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Nuclear Data Sheets for A = 215

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Abstract: Available information on decay characteristics and level structure for all nuclei with A = 215 has been examined. A summary and evaluation of experimental data, including adopted values and comparison with theory are presented. The individual level schemes are discussed, and comments pertaining to adopted spin and parity assignments and to gamma-ray multipolarities are given. Any apparent discrepancies and inconsistencies are pointed out.

Much of the level information in the A = 215 mass chain is obtained from the α-decay of the A = 219 parent nuclei. While a summary of these results is reflected in both the level schemes and in discussions under "Level Properties" and "Gamma-Ray Properties", the actual data are presented under the respective A = 219 parent.

Decay energies and separation energies have been taken systematically from the 1977 Mass Adjustment (76WaBo, 77Wa08). Detailed comparison has been made between the adopted α-energies and the input values to the Mass Adjustment.

Organization of Material: A summary level scheme for A = 215 is shown first, followed by further detailed schemes as may be necessary to illustrate the data. The next short section summarizes radius parameters used for the calculation of hindrance factors (HF) for the entire A-chain. Detailed data for each nucleus (in order of increasing Z) are given as follows:

1. Experimental decay data
2. Experimental reaction data
3. Adopted level properties and spin assignments
4. Gamma-ray properties
5. Compilers' comments

A reference list is given at the end of this review.

Cutoff Date: All information available before January 1976 has been considered in detail; a limited scan of more recent work was completed in May 1977.

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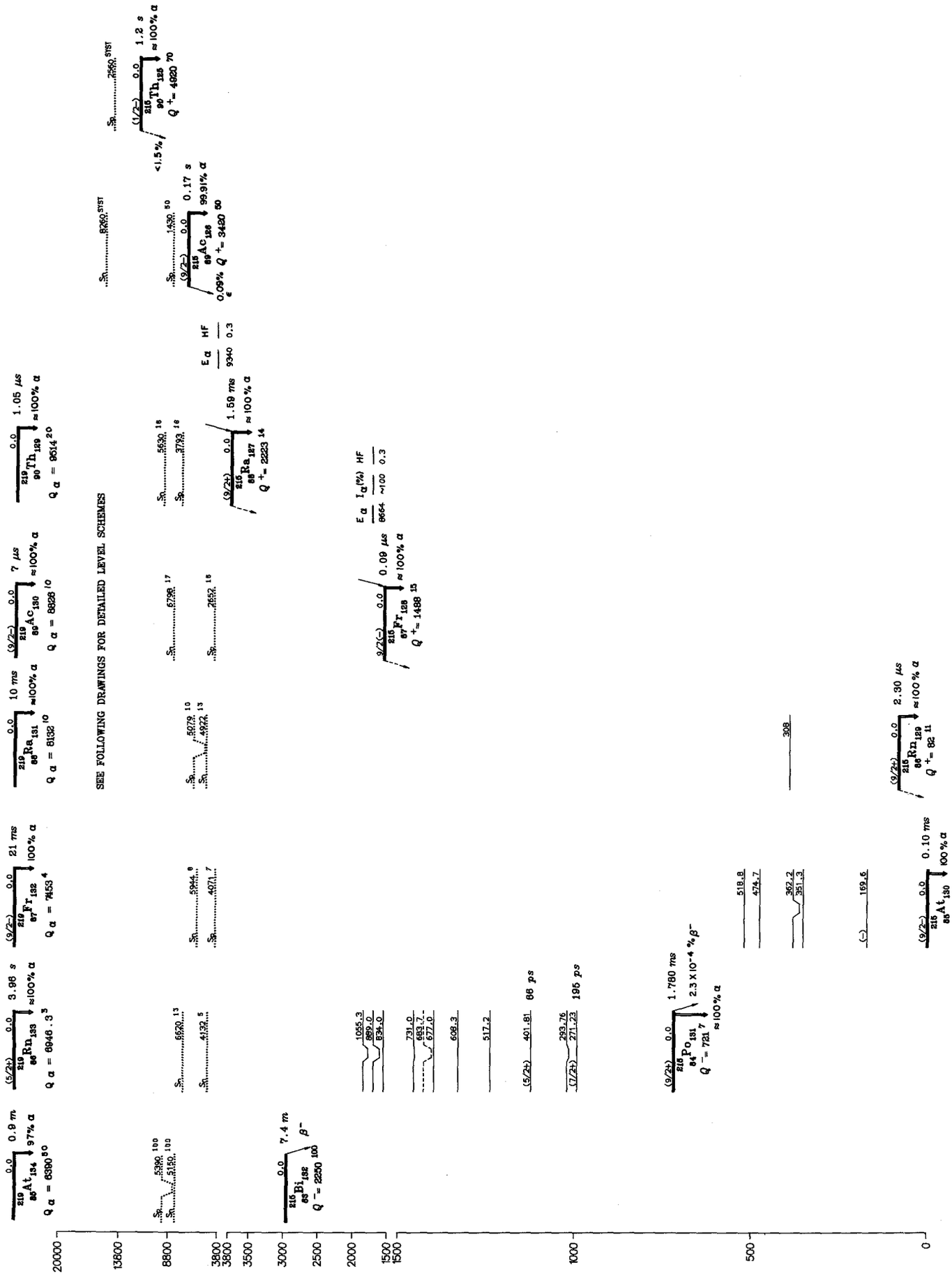
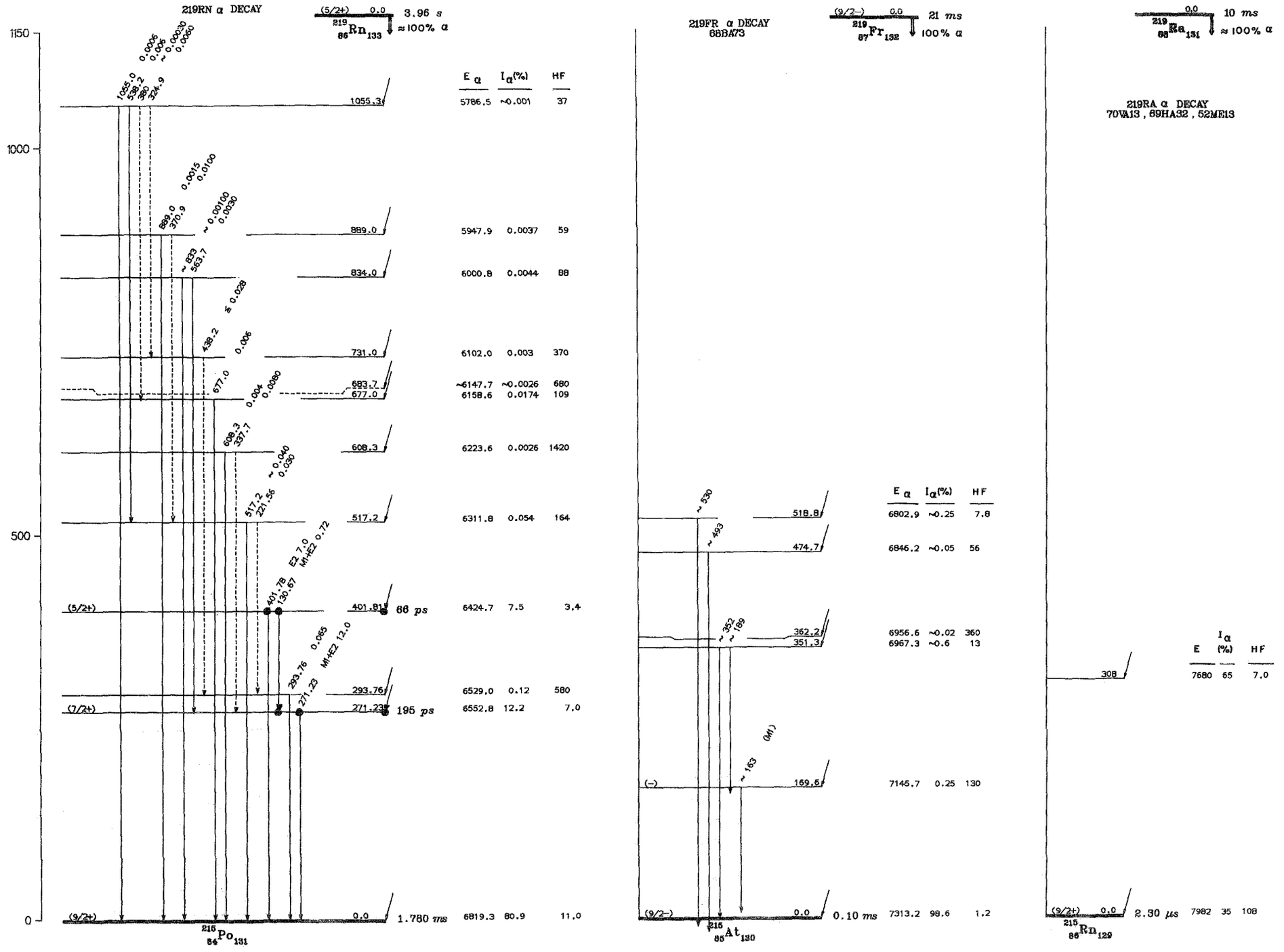

