^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	P. K. Joshi, B. Singh, S. Singh, A. K. Jain	NDS 138, 1 (2016)	15-Oct-2016

Includes ^{141}Pr(α,6nγ) from 1973VaYZ and 1973HaWF.

1987Xu01, 1990XuZW (thesis): ^{116}Cd(^{27}Al,4nγ),E(^{27}Al)=110-142 MeV. Measured excitation functions, Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$, and γ(t) using 4-n type BGO Compton-suppressed Ge(Li) detector at Stony Brook accelerator facility.

1986Lu07: ^{106}Pd(^{37}Cl,4nγ),E=148 MeV; observed 466 and 751 γ rays.

1973VaYZ, 1973HaWF: ^{141}Pr(α,6nγ),Eα=104 MeV. Measured Eγ, $\gamma(\theta)$, and $\gamma\gamma$-coin.

All data are from 1987Xu01 and 1990XuZW, except as noted. The gamma-ray energy uncertainties, relative Iγ values and $\gamma(\theta)$ data are from 1990XuZW thesis. Ordering of the higher transitions in the π[541]3/2$^-$, α=−1/2, band was made from intensity arguments for the various $\gamma\gamma$-coincidence gates and corroborated by dipole transitions to the $\pi h_{11/2}\otimes\nu h^2_{11/2}$ band.

^{139}Pm Levels

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
0.0	(5/2)$^+$		J$^\pi$: from Adopted Levels.
188.5[@] *10*	11/2$^-$	180 ms *20*	%IT=100; %ε+%β^+<0.05 T$_{1/2}$ and decay mode from Adopted Levels.
227.6?	(7/2$^+$)		
654.4[@] *11*	15/2$^-$		
778.7?[&] *13*	13/2$^-$		
1375.7[&] *13*	17/2$^-$		
1405.5[@] *12*	19/2$^-$		
1714.4[a] *14*	15/2		
1951.3[a] *14*	17/2		
2106.4[b] *15*	19/2$^+$		
2163.4[a] *15*	19/2		
2190.1[&] *14*	21/2$^-$		
2301.6[a] *14*	21/2		
2351.9[@] *14*	23/2$^-$		
2570.6[a] *15*	23/2		
2689.5[b] *16*	23/2$^+$		
2798.4[a] *16*	25/2		
2964.2[c] *16*	25/2$^+$		
3023.5[a] *17*			
3157.3[&] *16*	25/2$^-$		
3261.4[d] *16*	27/2$^-$		
3279.6[b] *19*	27/2$^+$		
3416.8[@] *17*	27/2$^-$		
3558.0[c] *19*	29/2$^+$		
3590.0[d] *19*	29/2$^-$		
3906.3[d] *21*	31/2$^-$		
4155.0[b] *21*	31/2$^+$		
4379.3[d] *24*	33/2$^-$		
4383.2[@] *20*	31/2$^-$		
4417.8[c] *21*	33/2$^+$		
4833[d] *3*	35/2$^-$		
5258.5[@] *23*	35/2$^-$		
5505.8[c] *23*	(37/2$^+$)		

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^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW (continued)

^{139}Pm Levels (continued)

E(level)[†]	J$^{\pi}$[‡]
6059.0[@] *25*	39/2$^-$
6722[@] *3*	43/2$^-$
7503[@] *3*	47/2$^-$
8445[@] *3*	51/2$^-$
9480[@] *4*	55/2$^-$
10592?[@]	(59/2$^-$)

[†] From least-squares fit to Eγ data.
[‡] From $\gamma(\theta)$ and membership in indicated band, except as noted. See the Adopted Levels for recommended assignments.
[#] For excited states above 650 keV, 1987Xu01 estimated $T_{1/2}\leq 10$ ns from $\gamma\gamma$(t).
[@] Band(A): $\pi 3/2[541],\alpha=-1/2$.
[&] Band(a): $\pi 3/2[541],\alpha=+1/2$ (?).
[a] Band(B): $\Delta J=1$ band based on 15/2. Positive parity given in Table 4.4 of 1990XuZW.
[b] Band(C): $\pi g_{7/2}\otimes\nu h^2_{11/2},\alpha=-1/2$ (?).
[c] Band(c): $\pi g_{7/2}\otimes\nu h^2_{11/2},\alpha=+1/2$ (?).
[d] Band(D): $\pi h_{11/2}\otimes\nu h^2_{11/2}$ (?).

