

¹³⁹La($\alpha,2n\gamma$) **1981Pr09,1986En06**

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 187,1 (2023)	12-Oct-2022

E=27 MeV (1981Pr09); 30 MeV (1988Ch39); 24 MeV (1977Na07).

Measured: γ , $\gamma\gamma$, $\gamma(\theta)$, $\gamma(t)$, ce, linear polarization of γ (1981Pr09), γ , ce at E(α)=24 MeV (1977Na07), γ (1988Ch39).

$\alpha(K)\text{exp}$ were normalized to $\alpha(K)(M2)=6.85\times 10^{-3}$ for 972 γ .

All γ -ray data are from 1981Pr09, except where noted otherwise.

¹⁴¹Pr Levels

E(level)	J ^{π} †	T _{1/2} †	Comments
0.0	5/2 ⁺	stable	
145.44 5	7/2 ⁺	1.85 ns 3	
1117.7 3	11/2 ⁻	4.8 ns 1	T _{1/2} : measured by 1981Pr09. Others: 5.1 ns 3 (1975Fr18), 4.80 ns 25 (1973Ej02), 4.6 ns 1 (1984Go12).
1126.6 3	3/2 ⁺		
1291.6 3	(5/2) ⁺		
1297.7 3	1/2 ⁺		
1434.6 3	3/2 ⁺		
1451.4	(7/2) ⁺		
1455.5 3	⁺		
1457.7 4	9/2 ⁺		
1494.2 4	11/2 ⁺		
1520.7 3	9/2 ⁺		
1583.8	5/2 ⁻		
1609.8 3	(3/2) ⁺		
1650.5 3	(9/2) ⁺		
1767.9 5	13/2 ⁺		
1796.8 5	15/2 ⁺	1.0 ns 1	
1851.4	(11/2 ⁺)		
1913.6?			
1986.5 5	(13/2 ⁺)		
2069.5 4	17/2 ⁺		
2108.8	15/2 ⁽⁺⁾		
2243.3			
2626.7? 5	(15/2 ⁻)		
2927.9 5	19/2 ⁻		
2963.3 6	19/2 ⁺		
3017.5 6	21/2 ⁺		
3019.6 6	(17/2 ⁻)	0.2 ns 1	
3397.3 7	21/2 ⁻		
3471.5 7	23/2 ⁻		
3527.2 8	(21/2 ⁻)		
3586.0 8	23/2 ⁺	0.2 ns 1	
3643.9 9			
4371.1 9	-		
4741.1 10			

† Adopted values.