SEE FOLLOWING DRAWINGS FOR DETAILED LEVEL SCHEMES
Q α = 6390 8
Q α = 6946.3 3
Q α = 8132 10
Q α = 7453 4
Q α = 9614 20
Q α = 8826 10
Q⁻ = 2250 100
Q⁺ = 1488 15
Q⁺ = 2223 14
Q⁺ = 4820 70
Q⁺ = 3420 60
Q⁻ = 7217
Q⁺ = 82 11
Eα HF 9340 0.3
Eα Iα(%) HF 8664 ~100 0.3
20000
13800
8800
3800
3800
3500
3000
2500
2000
1500
1500
1000
500
0



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DRAWING 2 A = 215

α-Hindrance Factors

The following values of the nuclear radius, R, and the radius parameter, r_0, for the parent nuclei were used to obtain the α-hindrance factors shown in Drawing 1 for A=215.

More detailed information on the α-decay to the levels in nuclei with A=215 is listed under the respective A=219 parent.

Parent	R(fm)	r_0(fm)	Daughter
^{219}At	9.274	1.539	^{215}Bi
^{219}Rn	9.329	1.548	^{215}Po
^{219}Fr	9.386	1.557	^{215}At
^{219}Ra	9.443	1.567	^{215}Rn
^{219}Ac	9.116	1.512	^{215}Fr
^{219}Th	8.789	1.458	^{215}Ra

Ground-State Decay Q⁻=2250 100

$T_{1/2}$	8 m 2	53Hy83
	A7.4 m 6	65Nu03

β^- to ^{215}Po 53Hy83

The presence of β^--decay is based on the observation of α-decay of the ^{215}Po daughter.[a]

Assignment[a]

Descendent of ^{219}At	53Hy83,65Nu03
Parent of ^{215}Po	53Hy83
Not ^{219}Rn or descendent of ^{219}Rn	65Nu03

[a]Neither 53Hy83 nor 65Nu03 was able to successfully extract the observed activity directly from the ^{227}Ac Source using Bi carriers