$\gamma(^{139}Pm)$

Dipole transitions from members of the $\pi 3/2[541]$, $\alpha=-1/2$, band to members of the $(\pi h_{11/2})(\nu h^2_{11/2})$ band mentioned by 1987Xu01 but not shown.
All the γ rays are seen in $\gamma\gamma$-coin data of 1987Xu01, 1990XuZW.

E$_\gamma$[†]	I$_\gamma$	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[‡]	α[a]	Comments
104.1 *2*	4.6 *1*	3261.4	27/2$^-$	3157.3	25/2$^-$	D		A$_2$=−0.23 *3*; A$_4$=+0.03 *4*
[x]132.0 *2*	2.0[#] *5*							
138.1 *2*	14.7 *1*	2301.6	21/2	2163.4	19/2	D+Q		A$_2$=−0.283 *14*; A$_4$=+0.074 *19*
[x]148.0[&]								
[x]149.9 *2*	1.9[#] *5*							
188.5		188.5	11/2$^-$	0.0	(5/2)$^+$	E3	1.501	α(K)=0.671 *10*; α(L)=0.642 *9*; α(M)=0.1512 *22* α(N)=0.0331 *5*; α(O)=0.00423 *6*; α(P)=3.38×10^{-5} *5* E$_\gamma$: from (α,6nγ), Iγ=60.
212.1 *2*	21.2 *2*	2163.4	19/2	1951.3	17/2	D		A$_2$=−0.294 *13*; A$_4$=−0.017 *19*
[x]224.4 *2*	6.8[#] *5*					D+Q		A$_2$=−0.271 *18*; A$_4$=+0.090 *25*
225.1 *5*	≤1	3023.5		2798.4	25/2			
[x]227.2 *2*	1.7[#] *5*							
227.6[b]		227.6?	(7/2$^+$)	0.0	(5/2)$^+$			E$_\gamma$: unresolved doublet.
227.6 *2*	10.8[#] *5*	2798.4	25/2	2570.6	23/2	D+Q		A$_2$=−0.213 *9*; A$_4$=+0.129 *13*
[x]236.5 *2*	1.2[#] *5*							
236.9 *2*	8.3 *2*	1951.3	17/2	1714.4	15/2	D+Q		A$_2$=−0.31 *3*; A$_4$=+0.10 *4*
[x]260.8 *5*	≤1							
[x]262.0 *2*	2.9[#] *4*					D+Q		A$_2$=−0.153 *8*; A$_4$=+0.119 *11*
268.7 *2*	19.0 *2*	2570.6	23/2	2301.6	21/2	D+Q		A$_2$=−0.393 *16*; A$_4$=+0.056 *22*
316.3 *2*	10.3[#] *5*	3906.3	31/2$^-$	3590.0	29/2$^-$	D+Q		A$_2$=−0.339 *18*; A$_4$=+0.128 *25*

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^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW (continued)

$\gamma(^{139}Pm)$ (continued)

