^{140}Pm ε decay (9.2 s) 2009Wi18,1975Ke09

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 154, 1 (2018)	20-Nov-2018

Parent: ^{140}Pm: E=0.0; J$^{\pi}$=1^{+}; $T_{1/2}$=9.2 s *2*; Q(ε)=6045 *24*; %ε+%β^{+} decay=100.0
^{140}Pm-E,J$^{\pi}$,$T_{1/2}$: From Adopted Levels, Gammas dataset.
^{140}Pm-Q(ε): From 2017Wa10.
Dataset based on unevaluated XUNDL file compiled by B. Singh (McMaster) from 2009Wi18.
2009Wi18: measured Eγ, Iγ, $\gamma\gamma$, $\gamma\gamma(\theta)$, mixing ratios using eight Compton-suppressed high-purity Ge clover detectors at the Wright Nuclear Structure Laboratory (WNSL) at Yale University.
1975Ke09: measured γ, $\gamma\gamma$, β^{+}.
Others:
1968Bl14,1970Ar17,1973HaWA,1973VaYZ,1975Za10: γ, $\gamma\gamma$.
1973VaYZ: ce.
1983Al06: β^{+}.
Level scheme of 1975Ke09 is confirmed and extended by 2009Wi18 which also give more precise γ ray energies and intensities, reason for which all these were adopted from 2009Wi18. The normalization is that of 1975Ke09.
2009Wi18 give combined level scheme from both 9.2 s, 1^{+} g.s. and 5.95 min, 8^{-} isomer ε+β^{+} decays. The only common decay path of them is the 773.6γ that uniquely decays from the first excited state of both levels schemes, the combined relative intensity of which is given as 100 *5* by 2009Wi18 (all the other γ and ε+β^{+} paths are separate). As the only transition populating the 774 level in the ε+β^{+} decay of the isomer is the 1028.1γ, its intensity, I(1028.1γ) = 81, gives the intensity of the 773.6γ in this decay, which leaves 19 parts for the intensity of this transition in the level scheme of the ε+β^{+} decay of g.s.

^{140}Nd Levels

E(level)†	J$^{\pi\ddagger}$	$T_{1/2}$‡	Comments
0.0	0^{+}	3.37 d *2*	%ε=100 $T_{1/2}$,%ε: from Adopted Levels.
773.48 *8*	2^{+}	1.40 ps *11*	
1412.86 *12*	0$^{+\#}$		
1489.30 *8*	(2)$^{+\#}$		
1934.99 *13*	3^{-}		
2139.68 *12*	2^{+}	152 fs *62*	E(level): possible one-phonon mixed-symmetry state, strongly mixed with fully-symmetric neighboring 2^{+} state (2009Wi18).
2332.12 *13*	2^{+}		E(level): possible one-phonon mixed-symmetry state, strongly mixed with fully-symmetric neighboring 2^{+} state (2009Wi18).
2358.59 *13*	0$^{+\#}$		
2466.85 *12*	2^{+}		
2546.75 *10*	0$^{+\#}$		
2584.99 *13*	0$^{+\#}$		
2610.93 *10*	(2^{+})$^{\#}$		
2713.80 *13*	2^{+}		
2832.80 *13*	(2^{+})		
2908.60 *13*	0$^{+\#}$		
3035.88 *18*	(1,2)		
3139.90 *13*	0$^{+\#}$		
3506.71 *22*	0^{+},1,2		

† From least-squares fit to the Eγ's.
‡ Adopted values.
$^{\#}$ From $\gamma\gamma(\theta)$ (2009Wi18).

^{140}Pm ε decay (9.2 s) 2009Wi18,1975Ke09 (continued)