$(AcA)^{215}_{84}Po_{131}$-1

Ground-State Decay

Q^-=721 7
Q_α=7526.5 8

$T_{1/2}$	1.83 ms 4			42Wa04
	1.778 5		delay coin	61Vo06
	1.784 6		delay coin	71Er02
	A1.780 ms 4	Weighted average		

α to ^{211}Pb[a] ≈100%

≈100% see β to ^{215}At

	I_α%	E_α	ΔQ_α		
α_0	–	7384.1 10	–	s	61Ry02
	≈100	7386.4[b] 10	–	s	62Wa18
	–	A7386.4 8	–	s	71Gr17
α_{439}	≈0.034	≈6956.7[b]	438	s	62Wa18
α_{445}	≈0.022	≈6950.1[b]	447	s	62Wa18

$Q_\alpha = E(\alpha_0) + E_{recoil}$ = 7526.5 8 76WaBo

β^- to ^{215}At A2.3×10^{-4}%

≈5×10^{-4}% 44Ka01,44Ka02
A2.3×10^{-4}% 2 50Av61
≈4×10^{-4}% 55Ad09

Based on the observation of the ≈8.0-MeV α attributed to the ^{215}At daughter.

$\gamma(^{211}Pb)$ following α-decay

	I_γ†	E_γ			
γ_1	–	443[c]	I_K/I_γ<0.05	$\alpha\gamma$, semi	65Va10
	0.048[d] 5	438.7 3		semi	68Br17
	0.064 2	438.9		semi	70Da09
	A≈0.04[e]	A438.8 3			

†Photons per 100 α-decays of ^{215}Po

[a] α-subscript gives the adopted energy, to the nearest keV, of the daughter level

[b] The original E_α-values of 62Wa18 have been increased by 2.3 keV because of a change in the calibration energy of the ^{215}Po α_0 from 7384.1 to 7386.4 (71Gr17, see above)

[c] 65Va10 see this γ-ray in $(\alpha_{439}+\alpha_{445})$ γ-coincidence results. No K X-rays were observed

[d] 68Br17 suggest I_γ may contain some contribution from a 438.7 γ-transition in ^{211}Bi following the β-decay of the ^{211}Pb daughter. The intensity of the ^{211}Bi 1270.2→831.8 transition is ≤0.04† (see 71PaMa)

[e] See footnote f on ^{219}Rn-2

A Adopted value

Ground-State Decay continued

$\alpha\gamma$	$(\alpha_{438}+\alpha_{444})(443\gamma)$	semi,scin	65Va10

Assignment

Well known. See, for example, 64Hy02, p. 423.

Adopted Level Properties, Spin Assignments

For additional information, see data under ^{219}Rn: α to ^{215}Po, $\gamma(^{215}Po)$, $\alpha\gamma$, $\alpha\gamma(t)$, $\alpha\gamma(\theta)$, $\alpha\gamma(t_\rightarrow)$, and $\gamma\gamma(\theta)$.

E(level)	J^π	Properties, J^π Reasons, Comments
0	$(9/2^+)$	$T_{1/2}$=1.780 ms 4 The shell model and analogy with ^{217}Rn (73Ma64) and ^{213}Po (73Ma63) would predict a $9/2^+$ g.s. assignment. This is supported by the favored α-decay to the $(9/2^+)$ ^{211}Pb g.s. (α-hindrance factor=1.4 using a value of 9.172 fm for the ^{211}Pb radius). A number of authors have suggested a $7/2^-$ g.s. spin assignment based on results of $(\alpha_{271})(271\gamma)$-angular correlation experiments [i.e., 67Le05, 69Be67, 70Da09; see $\alpha\gamma(\theta)$ under ^{219}Rn]. The analyses of these results are, however, open to some question. In order to reduce the number of possible spin sequences, several authors have assumed a 3/2 spin for the ^{219}Rn g.s. (69Be67, 70Da09). This assumption contrasts with the observation of 70Kr01 that, based on $\alpha\gamma(\theta)$ results for ^{223}Ra, a g.s. spin of 5/2 could not be ruled out for ^{219}Rn. Earlier authors (61Br32,65Cl05,67Le05) also used mixing ratios for the 271γ which were larger than are currently accepted (values of δ^2>25 as opposed to $\delta^2\leqslant$19; see also γ-Ray Properties under ^{215}Po). This larger value of δ^2 can lead to significantly different allowed spin values. 72HeYM, for example, indicate that $\alpha\gamma(\theta)$ results are only consistent with the frequently proposed 3/2–5/2–7/2 spin sequence for ^{219}Rn g.s. and ^{215}Po 271 keV and g.s.) if $\delta(271\gamma)<-5$ (δ^2>25). See $\alpha\gamma(\theta)$ under ^{219}Rn.