E_γ[†]	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
328.6 *2*	17.1[#] *5*	3590.0	29/2$^-$	3261.4	27/2$^-$	D+Q	A_2=−0.358 *13*; A_4=+0.077 *18*
337.5 *2*	6.3 *2*	2689.5	23/2$^+$	2351.9	23/2$^-$	D+Q	A_2=+0.43 *5*; A_4=+0.35 *6*
x393.6[&]							
393.6 *2*	5.6 *2*	2964.2	25/2$^+$	2570.6	23/2	D+Q	A_2=−0.84 *6*; A_4=+0.66 *7*
x396.3 *5*	≤1						
453.0[@]		3023.5		2570.6	23/2		
453.7 *2*	3.5[#] *4*	4833	35/2$^-$	4379.3	33/2$^-$	D+Q	A_2=−0.37 *3*; A_4=+0.22 *4*
465.9 *2*	100.0 *6*	654.4	15/2$^-$	188.5	11/2$^-$	Q	A_2=+0.284 *6*; A_4=−0.046 *9*
x468.5 *5*	≤1						
473.0 *2*	4.6[#] *4*	4379.3	33/2$^-$	3906.3	31/2$^-$	(D+Q)	A_2=−0.075 *26*; A_4=−0.32 *4* Negative A_4 is inconsistence with ΔJ=1 transition.
497.1[@]		2798.4	25/2	2301.6	21/2		
x533 *1*	≤1						Tentative placement from (37/2$^-$) to (35/2$^-$), only in Table 4.4 of 1990XuZW.
x537 *1*	≤1						
x551 *1*	≤1						
583.1 *2*	9.1 *2*	2689.5	23/2$^+$	2106.4	19/2$^+$	Q	A_2=+0.36 *4*; A_4=−0.12 *6*
590.1 *2*	9.0[#] *4*	3279.6	27/2$^+$	2689.5	23/2$^+$	Q	A_2=+0.12 *3*; A_4=−0.42 *4*
590.2 *5*	≤1	778.7?	13/2$^-$	188.5	11/2$^-$		
x591 *1*	≤1						
593.8 *2*	10.3 *2*	3558.0	29/2$^+$	2964.2	25/2$^+$	Q	A_2=+0.42 *3*; A_4=−0.28 *4*
597.0 *5*	≤1	1375.7	17/2$^-$	778.7?	13/2$^-$		
612.4 *2*	5.7[#] *4*	2964.2	25/2$^+$	2351.9	23/2$^-$	D+Q	A_2=−0.809 *34*; A_4=+0.63 *4*
x618 *1*	≤1						
663.1 *2*	4.5 *1*	6722	43/2$^-$	6059.0	39/2$^-$	(Q)	A_2=+0.30 *5*; A_4=−0.07 *7*
x672.6 *5*	≤1						
x693.0 *5*	≤1						
701.0 *2*	8.6[#] *5*	2106.4	19/2$^+$	1405.5	19/2$^-$	D+Q	A_2=−0.112 *13*; A_4=+0.026 *19* ΔJ=0 transition.
721.3 *2*	10.6 *2*	1375.7	17/2$^-$	654.4	15/2$^-$	D+Q	A_2=−0.92 *4*; A_4=+0.46 *5*
x732.2 *2*	4.0 *2*						A_2=+0.05 *6*; A_4=+0.20 *9*
751.3 *2*	57.2 *4*	1405.5	19/2$^-$	654.4	15/2$^-$	(Q)	A_2=+0.274 *10*; A_4=−0.001 *13*
x775.0 *2*	2.5 *1*					(Q)	A_2=+0.19 *9*; A_4=+0.08 *12* Placement from 35/2$^+$ to 31/2$^+$, only in Table 4.4 of 1990XuZW.
781.1 *2*	6.0 *2*	7503	47/2$^-$	6722	43/2$^-$	Q	A_2=+0.16 *5*; A_4=−0.43 *7*
784.5 *2*	6.7 *2*	2190.1	21/2$^-$	1405.5	19/2$^-$	D+Q	A_2=−0.73 *5*; A_4=+0.18 *6*
800.5 *2*	6.3 *1*	6059.0	39/2$^-$	5258.5	35/2$^-$	(Q)	A_2=+0.15 *5*; A_4=+0.07 *7*
x814.5 *5*	≤1						Tentative placement from (15/2$^+$) to (11/2$^+$), only in Table 4.4 of 1990XuZW.
814.5 *2*	8.0 *2*	2190.1	21/2$^-$	1375.7	17/2$^-$	(Q)	A_2=+0.29 *5*; A_4=+0.16 *6* Sign of A_4 is inconsistent with stretched quadrupole.
x847.3 *2*	2.6 *1*					D	A_2=−0.08 *9*; A_4=−0.01 *13*
859.8 *2*	3.4 *1*	4417.8	33/2$^+$	3558.0	29/2$^+$	(Q)	A_2=+0.64 *10*; A_4=+0.13 *14*
875.3 *2*	8.6[#] *4*	5258.5	35/2$^-$	4383.2	31/2$^-$	(Q)	A_2=+0.16 *6*; A_4=−0.03 *9*
875.4 *5*	≤1	4155.0	31/2$^+$	3279.6	27/2$^+$		
896.0 *2*	5.2 *2*	2301.6	21/2	1405.5	19/2$^-$	D+Q	A_2=−0.47 *6*; A_4=+0.17 *8*
909.5 *2*	6.3[#] *3*	3261.4	27/2$^-$	2351.9	23/2$^-$	(Q)	A_2=+0.22 *3*; A_4=0.00 *4*
x938.5 *2*	3.5[#] *5*						
942.0 *5*	≤1	8445	51/2$^-$	7503	47/2$^-$		
946.3 *2*	31.7 *3*	2351.9	23/2$^-$	1405.5	19/2$^-$	(Q)	A_2=+0.279 *16*; A_4=+0.174 *21* Sign of A_4 is inconsistent with stretched quadrupole.
x954.5 *2*	3.9 *2*						A_2=+0.12 *11*; A_4=+0.36 *15*