ε,β^+ radiations

E(decay)	E(level)	Iβ^+ †	Iε†	Log *ft*	I(ε+β^+)†	Comments
(2538 *24*)	3506.71	0.0040 *7*	0.018 *3*	6.32 *8*	0.022 *4*	av Eβ=684 *11*; εK=0.693 *7*; εL=0.0985 *10*; εM+=0.0282 *3*
(2905 *24*)	3139.90	0.0067 *12*	0.015 *3*	6.51 *8*	0.022 *4*	av Eβ=848 *11*; εK=0.588 *8*; εL=0.0833 *11*; εM+=0.0238 *3*
(3009 *24*)	3035.88	0.0033 *6*	0.0064 *11*	6.92 *8*	0.0097 *16*	av Eβ=895 *11*; εK=0.557 *8*; εL=0.0788 *11*; εM+=0.0225 *3*
(3136 *24*)	2908.60	0.0010 *2*	0.0017 *2*	7.54 *7*	0.0027 *4*	av Eβ=953 *11*; εK=0.519 *7*; εL=0.0734 *11*; εM+=0.0210 *3*
(3212 *24*)	2832.80	0.0099 *17*	0.014 *2*	6.63 *8*	0.024 *4*	av Eβ=987 *11*; εK=0.497 *7*; εL=0.0703 *10*; εM+=0.0201 *3*
(3331 *24*)	2713.80	0.039 *7*	0.047 *8*	6.14 *8*	0.086 *15*	av Eβ=1042 *11*; εK=0.464 *7*; εL=0.0654 *10*; εM+=0.0187 *3*
(3434 *24*)	2610.93	0.056 *10*	0.060 *11*	6.06 *8*	0.116 *21*	av Eβ=1089 *11*; εK=0.435 *7*; εL=0.0614 *10*; εM+=0.0175 *3*
(3460 *24*)	2584.99	0.029 *5*	0.030 *6*	6.37 *9*	0.059 *11*	av Eβ=1100 *11*; εK=0.429 *7*; εL=0.0604 *9*; εM+=0.0173 *3*
(3498 *24*)	2546.75	0.20 *3*	0.20 *3*	5.56 *7*	0.40 *6*	av Eβ=1118 *11*; εK=0.419 *7*; εL=0.0590 *9*; εM+=0.0168 *3*
(3578 *24*)	2466.85	0.027 *8*	0.024 *7*	6.50 *13*	0.051 *15*	av Eβ=1155 *11*; εK=0.398 *6*; εL=0.0561 *9*; εM+=0.01602 *25*
(3686 *24*)	2358.59	0.090 *17*	0.070 *13*	6.06 *9*	0.16 *3*	av Eβ=1204 *11*; εK=0.372 *6*; εL=0.0524 *9*; εM+=0.01495 *24*
(3713 *24*)	2332.12	0.085 *23*	0.065 *17*	6.10 *12*	0.15 *4*	av Eβ=1216 *11*; εK=0.366 *6*; εL=0.0515 *8*; εM+=0.01469 *23*
(3905 *24*)	2139.68	0.086 *15*	0.053 *9*	6.23 *8*	0.139 *24*	av Eβ=1305 *11*; εK=0.323 *5*; εL=0.0455 *8*; εM+=0.01297 *21*
(4556 *24*)	1489.30	1.34 *17*	0.45 *6*	5.43 *6*	1.79 *23*	av Eβ=1607 *12*; εK=0.213 *4*; εL=0.0299 *5*; εM+=0.00854 *13*
(4632 *24*)	1412.86	0.45 *8*	0.14 *3*	5.95 *9*	0.59 *11*	av Eβ=1643 *12*; εK=0.203 *3*; εL=0.0285 *5*; εM+=0.00814 *13*
(5272 *24*)	773.48	2.3 *4*	0.46 *8*	5.55 *8*	2.8 *5*	av Eβ=1943 *12*; εK=0.1385 *20*; εL=0.0194 *3*; εM+=0.00553 *8*
6045 *24*	0.0	83.6 *6*	10.0 *2*	4.334 *14*	93.6 *6*	av Eβ=2309 *12*; εK=0.0908 *12*; εL=0.01269 *16*; εM+=0.00362 *5* E(decay): from 2017Au03, based on 6080 *100* (1975Ke09), 6090 *40* (1983Al06), 6020 *30* (1995Ve08).

† Absolute intensity per 100 decays.

γ(^{140}Nd)

Iγ normalization: ΣIγ(g.s.)=6.4% *6*; Iβ^+/I(773γ)=17.8 *16* (1975He09).