¹³⁹La($\alpha,2n\gamma$) **1981Pr09,1986En06 (continued)**

$\gamma(^{141}\text{Pr})$									
E_γ †	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. ‡	$\delta^\#$	$\alpha^@$	Comments
28.9 2	64 2	1796.8	15/2 ⁺	1767.9	13/2 ⁺	(M1)		7.50	$\alpha(\text{L})= 5.87; \alpha(\text{M})= 1.229$ Mult.: $\alpha(\text{L})\text{exp}=9\ 3.$
74.2 1	12 2	3471.5	23/2 ⁻	3397.3	21/2 ⁻	M1		1.689	$\alpha(\text{K})= 1.439; \alpha(\text{L})= 0.1977; \alpha(\text{M})= 0.0416; \alpha(\text{N}+..)=0.01138$ Mult.: $A_2=-0.21\ 3, A_4=-0.06\ 5, \alpha(\text{K})\text{exp}=1.9\ 13.$ Coin with 454 γ .
91.7 1	42 1	3019.6	(17/2 ⁻)	2927.9	19/2 ⁻				
^x 115.1 3	3 1								
116.7 3	6 1	3643.9		3527.2	(21/2 ⁻)				
122.3 3	9 1	2108.8	15/2 ⁽⁺⁾	1986.5	(13/2 ⁺)	M1+E2	+0.06 3	0.456	Mult.: $A_2=-0.07\ 10, A_4=-0.04\ 40.$ $\alpha(\text{K})=0.38764; \alpha(\text{L})= 0.0534\ 4; \alpha(\text{M})=0.01121\ 9; \alpha(\text{N}+..)=0.00307$ E_γ : from 1988Ch39 . Mult.: $A_2=-0.05\ 2, A_4=+0.02\ 3, \text{pol}=-0.22\ 6, \alpha(\text{K})\text{exp}=0.35\ 4,$ $\alpha(\text{L})\text{exp}=0.071\ 6.$
145.44 5	1000	145.44	7/2 ⁺	0.0	5/2 ⁺				
145.7 3		1913.6?		1767.9	13/2 ⁺				Coin with 454 γ .
^x 170.7 3	3 1								Coin with 273 $\gamma, A_2=+0.06\ 16, A_4=-0.22\ 26.$
^x 178.4 3	12 1								Coin with 145 γ .
^x 207.0 3	2 1								
218.6 3	22 1	1986.5	(13/2 ⁺)	1767.9	13/2 ⁺				Mult.: $A_2=+0.39\ 6, A_4=+0.18\ 10, \alpha(\text{K})\text{exp}=0.084\ 12; \text{M1,E2}$ from 1981Pr09 but $\alpha(\text{K})\text{exp}$ is smaller than both calculated coefficients.
^x 246.7 3	4 1								
^x 248.0 3	4 1								(246 γ +248 γ) coin with 175 $\gamma, 273\gamma$.
272.7 1	633 12	2069.5	17/2 ⁺	1796.8	15/2 ⁺	M1+E2	+0.10 8	0.0818 3	$\alpha(\text{K})= 0.0698\ 4; \alpha(\text{L})=0.00945\ 5; \alpha(\text{M})=0.00198; \alpha(\text{N}+..)=0.00054$ Mult.: $A_2=-0.05\ 6, A_4=+0.23\ 10,$ for 272.7 γ +273.7 γ $\alpha(\text{K})\text{exp}=0.069\ 6, \alpha(\text{L})\text{exp}=0.011\ 2.$
273.7 3	191 4	1767.9	13/2 ⁺	1494.2	11/2 ⁺	M1+E2	+0.08 6	0.081	$\alpha(\text{K})=0.06918\ 21; \alpha(\text{L})=0.00936\ 3; \alpha(\text{M})=0.00196;$ $\alpha(\text{N}+..)=0.00054$ Mult.: $A_2=-0.09\ 8, A_4=-0.68\ 16,$ for 273.7 γ +272.7 γ $\alpha(\text{K})\text{exp}=0.069\ 6, \alpha(\text{L})\text{exp}=0.011\ 2.$
301.4 2	18 1	2069.5	17/2 ⁺	1767.9	13/2 ⁺	E2		0.0494	$\alpha(\text{K})= 0.0394; \alpha(\text{L})=0.00785; \alpha(\text{M})=0.00170; \alpha(\text{N}+..)=0.00045$ Mult.: $A_2=+0.25\ 3, A_4=-0.04\ 5, \text{pol}=+0.22\ 15, \alpha(\text{K})\text{exp}=0.041\ 5,$ $\alpha(\text{L})\text{exp}=0.012\ 3.$
302.6 3	111 3	1796.8	15/2 ⁺	1494.2	11/2 ⁺				
310.3 3	26 1	1767.9	13/2 ⁺	1457.7	9/2 ⁺	(E2)		0.0457	$\alpha(\text{K})= 0.0365; \alpha(\text{L})=0.00718; \alpha(\text{M})=0.00155; \alpha(\text{N}+..)=0.00041$ Mult.: $A_2=+0.52\ 23, A_4=+0.39\ 30.$
311.9 3	49 2	2108.8	15/2 ⁽⁺⁾	1796.8	15/2 ⁺	E2(+M1)		0.051 6	$\alpha(\text{K})=0.042\ 7; \alpha(\text{L})=0.0068\ 3; \alpha(\text{M})=0.00144\ 8$ $\alpha(\text{N})=0.000320\ 15; \alpha(\text{O})=4.99\times 10^{-5}\ 9; \alpha(\text{P})=3.0\times 10^{-6}\ 7$ Mult.: $A_2=+0.35\ 10, A_4=+0.13\ 14, \text{pol}=+0.50\ 20; \a1981Pr09adopted (M1) but E2(+M1) \Delta J=0 transition fits better with measured A_2, A_4 and pol values.$
^x 315.8 3	6 1								Coin with 273 $\gamma, 454\gamma, A_2=-0.65\ 10, A_4=-0.18\ 14.$

