13), 0.064 *15* (1972HeYM), 0.073 *7* (1970Kr01), 0.070 *14* (1970Da08), 0.070 *7* (1968Br17).
[x]532.9[&] *4*	0.030 *10*							I_γ: weighted average of Iγ=0.047 *16* (2015Co07), 0.024 *10* (1998Sh02). Iγ(per 100 decays of ^{223}Ra): 0.0028 *9* (2015Co07).
537.6[&] *1*	0.049 *8*	542.011	(7/2$^+$)	4.413	(9/2)$^+$	[M1+E2]	0.08 *5*	I_γ: weighted average of Iγ=0.051 *8* (2019Ma02), 0.055 *10* (2015Co07), 0.037 *12* (1998Sh02). Measured Iγ(per 100 decays of ^{223}Ra): 0.0033 *5* (2019Ma02), 0.0033 *6* (2015Co07).
542.0[&] *4*	0.028 *7*	542.011	(7/2$^+$)	0.0	5/2$^+$	[M1+E2]	0.08 *5*	I_γ: weighted average of Iγ=0.019 *8* (2019Ma02), 0.043 *9* (2015Co07), 0.024 *10* (1998Sh02). Measured Iγ(per 100 decays of ^{223}Ra): 0.0012 *5* (2019Ma02), 0.0026 *6* (2015Co07).
545.8[&] *5*	0.034 *14*	672.5		126.726	(11/2)$^+$	[D,E2]	0.07 *6*	I_γ: unweighted average of Iγ=0.047 *10* (2015Co07), 0.020 *10* (1998Sh02). Iγ/100 decays=0.0028 *6* (2015Co07).
574.1[&] *7*	0.034 *14*	732.84	(5/2$^+$,7/2)	158.631	(7/2)$^+$	[D,E2]	0.06 *5*	I_γ: unweighted average of Iγ=0.049 *21* (2015Co07), 0.020 *10* (1998Sh02). Iγ/100 decays=0.0029 *13* (2015Co07).

$^{219}_{86}Rn_{133}$-21

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02 (continued)

$\gamma(^{219}Rn)$ (continued)