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^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW (continued)

$\gamma(^{139}Pm)$ (continued)

E_γ[†]	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
							Placement from $19/2^-$ to $15/2^-$, only in Table 4.4 of 1990XuZW. Sign of A_4 is inconsistent with stretched quadrupole.
966.4 *2*	11.4 *3*	4383.2	$31/2^-$	3416.8	$27/2^-$	Q	A_2=+0.374 *25*; A_4=−0.15 *4*
967.3 *2*	5.1[#] *3*	3157.3	$25/2^-$	2190.1	$21/2^-$		
[x]1008.6 *2*	7.7 *2*						A_2=+0.27 *41*; A_4=−0.06 *6*
1035.0 *5*	≤1	9480	$55/2^-$	8445	$51/2^-$		
1060.0 *2*	4.0 *1*	1714.4	15/2	654.4	$15/2^-$	D+Q	A_2=+0.49 *12*; A_4=−0.54 *16* ΔJ=0 transition.
1064.9 *2*	13.2 *3*	3416.8	$27/2^-$	2351.9	$23/2^-$	(Q)	A_2=+0.13 *3*; A_4=+0.08 *5*
1088.0 *5*	≤1	5505.8	$(37/2^+)$	4417.8	$33/2^+$		
1112[b] *1*	≤1	10592?	$(59/2^-)$	9480	$55/2^-$		
1296.9 *2*	12.8 *3*	1951.3	17/2	654.4	$15/2^-$	D	A_2=−0.33 *6*; A_4=+0.06 *9*

[†] 1990XuZW state the energy accuracy to 0.2 keV, except 1 keV when Eγ is given to the nearest keV. Evaluators assign 0.5 keV for Eγ values listed to the nearest tenth of a keV and with Iγ≤1.

[‡] From the discussion of 1987Xu01 many of the transitions are apparently of a stretched quadrupole or dipole nature from $\gamma(\theta)$ data.

[#] From $\gamma\gamma$-coin data (1990XuZW).

[@] From level schemes in 1987Xu01 and 1990XuZW, γ not listed in Table 4.4 of 1990XuZW.

[&] Unresolved doublet.

[a] 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.

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

[x] γ ray not placed in level scheme.