$\gamma(^{141}\text{Pr})$ (continued)

E_γ^\dagger	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [‡]	$\delta^\#$	$\alpha^@$	Comments
340.9 3	21 1	2108.8	15/2 ⁽⁺⁾	1767.9	13/2 ⁺	(M1)		0.0455	$\alpha(\text{K})=0.0389$; $\alpha(\text{L})=0.00521$; $\alpha(\text{M})=0.00109$; $\alpha(\text{N}+..)=0.00030$ Mult.: $A_2=-0.10$ 6, $A_4=+0.06$ 7. Coin with 454 γ .
^x 364.4 3	6 1								Coin with 341 γ , $A_2=+0.30$ 20, $A_4=+0.21$ 38.
^x 368.8 3	8 1								
370.2 3	4 1	4741.1		4371.1	-				
^x 418.3 3	15 1								Coin with 273 γ , 650 γ , 1349 γ .
434.1 3	41 1	3397.3	21/2 ⁻	2963.3	19/2 ⁺	E1		0.00522	$\alpha(\text{K})=0.00449$; $\alpha(\text{L})=0.00058$; $\alpha(\text{M})=0.00012$ Mult.: $A_2=-0.15$ 4, $A_4=-0.08$ 6, $\text{pol}=+0.37$ 25, $\alpha(\text{K})\text{exp}=0.0033$ 8.
454.0 3	145 1	3471.5	23/2 ⁻	3017.5	21/2 ⁺	E1		0.00470	$\alpha(\text{K})=0.00404$; $\alpha(\text{L})=0.00052$; $\alpha(\text{M})=0.00011$ Mult.: $A_2=-0.20$ 2, $A_4=-0.05$ 3, $\text{pol}=+0.08$ 7, $\alpha(\text{K})\text{exp}=0.0028$ 5, $\alpha(\text{L})\text{exp}=9\times 10^{-4}$ 4.
507.6 3	29 3	3527.2	(21/2 ⁻)	3019.6	(17/2 ⁻)	E2		0.01094	$\alpha(\text{K})=0.00903$; $\alpha(\text{L})=0.00143$ Mult.: $A_2=+0.18$ 20, $A_4=+0.03$ 40, $\alpha(\text{K})\text{exp}=0.0076$ 15, $\alpha(\text{L})\text{exp}=0.0013$ 6.
509.7 3	40 20	3527.2	(21/2 ⁻)	3017.5	21/2 ⁺				
568.6 3	52 1	3586.0	23/2 ⁺	3017.5	21/2 ⁺	M1		0.01251	$\alpha(\text{K})=0.01065$; $\alpha(\text{L})=0.00140$ Mult.: $A_2=-0.25$ 7, $A_4=-0.08$ 11, $\text{pol}=-0.42$ 18, $\alpha(\text{K})\text{exp}=86\times 10^{-4}$ 12, $\alpha(\text{L})\text{exp}=19\times 10^{-4}$ 7.
^x 617.9 3	16 1								Coin with 273 γ , 650 γ , $A_2=-0.23$ 8, $A_4=+0.20$ 15.
650.2 3	766 15	1767.9	13/2 ⁺	1117.7	11/2 ⁻	E1		0.00212	$\alpha(\text{K})=0.00182$; $\alpha(\text{L})=0.00023$ Mult.: $A_2=-0.15$ 2, $A_4=-0.01$ 5, $\text{pol}=+0.21$ 4, $\alpha(\text{K})\text{exp}=0.0016$ 2, $\alpha(\text{L})\text{exp}=2\times 10^{-4}$ 1.
^x 669.3 3	31 1								Coin with 145 γ , 273 γ , 454 γ ; $A_2=-0.18$, $A_4=+0.04$ 14.
^x 711.5 3	13 1								Coin with 569 γ .
749.1 3	18 1	2243.3		1494.2	11/2 ⁺				Mult.: $A_2=-0.26$ 12, $A_4=-0.007$ 27.
^x 762.7 3	10 1								Coin with 273 γ .
795.1 3		1913.6?		1117.7	11/2 ⁻				
^x 795.7 3	12 1								
843.9 3	15 1	4371.1	-	3527.2	(21/2 ⁻)				Mult.: $A_2=+0.24$ 12, $A_4=-0.23$ 18.
854.6 3	43 2	2963.3	19/2 ⁺	2108.8	15/2 ⁽⁺⁾	(E2)		0.00303	$\alpha(\text{K})=0.00255$; $\alpha(\text{L})=0.00036$ Mult.: $A_2=+0.57$ 8, $A_4=-0.08$ 4, $\alpha(\text{K})\text{exp}=0.0023$ 4.
858.4 3	209 4	2927.9	19/2 ⁻	2069.5	17/2 ⁺	E1		0.00120	$\alpha(\text{K})=0.00103$; $\alpha(\text{L})=0.00013$ Mult.: $A_2=-0.17$ 3, $A_4=-0.01$ 4, $\text{pol}=+0.14$ 10, $\alpha(\text{K})\text{exp}=0.0010$ 5.
868.8 3	37 2	1986.5	(13/2 ⁺)	1117.7	11/2 ⁻	(E1)			Mult.: $A_2=-0.25$ 9, $A_4=-0.09$ 16, $\text{pol}=+0.51$ 50.
893.7 3	56 2	2963.3	19/2 ⁺	2069.5	17/2 ⁺	M1+E2	-0.7 3	0.0037 3	$\alpha(\text{K})=0.00315$ 24; $\alpha(\text{L})=0.00042$ 3 Mult.: $A_2=-0.77$ 4, $A_4=+0.05$ 6, $\alpha(\text{K})\text{exp}=0.0041$ 7.
899.6 3	55 2	4371.1	-	3471.5	23/2 ⁻	E2		0.00270	$\alpha(\text{K})=0.00228$; $\alpha(\text{L})=0.00031$ Mult.: $A_2=+0.38$ 5, $A_4=-0.12$ 8, $\alpha(\text{K})\text{exp}=0.0022$ 8.
948.0 3	305 6	3017.5	21/2 ⁺	2069.5	17/2 ⁺	E2		0.00241	$\alpha(\text{K})=0.00204$; $\alpha(\text{L})=0.00028$ Mult.: $A_2=+0.35$ 4, $A_4=-0.09$ 6, $\text{pol}=+0.30$ 10, $\alpha(\text{K})\text{exp}=0.0020$ 2, $\alpha(\text{L})\text{exp}=3\times 10^{-4}$ 1.