E_γ	I_γ[†e]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡#]	δ[@d]	α[c]	Comments
[x]159.8[a] *3*	3.6 *10*								%Iγ=1.0 *25*, using the calculated normalization.
[x]477.1[a] *3*	9.7 *19*								%Iγ=2.6 *4*, using the calculated normalization.
639.4 *1*	2.2 *3*	1412.86	0$^+$	773.48	2$^+$	E2		0.00624	A_2=+0.33 *1*; A_4=+1.00 *1* α(K)=0.00523 *8*; α(L)=0.000792 *11*; α(M)=0.0001694 *24* α(N)=3.77×10^{-5} *6*; α(O)=5.57×10^{-6} *8*; α(P)=3.12×10^{-7} *5* %Iγ=0.59 *10*, using the calculated normalization. Mult.: from α(K)exp=5.4×10^{-3} *13* (1973VaYZ). γγ(θ) for 639-774 cascade (2009Wi18).
716.1 *1*	3.3 *3*	1489.30	(2)$^+$	773.48	2$^+$	M1+E2	−1.22 *14*	0.00586 *19*	A_2=+0.388 *2*; A_4=+0.225 *3* α(K)=0.00498 *17*; α(L)=0.000693 *19*; α(M)=0.000147 *4* α(N)=3.29×10^{-5} *9*; α(O)=4.95×10^{-6} *14*; α(P)=3.07×10^{-7} *11* %Iγ=0.88 *12*, using the calculated normalization. Mult.: from α(K)exp=3.9×10^{-3} *6* (1973VaYZ). γγ(θ) for 716-774 cascade (2009Wi18).
773.74 *6*	19 *1*	773.48	2$^+$	0.0	0$^+$	E2		0.00396	α(K)=0.00334 *5*; α(L)=0.000483 *7*; α(M)=0.0001028 *15* α(N)=2.29×10^{-5} *4*; α(O)=3.42×10^{-6} *5*; α(P)=2.01×10^{-7} *3* %Iγ=5.1 *6*, using the calculated normalization. E_γ: from 1974FiZF. Mult.: from K/L=6.3 *10* (1973VaYZ); α(K)exp=2.7×10^{-3} *5* (1973VaYZ).
896.1 *2*	0.005 *4*	3035.88	(1,2)	2139.68	2$^+$				%Iγ=0.0013 *11*, using the calculated normalization.
977.5 *1*	0.028 *5*	2466.85	2$^+$	1489.30	(2)$^+$				%Iγ=0.0075 *16*, using the calculated normalization.
[x]1013.8[a] *3*	2.7 *11*								%Iγ=0.7 *3*, using the calculated normalization.
1057.6 *1*	0.9 *1*	2546.75	0$^+$	1489.30	(2)$^+$				%Iγ=0.24 *4*, using the calculated normalization.
1121.7 *1*	0.08 *1*	2610.93	(2$^+$)	1489.30	(2)$^+$				%Iγ=0.021 *4*, using the calculated normalization.
[x]1138.7[a] *3*	5.7 *21*								%Iγ=1.5 *5*, using the calculated normalization.
1161.5 *1*	0.14 *2*	1934.99	3$^-$	773.48	2$^+$				%Iγ=0.037 *7*, using the calculated normalization.
[x]1204.8[a] *3*	7.0 *15*								%Iγ=1.9 *4*, using the calculated normalization.
1366.2 *1*	0.42 *4*	2139.68	2$^+$	773.48	2$^+$	M1(+E2)	−0.08 *8*	0.00168 *3*	A_2=+0.24 *3*; A_4=+0.08 *3* α(K)=0.001410 *21*; α(L)=0.000182 *3*; α(M)=3.84×10^{-5} *6* α(N)=8.60×10^{-6} *13*; α(O)=1.315×10^{-6} *20*; α(P)=8.82×10^{-8} *14*; α(IPF)=3.72×10^{-5} *6* %Iγ=0.112 *16*, using the calculated normalization. γγ(θ) for 1366-774 cascade (2009Wi18).
1412.9[f] *5*	<0.0038	1412.86	0$^+$	0.0	0$^+$	E0			I_γ: ≤50.0038 limit from 1973VaYZ. Mult.: from α(K)exp>4.0×10^{-1}; K/L=4.6 *14* (1973VaYZ).