E_γ[†]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[c]	Comments
579.6[&] *3*	0.024[&] *10*	594.08	$(7/2)^-$	14.400	$(7/2)^+$	[E1]	0.0082	Others: Eγ=580.4 (1957Pi31). Eγ=580, Iγ≤2.0 (1966Po02). Iγ<0.05 (1970Da08).
584.3[&] *3*	0.024[&] *10*	598.721	$(5/2,7/2,9/2)^+$	14.400	$(7/2)^+$	[M1+E2]	0.06 *4*	
594.0[&] *3*	0.024[&] *10*	594.08	$(7/2)^-$	0.0	$5/2^+$	[E1]	0.0078	
598.721 *24*	1.432 *19*	598.721	$(5/2,7/2,9/2)^+$	0.0	$5/2^+$	[M1+E2]	0.06 *4*	Eγ=598.7 *1* (1998Sh02), 598.722 *24* (1976Bl13), 598.8 *10* (1972HeYM), 598.9 *5* (1970Kr01), 598.5 *7* (1970Da08), 598.5 *5* (1968Br17). I_γ: weighted average of Iγ=1.34 *6* (2019Ma02), 1.441 *19* (2015Co07), 1.43 *3* (2015Ko06), 1.5 *3* (1972HeYM), 1.48 *19* (1968Br17). Others: 1.66 *8* (1998Sh02), 1.65 *19* (1976Bl13), 1.8 *4* (1970Da08), 1.85 *17* (1970Kr01); all seem high as compared to values near 1.4, although, weighted average of all the values is 1.445 *23*, with reduced χ^2=2.3 as compared to critical χ^2=1.9. Measured Iγ(per 100 decays of ^{223}Ra): 0.086 *4* (2019Ma02), 0.0867 *12* (2015Co07), 0.0859 *18* (2015Ko06), 0.084 *4* (1976Bl13), 0.090 *18* (1972HeYM), 0.104 *10* (1970Kr01), 0.093 *15* (1970Da08), 0.080 *8* (1968Br17).
609.31 *4*	0.507 *25*	623.70	$(5/2^+,7/2,9/2^+)$	14.400	$(7/2)^+$	[D,E2]	0.048 *41*	Eγ=609.1 *1* (1998Sh02), 609.332 *36* (1976Bl13), 609.0 *10* (1972HeYM), 609.2 *5* (1970Kr01), 609.0 *10* (1970Da08), 609.1 *2* (1968Br17). Iγ from 2015Ko06. Evaluators assume that 2015Ko06 have applied correction for contributions from ^{219}Rn and ^{211}Pb decays for a line close to 609 keV. Others: 0.902 *10* (2015Co07), 1.00 *6* (1998Sh02), 0.98 *12* (1976Bl13), 0.68 *25* (1972HeYM), 1.21 *22* (1970Da08), 1.31 *17* (1970Kr01), 0.93 *13* (1968Br17). None of these authors mentioned contribution from ^{219}Rn and ^{211}Pb decays NRM weighted average of all the values is 0.905 *16*, with uncertainty in 2015Ko06 adjusted to 0.16. Measured Iγ(per 100 decays of ^{223}Ra): 0.0543 *7* (2015Co07, also from ^{219}Rn and ^{211}Pb decays), 0.0306 *15* (2015Ko06), 0.050 *3* (1976Bl13, also from ^{211}Pb decay), 0.041 *15* (1972HeYM), 0.073 *10* (1970Kr01), 0.063 *9* (1970Da08), 0.050 *5* (1968Br17). Absolute intensity of the 609.4γ from ^{219}Rn and ^{211}Pb decay can be 0.047% *7* according to data in the ENSDF database for these decays (as of April 2021), and 0.037% *9* according to DDEP evaluations: 2011BeZW for ^{219}Rn decay and 2013BeZP for ^{211}Pb decay.
619.1[&] *4*	0.080 *10*	623.70	$(5/2^+,7/2,9/2^+)$	4.413	$(9/2)^+$	[D,E2]	0.046 *39*	I_γ: weighted average of Iγ=0.085 *10* (2015Ko06) and 0.061 *20* (1998Sh02). Iγ/100 decays=0.0051 *6* (2015Co07). Other: Iγ/100 decays=0.0056 *12* (2015Co07) for a 619.8γ, assigned to the

$^{219}_{86}Rn_{133}$-22

γ(^{219}Rn) (continued)

E_γ [†]	I_γ [‡] [b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	α [c]	Comments
								decay of ^{219}Rn, although, this intensity agrees with that in 2015Ko06.
623.5[&] *3*	0.127 *13*	623.70	(5/2$^+$,7/2,9/2$^+$)	0.0	5/2$^+$	[D,E2]	0.042 *41*	Eγ=623.5 *3* (1998Sh02), 623.4 (1968Br17). Iγ: weighted average of Iγ=0.109 *31* (2019Ma02), 0.135 *14* (2015Co07), 0.121 *13* (2015Ko06), 0.15 *7* (1998Sh02), 0.15 *8* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.007 *2* (2019Ma02), 0.0082 *8* (2015Co07), 0.0073 *8* (2015Ko06), 0.008 *4* (1968Br17).
631.7[&][d] *7*	0.07[&] *5*	646.09	(5/2$^+$,7/2)	14.400	(7/2)$^+$	[D,E2]	0.042 *35*	Eγ=631.7 *7* (1998Sh02), 632.0 (1970Kr01), 632.0 *10* (1970Da08). Iγ: from 1998Sh02. Others: 0.57 *19* (1970Da08), <0.07 (1970Kr01), <0.037 (1972HeYM). Measured Iγ(per 100 decays of ^{223}Ra): <0.005 (1972HeYM), <0.01 (1970Kr01), 0.03 *1* (1970Da08).
641.7[&] *4*	0.029[&] *12*	646.09	(5/2$^+$,7/2)	4.413	(9/2)$^+$	[D,E2]	0.042 *35*	
646.1[&] *5*	0.07[&] *7*	646.09	(5/2$^+$,7/2)	0.0	5/2$^+$	[D,E2]	0.042 *34*	
696.9[&] *7*	0.012[&] *5*	711.34	(3/2$^+$ to 9/2$^+$)	14.400	(7/2)$^+$	[D,E2]	0.034 *28*	
711.3 *2*	0.056 *5*	711.34	(3/2$^+$ to 9/2$^+$)	0.0	5/2$^+$	[D,E2]	0.032 *27*	Eγ=711.3 *2* (1998Sh02), 711.2 *7* (1968Br17). Iγ: weighted average of Iγ=0.047 *6* (2019Ma02), 0.061 *5* (2015Co07), 0.063 *17* (1998Sh02), 0.065 *19* (1968Br17). Measured Iγ(per 100 decays of ^{223}Ra): 0.0030 *4* (2019Ma02), 0.0037 *3* (2015Co07), 0.0035 *10* (1968Br17).
718.4[&] *4*	0.024[&] *10*	732.84	(5/2$^+$,7/2)	14.400	(7/2)$^+$	[D,E2]	0.032 *27*	
728.4[&] *8*	0.042 *11*	732.84	(5/2$^+$,7/2)	4.413	(9/2)$^+$	[D,E2]	0.031 *26*	Iγ: weighted average of Iγ=0.040 *12* (2015Co07), 0.0049 *24* (1998Sh02). Iγ/100 decays=0.0024 *7* (2015Co07).
732.8[&] *6*	0.010[&] *5*	732.84	(5/2$^+$,7/2)	0.0	5/2$^+$	[D,E2]	0.030 *25*	
[x]737.2[&] *8*	0.0049[&] *24*							