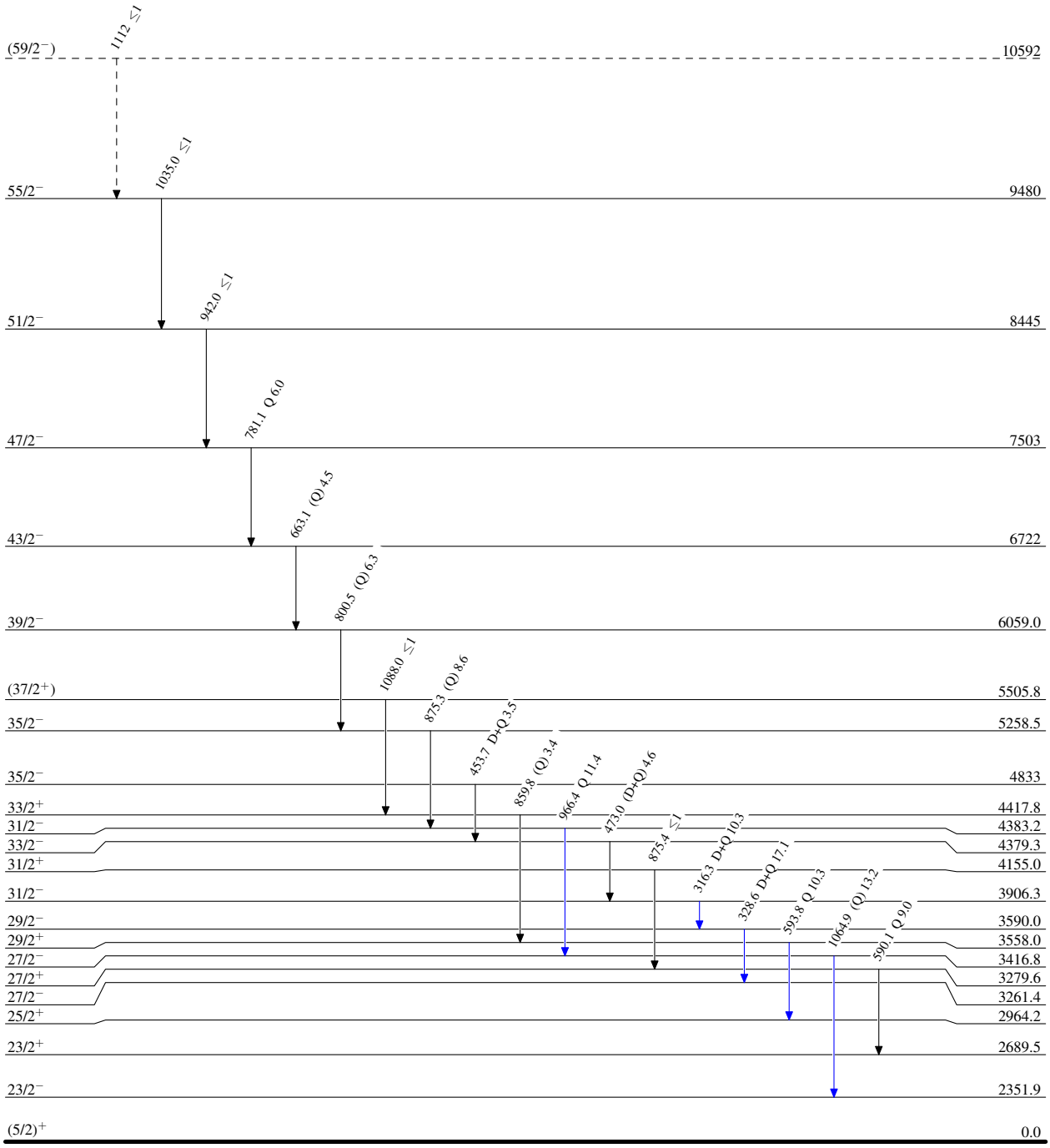
^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW

Level Scheme

Intensities: Relative I_γ

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)



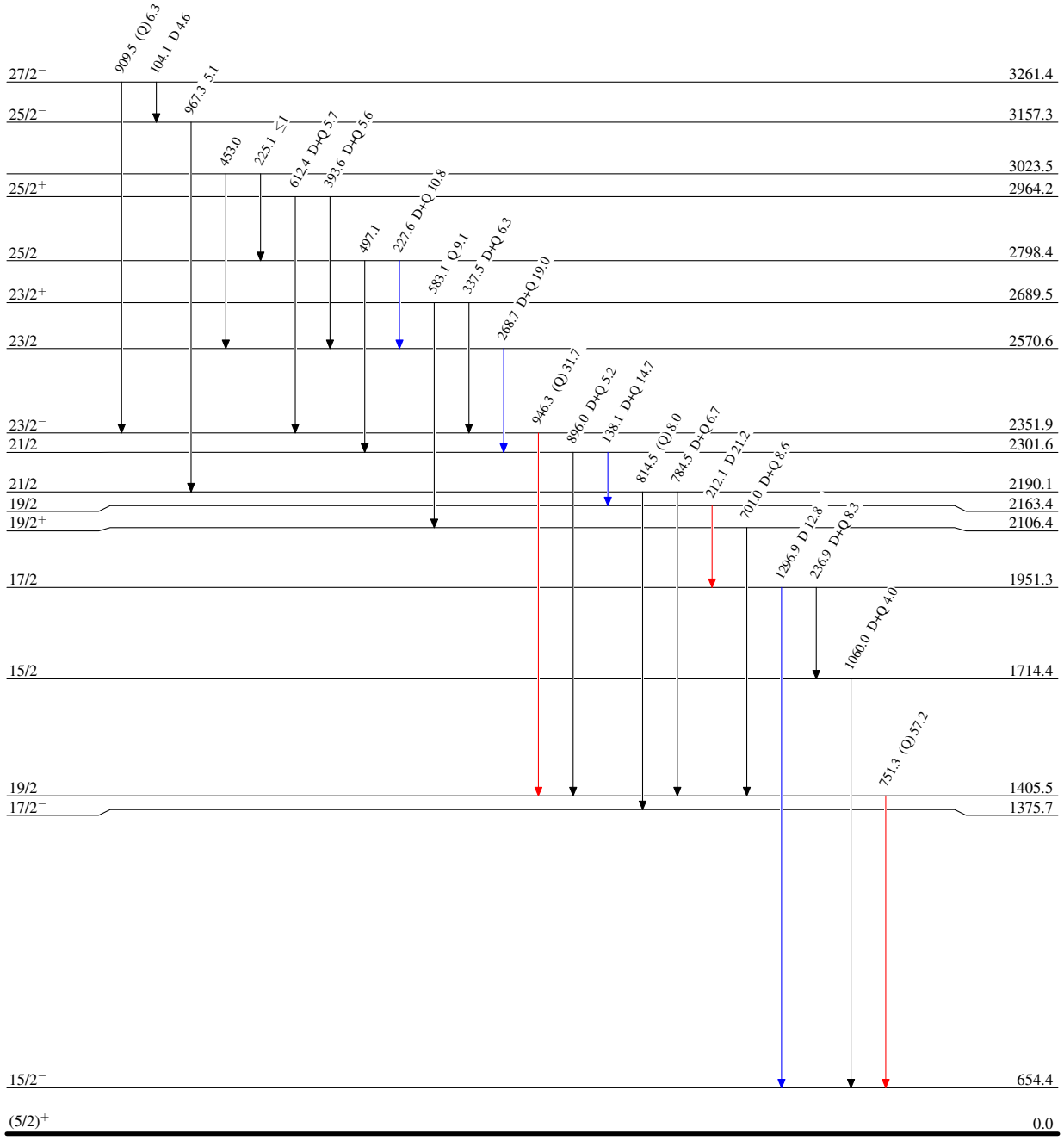
$^{139}_{61}Pm_{78}$

^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW

Level Scheme (continued)

Intensities: Relative I_γ

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$



$^{139}_{61}Pm_{78}$

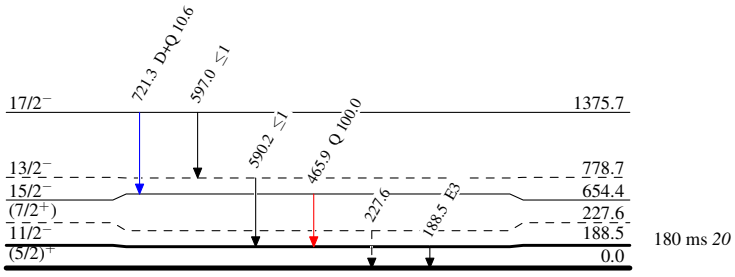
^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW

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)

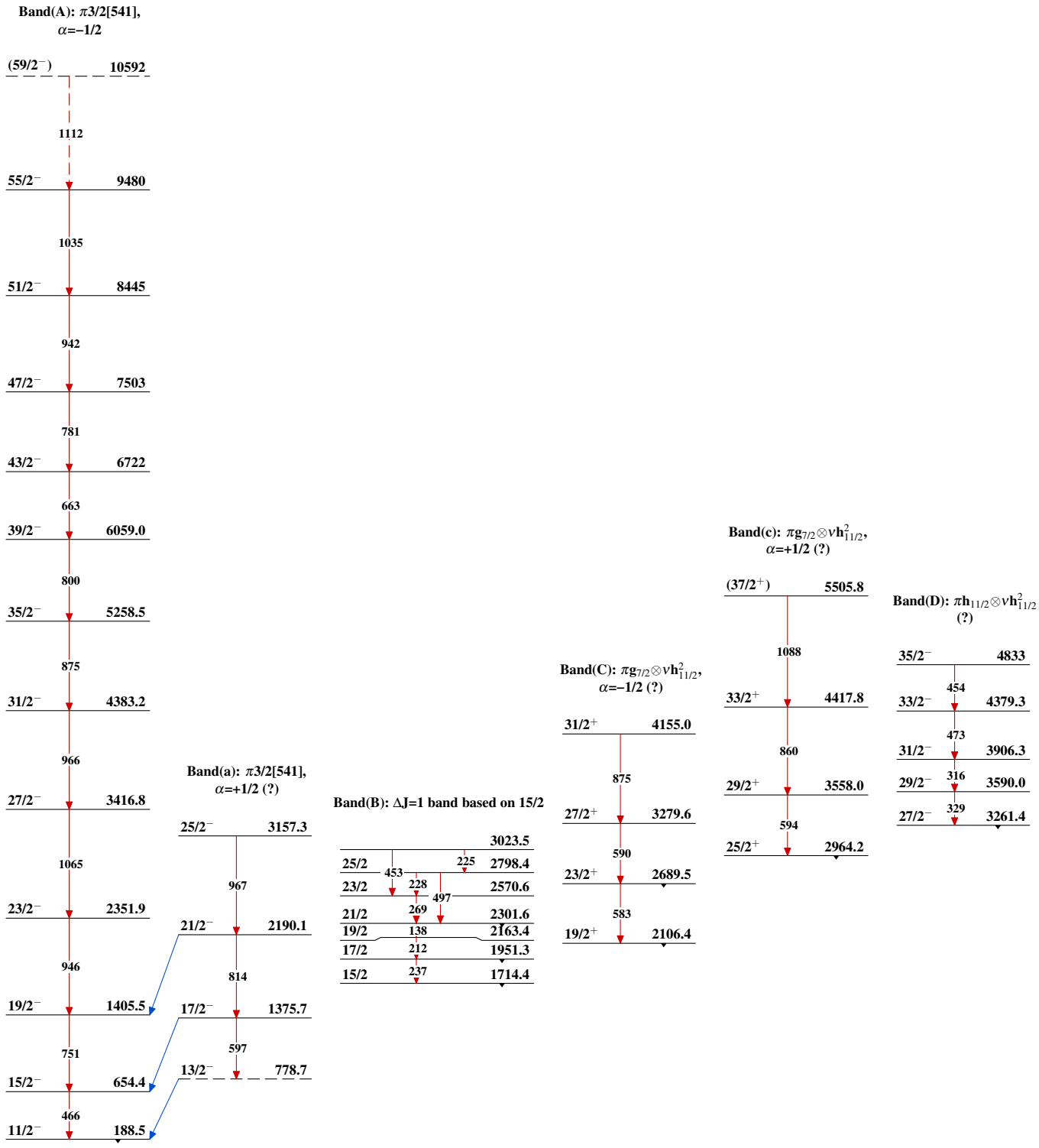
Level Scheme (continued)

Intensities: Relative I_γ



$^{139}_{61}Pm_{78}$

^{116}Cd(^{27}Al,4nγ) E=110-142 MeV 1987Xu01,1990XuZW



$^{139}_{61}Pm_{78}$