¹³⁹La($\alpha,2n\gamma$) **1981Pr09,1986En06** (continued)

$\gamma(^{141}\text{Pr})$ (continued)

E_γ^\dagger	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [‡]	$\alpha^\text{@}$	Comments
972.14 10	794 14	1117.7	11/2 ⁻	145.44	7/2 ⁺	M2	0.00858	$\alpha(\text{K})=0.00204$; $\alpha(\text{L})=0.00028$ Mult.: $A_2=+0.35$ 4, $A_4=-0.09$ 6, $\text{pol}=+0.30$ 10, $\alpha(\text{K})\text{exp}=0.0020$ 2, $\alpha(\text{L})\text{exp}=3\times 10^{-4}$ 1. $\alpha(\text{K})=0.00726$; $\alpha(\text{L})=0.0010$ E_γ : from 1988Ch39. Mult.: $A_2=+0.16$ 3, $A_4=0.00$ 5, $\alpha(\text{K})\text{exp}=6.85\times 10^{-3}$, $\alpha(\text{L})\text{exp}=0.0010$ 1, $\text{pol}=-0.18$ 10. Coin with 145 γ , 273 γ , 650 γ ; $A_2=-0.12$ 8, $A_4=+0.37$ 13.
^x 1095.7 3 1117.60 10	28 3 92 3	1117.7	11/2 ⁻	0.0	5/2 ⁺	E3	0.00349	$\alpha(\text{K})=0.00291$; $\alpha(\text{L})=0.00044$ E_γ : from 1988Ch39. Mult.: $A_2=+0.22$ 3, $A_4=-0.02$ 5, $\alpha(\text{K})\text{exp}=0.0032$ 8.
1126.6 3 1147.6 3 1269.6 3	8 2 5.4 6 23 2	1126.6 1291.6 4741.1	3/2 ⁺ (5/2) ⁺	0.0 145.44 3471.5	5/2 ⁺ 7/2 ⁺ 23/2 ⁻	(Q)		E_γ : observed only by 1977Na07. Mult.: $A_2=+0.60$ 24, $A_4=+0.03$ 33. Coin with 145 γ .
^x 1277.7 3 1288.7 3 1291.6 3 1297.7 3 1312.2 3 1348.7 3	9 1 3 3 15 4 162 27 59 2 433 8	1434.6 1291.6 1297.7 1457.7 1494.2	3/2 ⁺ (5/2) ⁺ 1/2 ⁺ 9/2 ⁺ 11/2 ⁺	145.44 0.0 0.0 145.44 145.44	7/2 ⁺ 5/2 ⁺ 5/2 ⁺ 7/2 ⁺ 7/2 ⁺	M1+E2 E2	0.00116	E_γ : observed only in (d,n γ) at $E(\text{d})=13.5$ MeV (1981Pr09). Mult.: $A_2=-0.03$ 7, $A_4=+0.11$ 11. $\alpha(\text{K})=0.00099$; $\alpha(\text{L})=0.00013$ Mult.: $A_2=+0.27$ 5, $A_4=-0.03$ 7, $\text{pol}=+0.26$ 11, $\alpha(\text{K})\text{exp}=0.0008$ 2.
1434.6 3 ^x 1449.5 3 1451.4 3 1455.5 3 1457.7 3 1509.1 3 1520.7 3	23 2 <35 <35 25 2 45 2	1434.6 1451.4 1455.5 1457.7 2626.7? 1520.7	3/2 ⁺ (7/2) ⁺ + 9/2 ⁺ (15/2 ⁻) 9/2 ⁺	0.0 0.0 0.0 1117.7 0.0	5/2 ⁺ 5/2 ⁺ 5/2 ⁺ 11/2 ⁻ 5/2 ⁺			E_γ : from 1977Na07. E_γ : observed only by 1977Na07. I_γ : $I(1455.5\gamma+1457.7\gamma)=33$ 2. I_γ : $I(1457.7\gamma+1455.5\gamma)=33$ 2. Mult.: D+Q from $A_2=-0.13$ 10, $A_4=-0.24$ 15 contradicts Q from $A_2=+0.15$ 1, $A_4=-0.07$ 2 in (p,2n γ).
1583.8 3 1609.8 3 1650.5 3 1705.9 3	8 2 18 2 9 2 5 1	1583.8 1609.8 1650.5 1851.4	5/2 ⁻ (3/2) ⁺ (9/2 ⁺) (11/2 ⁺)	0.0 0.0 0.0 145.44	5/2 ⁺ 5/2 ⁺ 5/2 ⁺ 7/2 ⁺			

[†] $\Delta E=0.1-0.3$ keV.

[‡] From polarization and $\alpha(\text{K})\text{exp}$, $\alpha(\text{L})\text{exp}$.

[#] From angular distribution data (1981Pr09).

[@] 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.

^x γ ray not placed in level scheme.

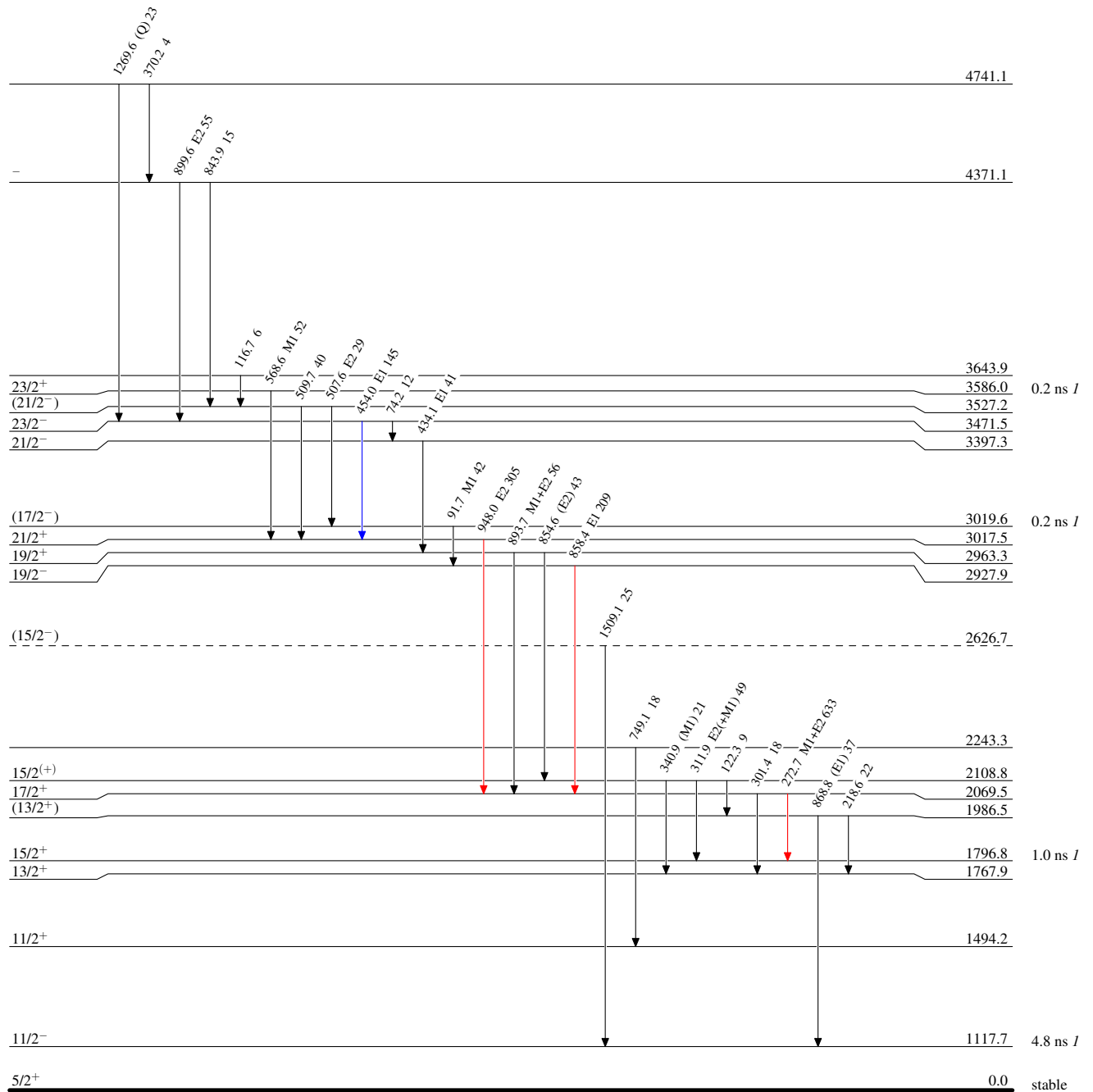
¹³⁹La(α,2nγ) 1981Pr09,1986En06

Level Scheme

Intensities: Type not specified

Legend

- I_γ < 2% × I_γ^{max}
- I_γ < 10% × I_γ^{max}
- I_γ > 10% × I_γ^{max}



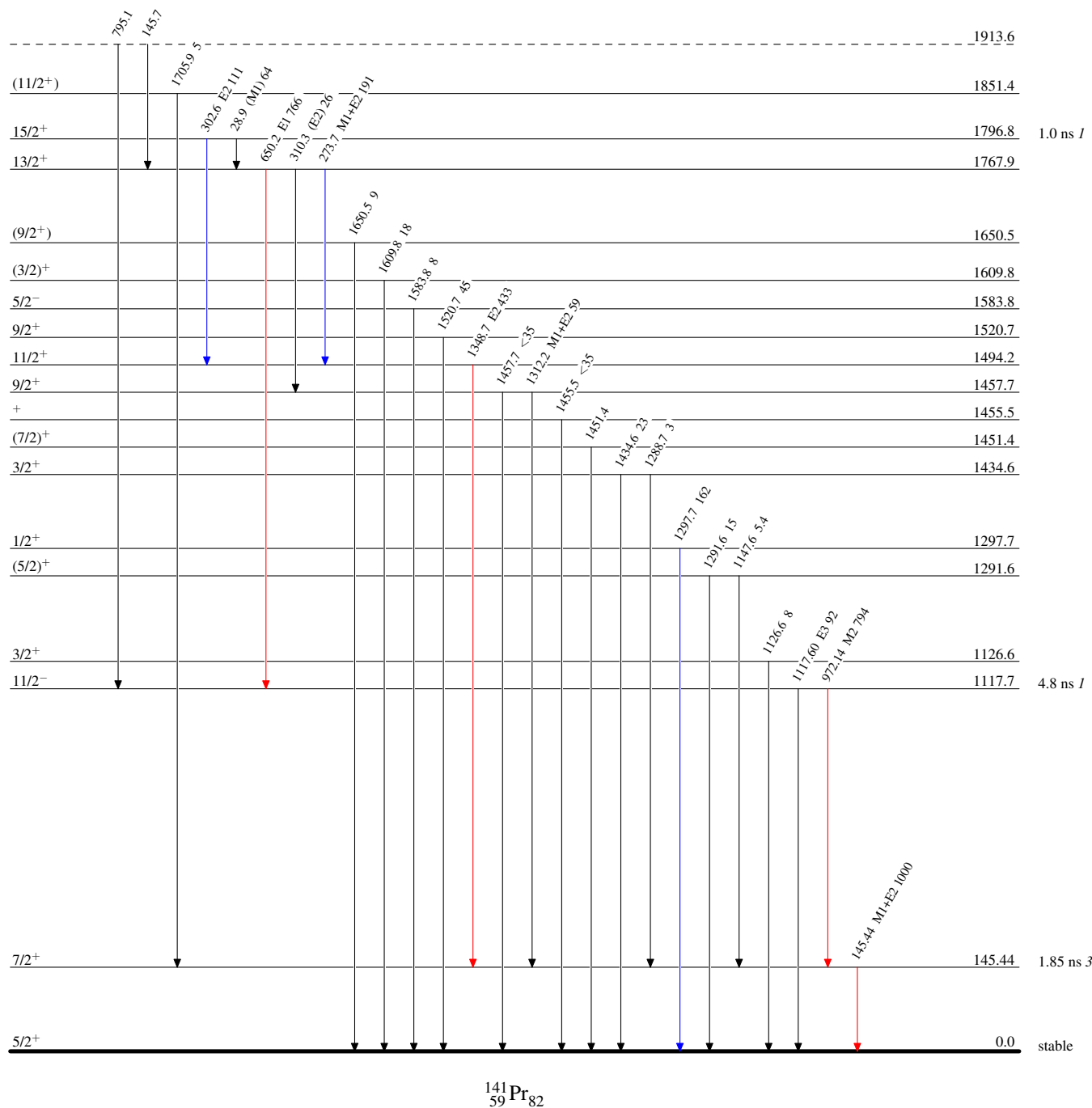
¹³⁹La($\alpha,2n\gamma$) 1981Pr09,1986En06

Level Scheme (continued)

Intensities: Type not specified

Legend

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



¹⁴¹Pr₈₂