$^{140}_{60}$Nd$_{80}$-3

γ(^{140}Nd) (continued)

E_γ	I_γ [†e]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [‡#]	δ [@d]	α [c]	Comments
1489.2 *1*	4.3 *2*	1489.30	(2)$^+$	0.0	0$^+$	(E2)		1.07×10^{-3}	α(K)=0.000860 *12*; α(L)=0.0001125 *16*; α(M)=2.37×10^{-5} *4* α(N)=5.30×10^{-6} *8*; α(O)=8.05×10^{-7} *12*; α(P)=5.22×10^{-8} *8*; α(IPF)=7.26×10^{-5} *11* %Iγ=1.15 *13*, using the calculated normalization. Mult.: from α(K)exp=6.1×10^{-4} *49* (1973VaYZ).
1558.6 *1*	0.31 *3*	2332.12	2$^+$	773.48	2$^+$	M1+E2	−0.19 *9*	1.31×10^{-3} *2*	A$_2$=+0.06 *8*; A$_4$=−0.05 *8* α(K)=0.001041 *18*; α(L)=0.0001340 *23*; α(M)=2.82×10^{-5} *5* α(N)=6.32×10^{-6} *11*; α(O)=9.67×10^{-7} *17*; α(P)=6.49×10^{-8} *12*; α(IPF)=0.0001027 *15* %Iγ=0.083 *12*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1558-774 cascade (2009Wi18).
1585.1 *1*	0.60 *7*	2358.59	0$^+$	773.48	2$^+$	E2		9.97×10^{-4}	A$_2$=+0.39 *5*; A$_4$=+0.97 *7* α(K)=0.000764 *11*; α(L)=9.94×10^{-5} *14*; α(M)=2.09×10^{-5} *3* α(N)=4.68×10^{-6} *7*; α(O)=7.11×10^{-7} *10*; α(P)=4.64×10^{-8} *7*; α(IPF)=0.0001072 *15* %Iγ=0.160 *25*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1585-774 cascade (2009Wi18).
1623.1 *2*	0.031 *1*	3035.88	(1,2)	1412.86	0$^+$				%Iγ=0.0083 *9*, using the calculated normalization.
1693.5 *2*	0.06 *1*	2466.85	2$^+$	773.48	2$^+$	M1+E2	−0.9 *+6−4*	0.00107 *9*	A$_2$=−0.24 *10*; A$_4$=−0.07 *12* α(K)=0.00078 *8*; α(L)=0.000101 *10*; α(M)=2.12×10^{-5} *20* α(N)=4.8×10^{-6} *5*; α(O)=7.3×10^{-7} *7*; α(P)=4.8×10^{-8} *5*; α(IPF)=0.000157 *5* %Iγ=0.016 *4*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1694-774 cascade (2009Wi18).
1773.1 *1*	0.58 *7*	2546.75	0$^+$	773.48	2$^+$	E2		9.06×10^{-4}	A$_2$=+0.30 *3*; A$_4$=+1.15 *5* α(K)=0.000619 *9*; α(L)=7.98×10^{-5} *12*; α(M)=1.679×10^{-5} *24* α(N)=3.76×10^{-6} *6*; α(O)=5.72×10^{-7} *8*; α(P)=3.76×10^{-8} *6*; α(IPF)=0.000186 *3* %Iγ=0.154 *25*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1773-774 cascade (2009Wi18).
1811.5 *1*	0.22 *3*	2584.99	0$^+$	773.48	2$^+$	E2		8.95×10^{-4}	A$_2$=+0.33 *1*; A$_4$=+0.90 *2* α(K)=0.000595 *9*; α(L)=7.66×10^{-5} *11*; α(M)=1.611×10^{-5} *23* α(N)=3.60×10^{-6} *5*; α(O)=5.49×10^{-7} *8*; α(P)=3.61×10^{-8} *5*; α(IPF)=0.000203 *3* %Iγ=0.059 *10*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1811-774 cascade (2009Wi18).
1837.4 *1*	0.25 *3*	2610.93	(2$^+$)	773.48	2$^+$	(E2)		8.89×10^{-4}	A$_2$=−0.31 *4*; A$_4$=+0.15 *5* α(K)=0.000579 *9*; α(L)=7.45×10^{-5} *11*; α(M)=1.567×10^{-5} *22* α(N)=3.51×10^{-6} *5*; α(O)=5.34×10^{-7} *8*; α(P)=3.52×10^{-8} *5*; α(IPF)=0.000215 *3* %Iγ=0.067 *11*, using the calculated normalization. $\gamma\gamma(\theta)$ for 1837-774 cascade (2009Wi18).