continued on next page

Adopted Level Properties, Spin Assignments continued

E(level)	J^π	Properties, J^π Reasons, Comments
0	continued	A g.s. spin of 7/2 for ^{215}Po has been explained on the basis of the Nilsson model (see, for example, 70Da09). 70Kr08 indicate that for small negative deformations ($\delta\approx-0.05$) the odd neutron should occupy the $11/2^+[606]$ orbit with the $9/2^+[604]$ being the next higher intrinsic state. The validity of a Nilsson discription of ^{215}Po is, however, highly suspect in view of the lack of observed rotational structure in ^{214}Po and ^{216}Po and the high excitation energy of their first 2^+ levels (609 and 545 keV, respectively).
		70Kr08 propose an $11/2^+$ assignment for ^{215}Po based on $\alpha\gamma(\theta)$, $\alpha\gamma(t_\rightarrow)$ and $\gamma\gamma(t_\rightarrow)$ results (see data under ^{219}Rn). The authors explain this spin as a possible weak coupling between $g_{9/2}$ and $i_{11/2}$ single-particle levels and a collective excitation of the even-even core. This explaination could serve to account for the large hindrance observed in the M1 transition rates between the 401,271 and g.s. [see $\alpha\gamma$(t) results on ^{219}Rn-3].
		An $11/2^+$ assignment for the ^{215}Po g.s. would also require, via $\alpha\gamma(\theta)$ and $\alpha\gamma(t_\rightarrow)$ results, a $7/2^+$ assignment for the ^{219}Rn g.s. and also a g.s. spin $>3/2^+$ for ^{223}Ra. Such assignments, especially in the case of ^{223}Ra, are in disagreement with the spins of 3/2 or $5/2^+$ and $1/2^+$ proposed, respectively, for these nuclei (see discussion of g.s. spin assignments on ^{219}Rn-6 and ^{223}Ra-9).
		72HeYM propose a $9/2^+$ g.s. spin based on $\alpha\gamma(\theta)$ results for both the 271- and 401-keV γ's. The main assumptions in the analysis of the results were that the ^{223}Ra g.s. was $1/2^+$ and that, because of the low α-hindrance factors of the levels involved, only L=4 α-wave admixtures of less than 10% were considered. A consequence of these results is a $5/2^+$ assignment for the ^{219}Rn g.s., in contrast to previous assumptions. 72HeYM also indicate that the linear polarization results of 70Kr08 do not provide much additional certainty on the correct choice of spins.[a]
		The compilers have adopted the $9/2^+$ assignment since it appears to be most consistent with the known information on ^{215}Po as well as ^{219}Rn and ^{223}Ra. The compilers do not feel, however, that an $11/2^+$ spin can be completely ruled out. Note that, as previously indicated, any latter change in the adopted $9/2^+$ assignment will also affect the other ^{215}Po spins as well as those in ^{219}Ra.

[a]72HeYM state that the spin sequence adopted by 70Kr08 (7/2–9/2–11/2 for the ^{219}Rn g.s. and ^{215}Po 271 and g.s.) give a theoretical B_2-value 2 error bars away from the experimental value, while the (5/2–7/2–9/2) sequence adopted by 72HeYM gives a theoretical B_2 which is 3 error bars away. (See data on ^{219}Rn–4.)

Adopted Level Properties, Spin Assignments continued

E(level)	J^π	Properties, J^π Reasons, Comments
271.23 5	$(7/2^+)$	$T_{1/2}$=195 ps 5
		A variety of spins have been proposed for this level based primarily on $\alpha\gamma(\theta)$ results (see on ^{219}Ra-4). Of the more recent results 67Le05,69Be67 and 70Da09 propose a $5/2^+$ assignment; 70Kr08 suggest a $9/2^+$ spin and 72HeYM assign $7/2^+$.
		The spin of this level is correlated with the g.s. spin via $(a_{271})(271\gamma)$ angular correlation results. The $7/2^+$ assignment adopted by the compilers is therefore predicted by the adopted g.s. spin of $9/2^+$ for the reasons discussed under that assignment. A g.s. spin assignment of $11/2^+$ would require a $9/2^+$ spin for this level.
		The low α-hindrance factor to this level, the g.s., and the 401-keV level suggests a relatively close correlation with the ^{219}Rn g.s. configuration.
293.76 15		Populated in α-decay. See also 22.5γ under Gamma Properties on ^{215}Po-3.
401.81 8	$(5/2^+)$	$T_{1/2}$=66 ps 7
		Based on $\alpha\gamma$-angular correlation results, as discussed under the g.s. spin assignment, a number of possible spins have been proposed for this level; $5/2^+$ has been suggested by 67Le05 and 70Da09; 9/2 or $11/2^+$ by 70Kr08; and 5/2 or $9/2^+$ by 72HeYM.
		The spin values adopted by the compilers are based on the $\alpha\gamma(\theta)$ results and the adopted g.s. spin, as discussed previously. A g.s. spin assignment of $11/2^+$ would require either a 9/2 or $11/2^+$ assignment for this level.
		Although the results of 72HeYM indicate that a $9/2^+$ assignment is also possible for this level, the compilers have adopted a $5/2^+$ spin based on the E2 nature of the 401.8γ and on the low α-hindrance factor (3.4) for α-decay to this level. The $\alpha\gamma(\theta)$ analyses for the $5/2^+$ spin are consistent with L=0,2 α-wave admixtures (δ_α^2=0.25), while a $9/2^+$ spin would require L=2,4 admixtures (δ^2=0.04) (see on ^{219}Rn-4).
517.2 3		For additional information see discussion of 115.4,221.56, and 517.2 γ-rays on ^{215}Po-3.
608.3 10		
677.0 10		There is a discrepancy of $\approx$4 keV between the excitation energy of this level reported in α-decay (672.6 keV) and the γ-energy associated with its decay (see 677γ and 377γ under Gamma Properties on ^{215}Po-3).
(683.7 3)		Level Proposed by 62Wa18 based on α-decay results. 65Va10 question the assignment of this α-group to ^{219}Rn (see footnote d on ^{219}Rn-1 and also 388γ on ^{215}Po-3).
731.0 10		Populated in α-decay. See also comments on the 438.2γ on ^{215}Po-3.
834.0 15		
889.0 15		
1055.3 12		