[†] Weighted average from 1998Sh02, 1976Bl13, 1972HeYM, 1970Da08, 1970Kr01, and 1968Br17, unless otherwise specified. In many cases, the averaging procedure reproduces values from 1976Bl13, as these are the most precisely quoted values, thus dominating the weighting method. It should be noted that recent publications by 2021Si11, 2019Ma02, 2015Co07, 2015Ko06, and 2015Pi10 focused on the determination of precise absolute γ-ray intensities, and did not report independent measurements of γ-ray energies.

[‡] Based on measured intensities by 2021Si11, 2019Ma02, 2015Co07, 2015Ko06, 2015Pi10, 1998Sh02, 1972HeYM, 1970Da08, 1970Kr01 and 1968Br17, as stated under comments for individual γ rays. Following procedure in 2015Co07, relative photon intensities are normalized to 100 for the 154.2-keV γ ray, as this transition is not interfered by any of the γ rays from the successive decays of ^{223}Ra in equilibrium, whereas the most intense γ ray of 269.5 keV is not fully resolved from a strong line at 271.3 keV γ from the decay of ^{219}Rn. Measured absolute intensities (per 100 decays of ^{223}Ra) are listed under comments. 1998Sh02 provide only the relative intensity data.

[#] From ce data unless otherwise stated.

$^{219}_{86}Rn_{133}$-23

$\gamma(^{219}Rn)$ (continued)

@ Deduced by evaluators from BriccMixing code, unless otherwise stated.
& From 1998Sh02.
a Reported by 1998Sh02, based on internal conversion electron data obtained using a magnetic spectrometer by N.T. Phuoc, Ph.D. thesis, University of Paris (Sud) (1972).
b For absolute intensity per 100 decays, multiply by 0.0602 *3*.
c Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
d Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