γ(^{140}Nd) (continued)

E_γ	I_γ [†e]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡#]	δ[@d]	α[c]	Comments
1935 *1*	<0.2[&]	1934.99	3^-	0.0	0^+				%Iγ=0.03 *3*, using the calculated normalization.
1940.3 *1*	0.32 *4*	2713.80	2^+	773.48	2^+	M1+E2	−0.96 *+35−26*	0.00096 *4*	A_2=−0.25 *10*; A_4=+0.05 *11* α(K)=0.00059 *3*; α(L)=7.5×10^{-5} *4*; α(M)=1.58×10^{-5} *8* α(N)=3.54×10^{-6} *17*; α(O)=5.4×10^{-7} *3*; α(P)=3.62×10^{-8} *19*; α(IPF)=0.000274 *6* %Iγ=0.085 *14*, using the calculated normalization. γγ(θ) for 1940-774 cascade (2009Wi18).
[x]1941.9[b] *7*	0.46 *10*								%Iγ=0.12 *3*, using the calculated normalization.
2059.3 *1*	0.09 *1*	2832.80	(2^+)	773.48	2^+				A_2=+0.03 *2*; A_4=−0.05 *2* %Iγ=0.024 *4*, using the calculated normalization. γγ(θ) for 2059-774 cascade (2009Wi18).
2135.1 *1*	0.010 *1*	2908.60	0^+	773.48	2^+	E2		8.67×10^{-4}	A_2=+0.28 *6*; A_4=+1.1 *1* α(K)=0.000440 *7*; α(L)=5.61×10^{-5} *8*; α(M)=1.179×10^{-5} *17* α(N)=2.64×10^{-6} *4*; α(O)=4.02×10^{-7} *6*; α(P)=2.67×10^{-8} *4*; α(IPF)=0.000356 *5* %Iγ=0.0027 *4*, using the calculated normalization. γγ(θ) for 2135-774 cascade (2009Wi18).
2139.2 *4*	<0.2[&]	2139.68	2^+	0.0	0^+				%Iγ=0.03 *3*, using the calculated normalization.
2333.2 *6*	<0.5[&]	2332.12	2^+	0.0	0^+				%Iγ=0.07 *7*, using the calculated normalization.
2366.4 *1*	0.08 *1*	3139.90	0^+	773.48	2^+	E2		8.91×10^{-4}	A_2=+0.5 *3*; A_4=+1.1 *4* α(K)=0.000366 *6*; α(L)=4.64×10^{-5} *7*; α(M)=9.74×10^{-6} *14* α(N)=2.18×10^{-6} *3*; α(O)=3.33×10^{-7} *5*; α(P)=2.22×10^{-8} *4*; α(IPF)=0.000466 *7* %Iγ=0.021 *4*, using the calculated normalization. γγ(θ) for 2366-774 cascade (2009Wi18).
2467.1 *6*	<0.2[&]	2466.85	2^+	0.0	0^+				%Iγ=0.03 *3*, using the calculated normalization.
2610.0 *5*	<0.2[&]	2610.93	(2^+)	0.0	0^+				%Iγ=0.03 *3*, using the calculated normalization.
2733.2 *2*	0.08 *1*	3506.71	0^+,1,2	773.48	2^+				%Iγ=0.021 *4*, using the calculated normalization.

† Relative intensities are obtained from γγ coin data normalized to 100 parts for 773.6γ (2009Wi18) for both ^{140}Pm ε g.s. decay (9.2 s) and ^{140}Pm ε isomer decay (5.95 min). By separation 19 parts are taken by the 773.6γ for ^{140}Pm ε g.s. decay (9.2 s) which is kept here as normalizing figure, while 81 parts are taken by the ^{140}Pm ε isomer decay (5.95 min).

‡ From α(K)exp (1973VaYZ, normalized to α(K)(773γ)=3.3×10^{-3} (E2), Iγ from 1975Ke09) and γγ(θ) (2009Wi18).

\# A_2 and A_4 coefficients are from email reply from E. Williams, (2009Wi18) to XUNDL compiler November 25, 2009.

@ From γγ(θ) (2009Wi18).

& From singles data (2009Wi18).

$\gamma(^{140}$Nd) (continued)

[a] Observed only by 1975Za10.
[b] Observed only by 1975Ke09.
[c] Additional information 1.
[d] If No value given it was assumed δ=1.00 for E2/M1, δ=1.00 for E3/M2 and δ=0.10 for the other multipolarities.
[e] For absolute intensity per 100 decays, multiply by 0.27 *3*.
[f] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{140}_{60}Nd_{80}$-6

^{140}Pm ε decay (9.2 s) 2009Wi18,1975Ke09

Decay Scheme

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