$(AcA)^{215}_{84}Po_{131}$ -3

Gamma-Ray Properties

E_γ	Λ	Λ Reasons, Comments
$X_{22.5}$		A 294→271 transition postulated by 70Da09 on the basis of an intensity balance.
$X_{115.4\ 5}$		γ tentatively assigned as a ^{215}Po 517→402 transition by 68Br17.
130.67 8	M1+E2 $\delta^2=0.32^{+7}_{-5}$	Multipolarity and mixing ratio established by L_1:L_2:L_3 ratios. See also under γγ(θ) results on ^{219}Rn-5.
(221.56 17)		Placement possible as a 517→294 ^{215}Po transition, or in the ^{219}Rn decay scheme, or both. (See footnote g, ^{219}Rn-1.) Energy agreement for ^{215}Po placement is not particularly good.
271.23 5	M1+E2 $\delta^2=14.6^{+48}_{-26}$ $\delta=(+)$	As one of the strongest γ-rays observed in this decay chain, this 271→g.s. transition has been investigated extensively (see data under ^{219}Rn). The multipolarity has been determined by K:L_1:L_2:L_3 ratios and by α_K. A number of different values for the mixing ratio, δ^2, have been deduced from ce-results. Values of 4, 8.1, 37.5, 11.5, 14.6, ⩾13, and 9 have been reported by 57Pi31,65Va10,67Le05,69Be67,70Da09, 70Kr08 and 72HeYM, respectively. The value of δ^2 is important in interpreting the results of angular-correlation experiments involving this γ-ray. Because of the intensity of this γ, it is frequently employed as the standard for determining relative γ-intensities. The compilers have adopted a value of 9.9 *10* for the absolute intensity of this transition and have normalized the measured relative intensities to this value. (see also footnote a on ^{219}Rn-2.)
293.76 15		Placed as 294→g.s. transition.
(324.9 10)		Placement as 1055→731 transition suggested by 67Da20.
(337.7 10)		Placement as 608→271 transition suggested by 67Da20.
(370.9 15)		889→576 placement based on αγ-results of 65Va10.
$X_{377.0\ 6}$		Placement as 677→294 transition tentatively suggested by 68Br17. Energy agreement is not good and γ not reported by other authors.
(380)		65Va10 report a 1055→677 transition based on αγ-coincidence results. The exact energy of this transition is not given.
$X_{388.0\ 6}$		Tentative placement as 684→294 transition suggested by 68Br17. Identification as a ^{215}Po γ-ray is tentative.
401.78 8	E2 $\delta^2>10$	Both α_K and the intensity balance of the 402 level suggest a relatively pure E2 transition. 70Kr08 indicate that, based on αγ(θ) and αγ(↑→) results, $\delta^2>32$ [see Comments on $(\alpha_{401})(401\gamma)(\uparrow\rightarrow)$ results on ^{219}Rn-5].

Gamma-Ray Properties continued

E_γ	Λ	Λ Reasons, Comments
(438.2 6)		The αγ-coincidence results of 65Va10 establish a γ of this energy as a transition in ^{211}Pb(see on ^{215}Po-1). A second γ-ray of this energy is also proposed in the ^{211}Bi β-daughter (see 71PaMa). The presence of an additional γ at this energy as a 731→294 transition must be considered tentative because of uncertainties in the values of I_γ. (See also footnote f on ^{219}Rn-2.)
517.2 3		The αγ-results of 65Va10 place this as a 517→g.s. transition. It should be noted that the intensity reported by 70Da09 for this γ-ray is lower by a factor of 2 than that reported by earlier authors.
538.2 15		αγ-coincidence results place γ as a 1055→517 transition.
563.7 15		Placed by αγ-coincidence data as an 834→271 transition.
608.3 10		608→g.s. transition from αγ-coincidence results
$X_{666.0\ 40}$		Not placed in decay scheme.
677.0 10		Placed as 677→g.s. transition from αγ-coincidence results. The E_γ-values reported by various authors are not in good agreement either with each other or with the excitation energy of 672.6 keV determined from α-decay. The value of I_γ reported by 70Da09 also differs considerably with previous value. The compilers suggest the presence of two γ-rays at this energy, one of which may be the 675.2 *3* γ-ray (I_γ=0.10) seen in the decay of ^{214}Pb(71PaMa).
(833)		65Va10 report a 834→g.s. transition based on αγ-coincidence results. The exact energy of this γ-ray is not given.
889.0 15		αγ-results place γ as a 889→g.s. transition.
1055.0 20		αγ-results place γ as a 1055→g.s. transition.

Comment

B. Level Scheme

The ^{215}Po level scheme is based on α- and γ-decay information from the ^{219}Ra parent. Spin assignments in ^{215}Po are strongly coupled with ^{219}Rn spin assignments. For specific information or comments on levels or spin assignments, see discussion of the specific level under Adopted Level Properties, Spin Assignments. Comments on γ-rays, including γ's not shown in the decay scheme, are given under Gamma-Ray Properties.

XNot shown in ^{215}Po decay scheme

$^{215}_{85}At_{130}$

$^{215}_{85}At_{130}$

Ground-State Decay

β-stable Q_α=8178 4

$T_{1/2}$ 0.10 ms 2 51Me10

α to ^{211}Bi[a] 100%

	I_α%	E_α	ΔQ_α		
α_0	–	8007[b] 20	–	ic	51Me10
	100	8010[c] 10	(0)	semi	66Gr07
	–	[A]8026 4	–	semi	73BoXW
α_{405}[d]	0.05 2	7610[c] 10	(408)	$\alpha\gamma$,semi	66Gr07

$Q_\alpha = E(\alpha_0) + E_{recoil}$ = 8178 4 76WaBo

$\gamma(^{211}Bi)$ following α-decay

	I_γ	E_γ		
γ	weak	≈404	$\alpha\gamma$,scin	66Gr07
$\alpha\gamma$	(E_α>6.6 MeV)(404γ)		semi,scin	66Gr07
	(α_{404})(E_γ>400 keV)		semi,scin	66Gr07

Assignment

Descendent ^{219}Rn	44Ka02
Descendent ^{227}Th	50Av61
Assignment from α-β decay cycle	44Ka02,50Av61
Descendent ^{227}Pa	51Me10

[a] α-subscript gives the adopted energy, to the nearest keV, of the daughter level

[b] The original E_α-value of 51Me10 has been increased by 7 keV because of changes in the calibration energies of the ^{212}Bi α_0 and α_{40} and the ^{211}Bi α_0 from 6081, 6042, and 6619, respectively, to 6090.1, 6050.8, and 6623.1 keV.