$^{219}_{86}Rn_{133}$-24

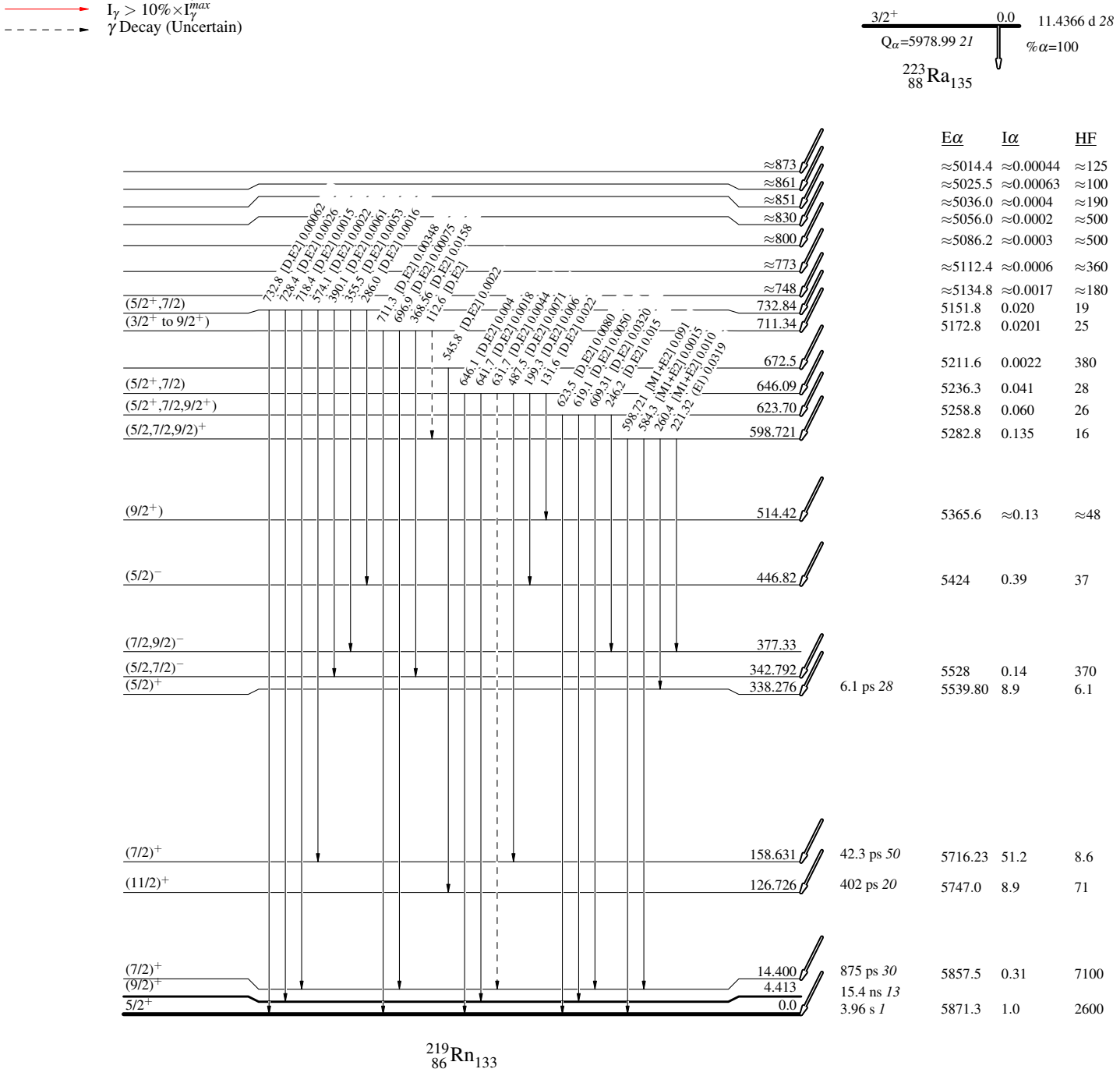
^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)