[c] The α-calibration standards used by 66Gr07 were not given. The compilers have, however, increased the original α-energy values reported by 66Gr07 by 10 keV based on changes in the energy value of other α-peaks present in their data

[d] This α-decay is assumed to populate the known level in ^{211}Bi at 404.8 keV

[A] Adopted value

[B] See Comment B, this page

[X] Not placed in ^{215}At level scheme

Adopted Level Properties, Spin Assignments

The levels of ^{215}At are based on the α-decay information from the ^{219}Fr parent. (See ^{219}Fr α to ^{215}At listing.)

E(level)	J^π	Properties, J^π Reasons, Comments
0	$(9/2^-)$	$T_{1/2}$=0.10 ms 2 J^π suggested by the shell model, a $(1h_{9/2})^3$ configuration, and by analogy with both ^{213}At and ^{217}At. This assignment is supported by the favored α-transition to the $(9/2^-)$ ^{211}Bi g.s. (α-hindrance factor=2.7).
169.6 20	(–)	π based on tentative M1 transition to the g.s.
351.3 20		Seen in α-decay. Low α-hindrance factor (13) suggests a configuration similar to the ^{219}Fr and ^{215}At g.s.
362.2 30		Weakly populated in α-decay.
[B]474.7 25		Weakly populated in α-decay.
[B]518.8 20		The low α-hindrance factor to this level (7.8) suggests a configuration similar to the ^{215}At and ^{219}Fr g.s.

Note: The log ft ≈4.6 for β-decay from ^{215}Po$(9/2^+)$ would suggest a low-lying positive-parity level in ^{215}At.

Gamma-Ray Properties

Gamma-ray data are listed under ^{219}Fr-$\gamma(^{215}$At) and are based on the work of 66Gr07. No experimental uncertainties or intensities were given for the observed γ's.

E_γ	Λ	Reasons, Comments
163	(M1)	Tentative multipolarity based on ratio of I(K X-ray)/I_γ observed in $\alpha\gamma$-coincidence results.
[X](178)		γ-ray inferred from $\alpha\gamma$-results.
189		
352		
[B]493 [B]530		The reported energies of these γ-rays may be in error.

Comment

B. There exists an apparent discrepancy between the level energies observed in α-decay and the γ-energies depopulating the levels. See footnote d on ^{219}Fr–1 for additional information.

$^{215}_{86}Rn_{129}$

$^{215}_{86}Rn_{129}$

Ground-State Decay

Q^+= 82 11
Q_α=8840[b] 8

$T_{1/2}$ 2.30 μs 10 70Va13

α to ^{211}Po[a]

	I_α	E_α	ΔQ_α		
a_0[b]	–	8600 100	–	ic	52Me13
	–	8670 20	–	semi	69Ha32
	100	A8674[c] 8	–	semi	70Va13

$Q_\alpha = E(a_0) + E_{recoil}$ = 8840[b] 8

Note: 76WaBo used $E(a_0)$ = 8675 8 as input to the mass adjustment. No adjustment of this value was required.

Assignment

Descendent ^{227}U 52Me13,69Ha32
Predecessor of ^{211}Po 69Ha32

^{231}Pa(p,5n)^{227}U(3α) excitation function 69Ha32

Reactions

^{208}Pb(^{18}O,3n)^{223}Th(2α) 70Va13

^{232}Th(α,9n)^{227}U(3α) 52Me13

^{231}Pa(p,5n)^{227}U(3α) 69Ha32

See also Reactions under ^{219}Ra

[a] α-subscript gives the adopted energy, to the nearest keV, of the daughter level

[b] The value for Q_α has been obtained by assuming that the observed α-group populates the ^{211}Po g.s. This assumption is consistent with predictions for the value of $E(a_0)$ based on α-decay systematics

[c] The original E_α-value of 70Va13 has been decreased by 1 keV because of a change in the calibration energy of the ^{212}Po α-standard from 8785.4 to 8784.3 keV (71Gr17)

Adopted Level Properties, Spin Assignments

For additional information see under ^{219}Ra, α to ^{215}Rn.

E(level)[d]	J^π	Properties, J^π Reasons, Comments
0	$(9/2^+)$	$T_{1/2}$=2.30 μs 10 Assignment is suggested by analogy with ^{213}Rn, ^{217}Rn, and ^{213}Po. This assignment is supported by the favored α-decay to the $(9/2^+)$ g.s. of ^{211}Po (α-hindrance factor = 1.5 using a radius value of 9.331 fm for ^{215}Rn). Assignment of the odd neutron to the $(2g_{9/2})$ is expected by the shell model.
308 10		Strongly populated in ^{219}Ra α-decay.

[d] See also footnote b under ^{219}Ra

[A] Adopted value

$^{215}_{87}Fr_{128}$

$^{215}_{87}Fr_{128}$

Ground-State Decay

Q^+=1488 15
Q_α=9537[a] 9

$T_{1/2}$	<0.5 μs	70Bo13
	0.087 6	73HaZO
	0.12 2	74No02
	[A]0.09 μs 1 Weighted average	

α to ^{211}At ≈100%

log ft systematics

	I_α%	E_α	ΔQ_α		
α_0	–	≈9400	–	semi	61Gr43
	100	9366[b] 15	–	semi	70Bo13
	–	9370 20	–	semi	73HaZO
	–	9355[c] 10	–	semi	74No02
		[A]9360 8 Weighted average			

$Q_\alpha = E(\alpha_0) + E_{recoil}$ = [A]9537[a] 9 76WaBo

Note: 76WaBo used $E(\alpha_0)$ = 9359 9 as input to the mass adjustment. No adjustment of this value was required.

Q_α=9380	α-decay syst.	66Vi03
Q_α=9306	Theory	67Ze05
Q_α=9050	Theory	69GaGe

Assignment

^{208}Pb(^{11}B,4n)^{215}Fr	excit. function	61Gr43
Descendent of ^{223}Pa		70Bo13
^{205}Tl(^{22}Ne,4n)^{223}Pa(2α) ^{208}Pb(^{19}F,4n)^{223}Pa(2α) ^{209}Bi(^{20}Ne,α2n)^{223}Pa(2α)	excit. function, cross bombardment	70Bo13

[a]The value for Q_α has been obtained by assuming that the observed α-group populates the ^{211}At g.s. This assumption is consistent with predictions of Q_α based on theory and α-decay systematics (see above note)

[b]The original E_α-value of 70Bo13 has been increased by 1 keV because of a change in the calibration energy of the ^{212}Po α from 8785.0 to 8784.3 keV *6* (71Gr17)

[c]It should be noted that the value for E_α quoted by 74No02 is based on relatively poorly known α-energy standards (primarily ^{217}Ac E_α=9650 *10* and ^{218}Ac E_α=9205 *10*)

[A]Adopted value

Metastable State

Not observed

74No02 report that, following the ^{209}Bi(^{12}C,α2n)^{215}Fr reaction, no delayed γ-rays were observed in a time interval >10 ns.

Reactions

^{205}Tb(^{13}C,3n)^{215}Fr	65 MeV	73HaZO
^{208}Pb(^{11}B,4n)^{215}Fr	excitation functions	61Gr43
^{209}Bi(^{12}C,α2n)^{215}Fr	73–80 MeV	74No02

Authors obtained the angular distribution for the reaction between ≈3° and 30°(lab). The distribution exhibits a broad maximum at ≈15°(lab) in contrast to the ^{209}Bi(^{12}C,xn) reactions also studied.

Adopted Level Properties, Spin Assignments

For additional information see data under ^{219}Ac, α to ^{215}Fr.

E(level)	J^π	Properties, J^π Reasons, Comments
0	$9/2^{(-)}$	$T_{1/2}$=0.09 μs 1 The spin assignment is determined by the favored α-decay to the $9/2^{(-)}$ g.s. of ^{211}At (α-hindrance factor=0.45 using a radius of 8.922 fm for ^{215}Fr). This assignment is strongly supported by analogy with ^{217}Fr, ^{213}Fr, ^{213}At, and ^{217}Ac. The shell model would suggest a $(1h_{9/2})^5$ configuration by analogy with ^{211}At.

$^{215}_{88}Ra_{127}$

Ground-State Decay — Q^+=2223 14; Q_α=8867[c] 4

$T_{1/2}$

1.6 ms	61Gr43,62Gr20
1.7 2	68Va18
1.56 10	70To18
$A_{1.59\ ms\ 9}$ Weighted average	

α to ^{211}Rn[a] ≈100% — log ft systematics

	I_α§	E_α	ΔQ_α		
α_0	–	8700	–	semi	61Gr43
	–	8730	–	semi	66Ro12
	95.7 10	8699[b] 5	–	semi	68Va18
	96.0	8701 5	–	semi	70To18
	A,U95.9 10	A,W8700 4			
α_{538}	1.3 5	8169[b] 8	(540)	semi	68Va18
	1.4	8175 8	(536)	semi	70To18
	A,U1.35 40	A,W8172 6	A_{538}		
α_{833}	3.0 5	7881[b] 8	(833.5)	semi	68Va18
	2.6	7885 8	(831.5)	semi	70To18
	A,U2.8 4	A,W7883 6	$A_{832.5}$		

§α-particles per 100 α-decays of ^{215}Ra

$Q_\alpha=E(\alpha_0)+E_{recoil}$=8867[c] 5 — 76WaBo

Note: 76WaBo used $E(\alpha_0)$ = 8702 5 as input to the mass adjustment. No adjustment of this value was required.

Assignment

$^{209}Bi(^{11}B,5n)^{215}Ra$ excitation function — 61Gr43,62Gr20

$^{206}Pb(^{16}O,3n)^{219}Th(\alpha)$ 85–120 MeV excitation function, $\sigma_{max.}$ at ≈95 meV — 68Va18

$^{206,208}Pb(^{20}Ne,\alpha xn)^{219}Th(\alpha)$ — 68Va18

Adopted Level Properties, Spin Assignments

For additional information see data under ^{217}Th, α to ^{215}Ra.

E(level)	J^π	Properties, J^π Reasons, Comments
0	$(9/2^+)$	A $(2g_{9/2})$ configuration for the odd neutron is suggested by the shell model. This assignment is supported by the α-decay systematics of N=127, even-Z nuclides (i.e., ^{211}Po and ^{213}Rn). These systematics show that the $9/2^+$ parent decays primarily (≈99%) to the $1/2^-$ g.s. with ≈1% branching to $5/2^-$ and $3/2^-$ levels at ≈550 and ≈860 keV, respectively. (α-hindrance factor for decay to the g.s. 538, and 833 levels are 37, 97, and 6.5, respectively, using a radius value of 8.640 fm for ^{215}Ra.)

[a]α-subscript gives the adopted energy, to the nearest keV, of the daughter level

$^{215}_{89}Ac_{126}$

Ground-State Decay — Q^+=3420 50; Q_α=7746[e] 5

$T_{1/2}$. 0.17 s 1 — 68Va04

α to ^{211}Fr $A_{99.91\%}$

99.91% 2		semi	68Va04

	I_α	E_α	ΔQ_α		
α	–	7604[d] 5	–	semi	68Va04

$Q_\alpha=E(\alpha_0)+E_{recoil}$=7746[e] 5 — 76WaBo

Note: 76WaBo used $E(\alpha_0)$ = 7602 5 as input to the mass adjustment. No adjustment of this value was required.

ϵ to ^{215}Ra $A_{0.09\%}$

†0.09% 2†	semi	68Va04

†Branching ratio was obtained by observing the presence of the 8.70 MeV 2 ^{215}Ra α-group in the ^{203}Tl (^{16}O,4n) ^{215}Ac results

Assignment

$^{203}Tl(^{16}O,4n)^{215}Ac$ 70–155 MeV
$^{205}Tl(^{16}O,6n)^{215}Ac$ 80–130 MeV
$^{209}Bi(^{12}C,6n)^{215}Ac$ 60–120 MeV
} excitation functions — 68Va04

Parent ^{211}Fr; Parent ^{215}Ra — 68Va04

$^{197}Au(^{20}Ne,2n)^{215}Ac$ not observed (90–200 MeV ^{20}Ne) — 68Va04

Adopted Level Properties, Spin Assignments

E(level)	J^π	Properties, J^π Reasons, Comments
0	$(9/2^-)$	The spin assignment is suggested by the shell model and by analogy with ^{213}Fr and ^{217}Ac. (α-hindrance factor for decay to the ^{211}Fr g.s.=1.3.)

[b]The original E_α-values of 68Va18 have been increased by 1 keV because of a change in the calibration energies of the ^{219}Rn and ^{212}Po α's from 6817.6 and 8785.4 to 6819.3 and 8784.3 keV

[c]The value of Q_α was obtained by assuming that the α_0-group populates the ^{211}Rn g.s. Strong population of the g.s. is expected by comparison with other N=127, even-Z isotopes (i.e., ^{213}Rn)

[d]The original E_α-value of 68Va04 has been increased by 2 keV because of a change in the calibration energy of the ^{215}Po α from 7384.1 to 7386.4 keV (71Gr17)

[e]The value of Q_α was obtained by assuming that the observed α-group populates the ^{211}Fr g.s. This assumption is consistent with an expected E_α≈7600 from α-decay systematics

[A]Adopted value
[U]Unweighted average
[W]Weighted average

$^{215}_{90}Th_{125}$

$^{215}_{90}Th_{125}$

Ground-State Decay

Q^{+}≈4920 syst.
Q_α=7667[c] 8

$T_{1/2}$ 1.2 s 2 68Va18

α to ^{211}Ra[a] >98.5%

>98.5% 68Va18

	I_α§	E_α[b]	ΔQ_α		
α_0	40 3	7524 8	–	semi	68Va18
α_{131}	52 3	7395 8	(131)	semi	68Va18
α_{195}	8 3	7333 10	(195)	semi	68Va18

§α-particles per 100 α-decays of ^{215}Th

$Q_\alpha=E(\alpha_0)+E_{recoil}$=7667[c] 8 76WaBo

ϵ to ^{215}Ac <1.5%

Not observed 68Va18

No 1.2-s component was found in the measured half-life of the 0.17-s ^{215}Ac peak present in the α-spectrum.

Assignment

$^{206}Pb(^{16}O,7n)^{215}Th$ excitation function 68Va18
90–160 MeV ^{16}O ($\sigma_{max.}$ at ≈128 MeV)
Agreement with α-decay systematics 68Va18

See also 72Su07 for $^{192}Os(^{28}Si,5n)$ excitation function.

[a]α-subscript gives the adopted energy, to the nearest keV, of the daughter level

[b]The original E_α-values of 68Va18 have been increased by 2 keV because of a change in the calibration energy of the ^{215}Po α from 7384.1 to 7386.4 keV (71Gr17)

[c]The value of Q_α was obtained by assuming that the α_0-group populates the ^{211}Ra g.s. This assumption is consistent with the predictions of α-decay systematics. Strong population of the ^{211}Ra g.s. is also expected from the α-decay systematics of N=125, even-Z nuclides

Adopted Level Properties, Spin Assignments

E(level)	J^π	Properties, J^π Reasons, Comments
0	$(1/2^-)$	A $(3p_{1/2})$ configuration for the odd neutron is suggested by the shell model. This assignment is strongly supported by the α-decay systematics of N=125, even-Z nuclides (i.e., ^{213}Ra, ^{211}Rn, ^{209}Po). The α-decay of these $1/2^-$ isotopes strongly populate a $5/2^-$ g.s. and $1/2^-$ excited level with a similar α-branch (<10%) to higher $3/2^-$ level (68Va18). The α-hindrance factors for decay to the ground, 131-, and 195-keV states are 5.7, 1.6, and 6.3, respectively (using a radius value of R=8.750 fm for ^{215}Th).

($^{215}_{91}Pa_{124}$)

Ground-State Decay Q_α=8254 syst.

$T_{1/2}$ Not observed

α to ^{211}Ac Not observed

Estimated E_{α_0}=8100 30 α-decay syst. 68Va18

($^{215}_{92}U_{123}$)

Ground-State Decay Q_α=8549 syst.

$T_{1/2}$ Not observed

α to ^{211}Th Not observed

Estimated E_{α_0}=8390 50 α-decay syst. 68Va18

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