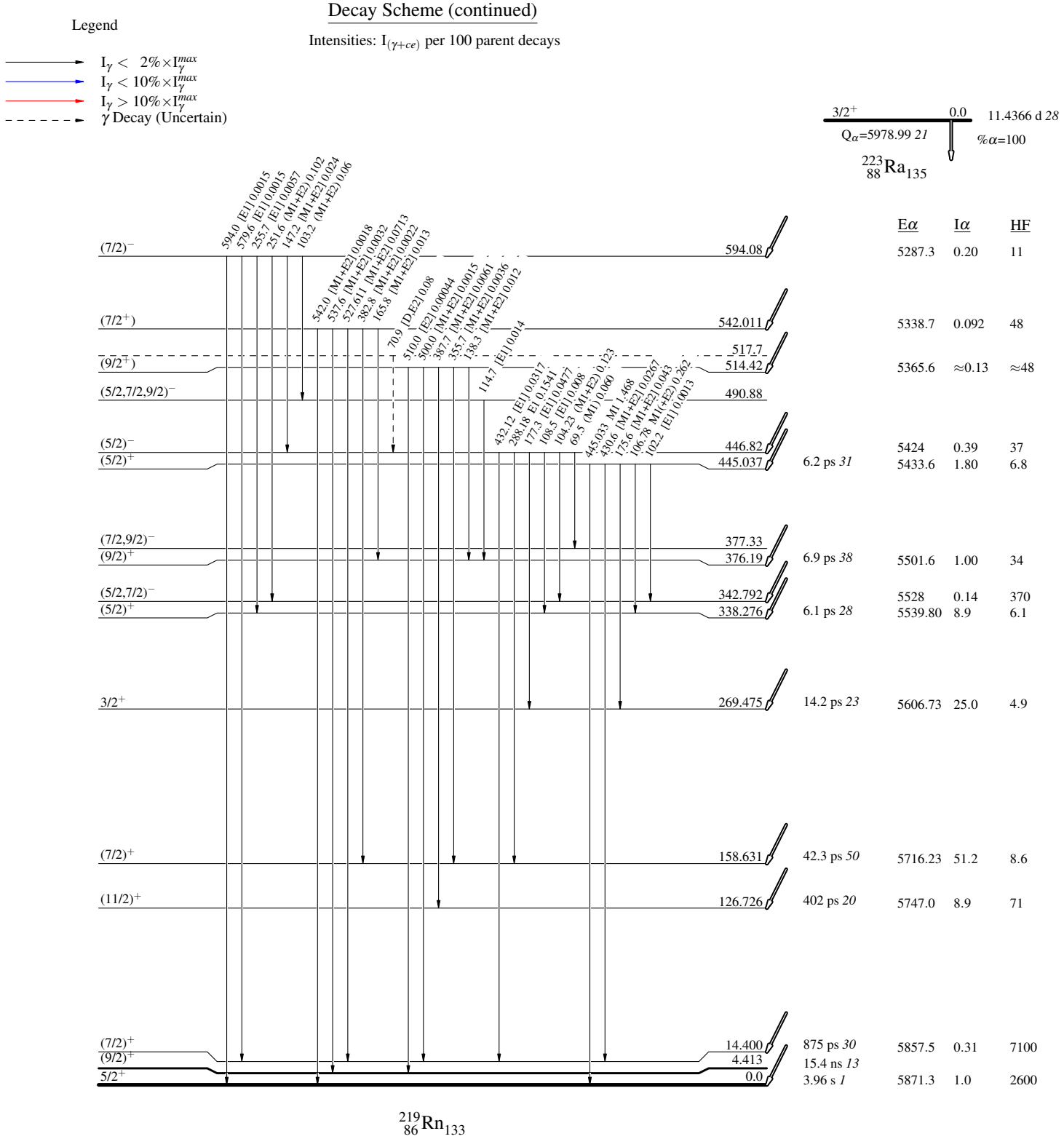
Eα	Iα	HF
≈5014.4	≈0.00044	≈125
≈5025.5	≈0.00063	≈100
≈5036.0	≈0.0004	≈190
≈5056.0	≈0.0002	≈500
≈5086.2	≈0.0003	≈500
≈5112.4	≈0.0006	≈360
≈5134.8	≈0.0017	≈180
5151.8	0.020	19
5172.8	0.0201	25
5211.6	0.0022	380
5236.3	0.041	28
5258.8	0.060	26
5282.8	0.135	16
5365.6	≈0.13	≈48
5424	0.39	37
5528	0.14	370
5539.80	8.9	6.1
5716.23	51.2	8.6
5747.0	8.9	71
5857.5	0.31	7100
5871.3	1.0	2600

$^{219}_{86}Rn_{133}$

^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



^{223}Ra α decay (11.4366 d) 2015Co07,2015Ko06,1998Sh02

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays