Nuclear Data Sheets for A = 139^{*}

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Abstract: The experimental nuclear spectroscopic data for known nuclides of mass number 139 (Sn, Sb, Te, I, Xe, Cs, Ba, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy) have been evaluated and presented together with adopted properties for levels and gamma rays. This evaluation represents a revision of previous one (2001Bu16) by T.W. Burrows. Since then extensive new data have become available for many A=139 nuclides although, no excited state data are yet available for ¹³⁹Sn, ¹³⁹Sb, ¹³⁹Tb, and ¹³⁹Dy. The decay schemes of ¹³⁹Sn, ¹³⁹Sb, ¹³⁹I, ¹³⁹Tb and ¹³⁹Dy nuclei are not known, and those for ¹³⁹Gd and ¹³⁹Eu are poorly known. Particle-transfer data are available for ¹³⁹Ba, ¹³⁹La, ¹³⁹Ce and ¹³⁹Pr. Limited high-spin data are available for ¹³⁹Te, ¹³⁹I, ¹³⁹Cs, ¹³⁹Ba, ¹³⁹La and ¹³⁹Ce, while such data are extensive for ¹³⁹Pr, ¹³⁹Nd, ¹³⁹Pm, ¹³⁹Sm, ¹³⁹Eu and ¹³⁹Gd. Recent ¹³⁹Pm high-spin data from two independent studies using the same reaction and similar beam energy are in conflict and could be improved using state-of-the-art large gamma-detector arrays in contrast to the smaller arrays currently used. Cases for which no new experimental information are available since the last update have undergone checking resulting in some changes in the current work, but for the most part these are taken from the previous evaluations. Thus, the present work has greatly benefited from all prior NDS evaluations (2001Bu16, 1989Bu12, 1981Pe04, 1974Gr46), but at the same time data presented herein supersede those in the earlier evaluations.

Cutoff Date: Literature available up to October 15, 2016 has been consulted. Main source of bibliographic information was the NSR database (2011Pr03) available at NNDC, BNL webpage.

General Policies and Organization of Material: see <http://www.nndc.bnl.gov/nds/NDSPolicies.pdf>.

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General Comments: The statistical analysis of γ -ray data and deduced level schemes is carried out through computer codes available at data center in Brookhaven (www.nndc.bnl.gov). Theoretical conversion coefficients are from BrIcc code (2008Ki07) with "Frozen Orbitals" approximation, and with an implicit uncertainty of 1.4%. Measured static magnetic dipole are from 2014StZZ compilation, and electric quadrupole moments from 2016St14 evaluation, when available. All Q values and particle separation energies are from 2012Wa38 (AME-2012). When weighted or other averages are taken, the recommended uncertainty is generally not lower than the lowest uncertainty in a set of measurements that is being averaged.

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Skeleton Scheme for A=139

Skeleton Scheme for A=139 (continued)

Skeleton Scheme for A=139 (continued)

Ground-State and Isomeric-Level Properties

Nuclide	Level	J π	T _{1/2}	Decay Modes
^{139}Sn	0.0		130 ms 60	% β^- =100; % β^-n =?; % β^-2n =?; % β^-3n =?
^{139}Sb	0.0	(7/2+)	93 ms 13	% β^- =100; % β^-n =90 10; % β^-2n =?; % β^-3n =?
^{139}Te	0.0	(7/2-)	1.6 s 3	% β^- =100; % β^-n =?
^{139}I	0.0	(7/2+)	2.280 s 11	% β^- =100; % β^-n =10.0 3
^{139}Xe	0.0	3/2-	39.68 s 14	% β^- =100
^{139}Cs	0.0	7/2+	9.27 min 5	% β^- =100
^{139}Ba	0.0	7/2-	82.93 min 9	% β^- =100
^{139}La	0.0	7/2+	stable	
	1800.4 (17/2+)		315 ns 35	%IT=100
^{139}Ce	0.0	3/2+	137.63 d 3	% ϵ =100
	754.24 11/2-		57.58 s 32	%IT=100
^{139}Pr	0.0	5/2+	4.41 h 4	% ϵ +% β^+ =100
^{139}Nd	0.0	3/2+	29.7 min 5	% ϵ +% β^+ =100
	231.16 11/2-		5.50 h 20	% ϵ +% β^+ =87.0 10; %IT=13.0 10
	2616.9 (23/2+)		277 ns 2	%IT=100
^{139}Pm	0.0	(5/2)+	4.15 min 5	% ϵ +% β^+ =100
	188.7 (11/2)-		180 ms 20	%IT=100; % ϵ +% β^+ <0.05
^{139}Sm	0.0	1/2+	2.57 min 10	% ϵ +% β^+ =100
	457.38 11/2-		10.7 s 6	%IT=93.7 5; % ϵ +% β^+ =6.3 5
^{139}Eu	0.0	(11/2)-	17.9 s 6	% ϵ +% β^+ =100
	148.3 (7/2+)		10 μ s 2	%IT=100
^{139}Gd	0.0	(9/2-)	5.8 s 9	% ϵ +% β^+ =100; % ϵp >0
	0+x		4.8 s 9	% ϵ +% β^+ =100; % ϵp >0
^{139}Tb	0.0		1.6 s 2	% ϵ +% β^+ >0; % ϵp =?; % p =?
^{139}Dy	0.0	(7/2+)	0.6 s 2	% ϵ +% β^+ =100; % ϵp =11
^{140}I	0.0	(4-)	0.86 s 4	% β^-n =9.3 10; ...
^{140}Tb	0.0	7+	2.0 s 5	% ϵp =0.26 13; ...
^{140}Ho	0.0	(6-,0-,8+)	6 ms 3	% p =100

Adopted Levels

$Q(\beta^-)=10950$ CA; $S(n)=1300$ CA; $S(p)=17400$ CA; $Q(\alpha)=-7390$ CA 1997Mo25.

$S(2n)=4860$, $S(2p)=32740$, $Q(\beta^-n)=7090$, $Q(\beta^-2n)=5620$ (theory,1997Mo25).

2015Lo04: ^{139}Sn nuclide produced at RIBF-RIKEN facility in $^9\text{Be}(^{238}\text{U},\text{F})$ reaction at $E=345$ MeV/nucleon with an average intensity of 6×10^{10} ions/s. Identification of ^{139}Sn was made by determining atomic Z and mass-to-charge ratio A/Q , where Q =charge state of the ions. The selectivity of ions was based on magnetic rigidity, time-of-flight and energy loss. The separated nuclei were implanted at a rate of 50 ions/s in a stack of eight double-sided silicon-strip detector (WAS3ABi), surrounded by EURICA array of 84 HPGe detectors. Correlations were recorded between the implanted ions and β rays. The half-life of ^{139}Sn isotope was measured from the correlated ion- β decay curves and maximum likelihood analysis technique as described in 2014Xu07. Comparison of measured half-lives with FRDM+QRPA, KTUY+GT2 and DF3+CQRPA theoretical calculations.

Theoretical calculations:

2014Mi23: calculated β -delayed-neutron emission probabilities.

2007Ji14: calculated levels, J , π , $B(E2)$, $B(M1)$, g -factors, electric quadrupole moments.

2007Ka40: calculated binding energies, $S(n)$, $S(2n)$, level energies, J , π , $B(E2)$.

 ^{139}Sn Levels

E(level)	$T_{1/2}$	Comments
0.0	130 ms 60	$\% \beta^- = 100$; $\% \beta^-n = ?$; $\% \beta^-2n = ?$; $\% \beta^-3n = ?$ Theoretical $T_{1/2} = 236$ ms, $\% \beta^-n = 48.8$, $\% \beta^-2n = 31.9$, $\% \beta^-3n = 0.45$ (2003Mo09). Theoretical $T_{1/2} = 27.6$ ms, $\% \beta^-n = 41.6$, $\% \beta^-2n = 0.7$, $\% \beta^-3n = 0.1$ (2016Ma12). E(level): measured half-life is assumed to correspond to the ground state of ^{139}Sn . $J\pi$: 5/2- from theoretical considerations (1997Mo25). $T_{1/2}$: measured by 2015Lo04 from (implanted ions) β correlated curves in time and position using maximum likelihood method. See 2015Lo04 for comparison of their experimental value with theoretical values.

Adopted Levels

Q(β^-)=10420 SY; S(n)=3320 SY; S(p)=12220 SY; Q(α)=-5690 SY 2012Wa38.
 Estimated uncertainties (2012Wa38): $\Delta Q(\beta^-)$ =400, $\Delta S(n)$ =500, $\Delta S(p)$ =720, $\Delta Q(\alpha)$ =570 (2012Wa38).
 S(2n)=5900 500, Q(β^-n)=7840 400 (syst,2012Wa38). S(2p)=28230 (theory,1997Mo25).
 1994Be24: ¹³⁹Sb produced and identified in Pb(²³⁸U,X) reaction at E=750 MeV/nucleon at GSI facility. Target thickness=1.25 g/cm². Measured projectile fission fragment yields, mass, charge, and velocity distributions, and production σ . Fragment separator, energy-loss, TOF techniques.
 1998Do08: Pb(²³⁸U,X) E=750 MeV/nucleon at GSI, measured fractional independent yield of the low-energy fission component. This work is from the same lab as 1994Be24.
 2011Ar18: ¹³⁹Sb produced by bombardment of UC_x target with 1 GeV protons followed by selective ionization with the Resonance Ionization Laser Ion Source (RILIS) and high-resolution mass separator at ISOLDE-CERN facility. Measured delayed neutrons to deduce half-life and P_n (delayed neutron emission probability). Comparison with calculations for spherical and nonspherical shapes.
 2015Le14: decay of ¹³⁹Sb to ¹³⁸Te through β^-n decay mode studied by γ -ray spectroscopy.

¹³⁹Sb Levels

E(level)	J π	T _{1/2}	Comments
0.0	(7/2+)	93 ms 13	<p>%β^-=100; %β^-n=90 10 (2011Ar18); %β^-2n=? ; %β^-3n=? Theoretical T_{1/2}=503 ms, %β^-n=76.9, %β^-2n=9.96, %β^-3n=0.02 (2003Mo09). Theoretical T_{1/2}=52.7 ms, %β^-n=44.7, %β^-2n=0.2, %β^-3n=0.1 (2016Ma12). E(level): observed activity of 93 ms is assumed to belong to the g.s. Jπ: 7/2+ proposed in calculations (2007Ji14) and in systematics (2012Au07); 1/2+ (theoretical prediction,1997Mo25). T_{1/2}: measured by 2011Ar18 from decay curve for delayed neutrons and five-component fit to the decay curve, which included daughters 1.4-s ¹³⁸Te and 1.6-s ¹³⁹Te; and grand-daughters, 6.3-s ¹³⁸I and 2.28-s ¹³⁹I. In Table I, 2011Ar18 quote half-life with somewhat different uncertainty: 93 ms +14-3. 1994Be24 assigned 8 counts to ¹³⁹Sb activity with an estimated σ=3 μb. Measured yield of the low-energy fission component=0.0002 2 (1998Do08).</p>

Adopted Levels, Gammas

Q(β⁻)=8254 29; S(n)=2580 6; S(p)=12960 SY; Q(α)=-1998 5 2012Wa38.

Estimated uncertainty: ΔS(p)=300 (2012Wa38).

S(2n)=7043 4, S(2p)=25000 500 (syst), Q(β⁻n)=3704 7 (2012Wa38).

1994Be24, 1998Do08: E=750 MeV/nucleon. Measured projectile fission fragment yields, mass, charge, and velocity distributions, and production σ. Fragment separator, energy-loss, TOF techniques. 1998Do08 studied low-energy fission component features.

Mass measurements: 2013Val2: measured mass excess=-60191 keV 17 (CPT mass spectrometer), 2012Ha25 (JYFLTRAP Penning trap), 2004Ge18.

2007Ji14: calculated levels, J, π, pairing and quadrupole interaction.

¹³⁹Te Levels

Cross Reference (XREF) Flags

A ²⁴⁸Cm SF Decay

E(level)	Jπ [†]	XREF	T _{1/2}	Comments
0.0	(7/2-)	A	1.6 s 3	%β ⁻ =100; %β ⁻ n=? Theoretical T _{1/2} =2.10 s, %β ⁻ n=26.6 (2003Mo09). Theoretical T _{1/2} =0.115 s, %β ⁻ n=0.7 (2016Ma12). Jπ: from the systematic trend of yrast excitations in N=87 isotones. Alternate assignment of 5/2- is less likely since the 271 level fits the systematics for the 9/2- levels in N=87 isotones and the 271γ has a stretched dipole character. 2007Ji14 give 5/2- from their theoretical calculations, also the same in 2012Au07 from systematics. 1997Mo25 give 3/2- from theoretical predictions. T _{1/2} : 1.6 s 3 from analysis of composite integral decay curve for ¹³⁹ Sb, ¹³⁹ Te, ¹³⁸ Te and ¹³⁷ I background (2007ArZQ thesis, same value also cited in 2011Ar18). The statistics is very weak in the decay curve shown in figure 77 of 2007ArZQ. In the opinion of the evaluators this half-life should be viewed with caution. Systematic value=0.5 s (2012Au07), and theoretical half-life=2.10 s (2003Mo09). In 2006KeZZ (GSI annual report), half-life is listed as 598 ms 20 from integral β counting, but in e-mail reply of Sept 29, 2008 from K.L. Kratz, the half-lives in the report were pointed out as questionable due to calibration issues. Perhaps based on this report, value of 0.60 s is listed in KAPL 2009 Wall Chart of Nuclides. Configuration=v2f _{7/2} ³ ⊗vi _{13/2} ² ₀₊ . Configuration=v2f _{7/2} ² ₀₊ ⊗vi _{13/2} ² ₀₊ ⊗v1h _{9/2} .
271.0 10	(9/2-)	A		
627.5 [‡] 15	(13/2-)	A		
1063.9 [‡] 18	(17/2-)	A		
1598.7 [‡] 20	(21/2-)	A		
2210.5 [‡] 23		A		

[†] From γγ(θ) data, assuming Jπ(g.s.)=7/2- and Δπ=no for stretched dipole and quadrupole transitions.

[‡] (A): Band built on (13/2-). Configuration=v1h_{9/2}⊗(first 2+ in ¹³⁸Te).

γ(¹³⁹Te)

E(level)	Eγ	Mult. [†]
271.0	271.0	D
627.5	356.5	Q
1063.9	436.4	Q
1598.7	534.8	Q
2210.5	611.8	

[†] From γγ(θ) in SF decay. Mult=Q and D indicate stretched quadrupole (most likely E2), and stretched dipole (most likely M1+E2), respectively.

Adopted Levels, Gammas (continued)

(A) Band built on
(13/2-).

$^{139}_{52}\text{Te}_{87}$

^{248}Cm SF Decay 2000Ur06

Parent ^{248}Cm : $E=0.0$; $J\pi=0+$; $T_{1/2}=3.48\times 10^5$ y 6; %SF decay=0.0038 21.

$^{248}\text{Cm}-T_{1/2}$: From ^{248}Cm Adopted Levels in the ENSDF database (Sept 2014 update).

^{248}Cm -%SF decay: From 0.046 29 per 100 fissions (1994EnZZ) and %SF=8.39 16 (^{248}Cm Adopted Levels in the ENSDF database, Sept 2014 update).

2000Ur06: measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin using EUROGAM2 array of Compton-suppressed Ge detectors. Identification of ^{139}Te γ rays made by gating on known transitions in complementary Ru isotopes. Mass identification made using the technique of mass correlation proposed by 1991Ho16: $\langle A(\text{Ru}) \rangle = 106.3$ 2 resulting in $\langle A(\text{Te}) \rangle = 138.8$ 2. The ordering of the gammas in the level scheme was established on the basis of the measured $I\gamma$ values. Consult 2000Ur06 for additional discussions on the systematics of N=87 isotones.

^{139}Te Levels

E(level)	$J\pi^\dagger$	Comments
0.0	(7/2-)	$J\pi$: from the systematic trend of yrast excitations in N=87 isotones. Alternate assignment of 5/2- less likely since the 271 level fits the systematics for the 9/2- levels in N=87 isotones and the 271 γ has a stretched dipole character. Configuration= $\nu 2f_{7/2}^3 \otimes \nu i_{13/2}^2 0_+$ Configuration= $\nu 2f_{7/2}^2 \otimes \nu i_{13/2}^2 0_+ \otimes \nu 1h_{9/2}$
271.0	(9/2-)	
627.5 ‡	(13/2-)	
1063.9 ‡	(17/2-)	
1598.7 ‡	(21/2-)	
2210.5 ‡		

† From $\gamma\gamma(\theta)$ data, assuming $J\pi(\text{g.s.})=(7/2-)$ and $\Delta\pi=\text{no}$ for stretched dipole and quadrupole transitions.

‡ (A): Band built on (13/2-). Configuration= $\nu 1h_{9/2} \otimes (\text{first } 2+ \text{ in } ^{138}\text{Te})$.

$\gamma(^{139}\text{Te})$

$E\gamma$	E(level)	Mult.	Comments
271.0	271.0	D	Mult.: see comment for 356.5 γ .
356.5	627.5	Q	Mult.: (356.5+534.8 γ +436.4 γ)(271 γ)(θ): $A_2=-0.08$ 3, $A_4=-0.04$ 4 consistent with stretched quadrupole - stretched dipole cascade. Mult.: see comment for 436.4 γ .
436.4	1063.9	Q	Mult.: (436.4 γ)(356.5 γ)(θ): $A_2=+0.11$ 5, $A_4=-0.05$ 5 consistent with stretched quadrupole - stretched quadrupole cascade.
534.8	1598.7	Q	Mult.: (534.8 γ +436.4 γ)(356 γ)(θ): $A_2=+0.12$ 4, $A_4=-0.04$ 4 consistent with stretched quadrupole - stretched quadrupole cascade.
611.8	2210.5		

Adopted Levels, Gammas

$Q(\beta^-)=7186\ 29$; $S(n)=4550\ 29$; $S(p)=10052\ 29$; $Q(\alpha)=-1194\ 29$ (2012Wa38).

$S(2n)=8250\ 30$, $S(2p)=23010\ 300$, $Q(\beta^-\text{n})=3442\ 29$ (2012Wa38).

^{139}I first reported by 1949Su14 with a half-life of $2.7\ \text{s}$ *1*, the isotope formed in the fission process and followed by chemical separation.

Later studies of the decay of ^{139}I include 1958Co72, 1959Pe28, 1971Kr22, 1971BrYH, 1972Sc48, 1973Ad04, 1974Ru07, 1974Kr21, 1974Gr29, 1975Kr17, 1975As04, 1975Al11, 1976Lu02, 1980Lu04, 1980Al15, 1981Ho07, 1982Al01, 1983En05, 1985Ro13, 1987RoZW, 1992Gr06, 1993Ru01, 1997Gr20.

Precise mass measurement: 2013Va12 (mass excess=-68470.7 keV *40* CPT mass spectrometer).

Nuclear structure calculations: 2006Ks01: pairing plus quadrupole model.

 ^{139}I Levels

Cross Reference (XREF) Flags

A ^{248}Cm SF Decay

E(level)	$J\pi^\dagger$	XREF	$T_{1/2}$	Comments
0.0 ‡	(7/2+)	A	2.280 s <i>11</i>	<p>$\% \beta^-=100$; $\% \beta^-\text{n}=10.0\ 3$. $J\pi$: syst of ^{137}I, ^{139}Cs, and ^{141}Cs. Supported by suggestion of 1980KeZQ that there is no direct feeding of the $^{139}\text{Xe}\ 3/2^-$ g.s. based on agreement of E_β from singles and from β-528γ and by $\langle E_\beta \rangle$ measurement of 1982Al01.</p> <p>$T_{1/2}$: from timing of β and neutrons (1993Ru01). Others: 2.29 s <i>2</i> (1980Al15, timing of β, γ and neutrons); 2.30 s <i>5</i> (1976Lu02), 2.4 s <i>2</i> (1975As04), 2.47 s <i>15</i> (1974Gr29), 2.27 s <i>27</i> (1974Kr21), 2.0 s <i>5</i> (1971BrXW), 2.0 s <i>4</i> (1958Co72), 2.7 s <i>1</i> (1949Su14). Weighted average of all the values, except from 1949Su14, is 2.284 s <i>10</i> with a $\chi^2=0.5$. $\% \beta^-\text{n}$: weighted average of 15% <i>3</i> (1972Sc48), 10% <i>3</i> (1974Kr21), 10.2% <i>9</i> (1975As04), 9.5% <i>6</i> (1980Lu04, 1976Lu02, 1974Ru07), 9.1% <i>7</i> (1980Al15, 1981Ho07), and 10.3% <i>4</i> (1993Ru01). Others: 1959Pe28, 1958Co72.</p> <p>$J\pi$: from systematics of neighboring nuclides (2002Ur02).</p>
209.5 <i>10</i>	(5/2+)	A		
418.6 § <i>9</i>	(9/2+)	A		
435.0 ‡ <i>9</i>	(11/2+)	A		
816.0 § <i>10</i>	(13/2+)	A		
928.9 ‡ <i>12</i>	(15/2+)	A		
1280.5 § <i>12</i>	(17/2+)	A		
1564.5 ‡ <i>14</i>	(19/2+)	A		
1762.0 § <i>14</i>	(21/2+)	A		
2035.7 ‡ <i>15</i>	(23/2+)	A		
2221.2 <i>16</i>	(17/2 to 21/2)	A		$J\pi$: γ to (17/2+).
2316.1 <i>17</i>	(19/2 to 23/2)	A		$J\pi$: γ to (19/2+).
2392.3 <i>17</i>	(19/2 to 23/2)	A		$J\pi$: γ to (19/2+).
2490.8 § <i>17</i>	(25/2+)	A		
2688.5 ‡ <i>18</i>	(27/2+)	A		
3332.3 ‡ <i>7</i>		A		$J\pi$: γ to (27/2+) suggests (27/2 to 31/2); (31/2+) if band member.

† Above 210 keV excitation, all assignments are based on multiplicities of transitions and associated band structures. Ascending spins are assumed for levels populated in fission fragments following SF decay of ^{248}Cm as the excitation energy rises.

‡ (A): g.s. band.

§ (B): Band based on 9/2+.

Adopted Levels, Gammas (continued)

$\gamma(^{139}\text{I})$					
E(level)	E γ	I γ	Mult. [†]	α	Comments
209.5	209.5	100			
418.6	209 $\frac{1}{2}$	5.0 25			
	418.6	100 5	M1+E2	0.0151 9	
435.0	435.0	100	E2	0.01277	
816.0	381.0	10.9 16	D		
	397.4	100 5	E2	0.01670	
928.9	493.9	100	E2	0.00886	
1280.5	351.5	21.4 24			
	464.5	100 5	E2	0.01055	
1564.5	635.5	100	E2	0.00449	
1762.0	197.6	80 8	M1+E2	0.137 25	Mult.: from $\gamma\gamma(\theta)$ and measured K-conversion coefficient.
	481.6	100 8	E2	0.00952	
2035.7	273.8	100 11	(D+Q)		
	471.2	33 6	(Q)		
2221.2	940.7	100			
2316.1	751.6	100			
2392.3	827.8	100			
2490.8	728.8	100	(Q)		
2688.5	652.7	100			
3332.3	643.8 $\frac{1}{2}$	100			

[†] From $\gamma\gamma(\theta)$ and directional linear polarization measurements, except where noted.

 $\frac{1}{2}$ Placement of transition in the level scheme is uncertain.

(A) g.s. band
(B) Band based on 9/2+

²⁴⁸Cm SF Decay ²⁰⁰²Ur02

Parent ²⁴⁸Cm: E=0; J π =0⁺; T_{1/2}=3.48 $\times$ 10⁵ y 4; %SF decay=0.0038 21.

²⁴⁸Cm-T_{1/2}: From ²⁴⁸Cm Adopted Levels in the ENSDF database (Sept 2014 update).

²⁴⁸Cm-%SF decay: From 0.046 29 per 100 fissions (1994EnZZ) and %SF=8.39 16 (²⁴⁸Cm Adopted Levels in the ENSDF database, Sept 2014 update).

²⁰⁰²Ur02: Measured E γ , I γ , $\gamma\gamma$, $\gamma\gamma(\theta)$, $\gamma\gamma$ (directional linear polarization) using EUROAM2 array of Compton-suppressed Ge detectors at Strasbourg facility. K-shell conversion coefficient of 197.6 γ measured by triple γ coin using Ge and LEPS detectors and comparing K-x-ray and γ -ray intensities. Identification of γ rays in ¹³⁹I nuclide was based on observed correlations between γ rays in ¹³⁹I and in complementary fission fragments of Tc isotopes of mass 105-107.

²⁴⁸Cm SF Decay 2002Ur02 (continued)

¹³⁹I Levels

E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]
0.0 §	(7/2+)	1280.5 # 12	(17/2+)	2392.3 17	(19/2, 23/2)
209.5 10	(5/2+)	1564.5 § 14	(19/2+)	2490.8 # 17	(25/2+)
418.6 # 9	(9/2+)	1762.0 # 14	(21/2+)	2688.5 § 18	(27/2+)
435.0 § 9	(11/2+)	2035.7 § 15	(23/2+)	3332.3 § 7	
816.0 # 10	(13/2+)	2221.2 16	(17/2, 21/2)		
928.9 § 12	(15/2+)	2316.1 17	(19/2, 23/2)		

[†] From least-squares fit to E_γ data, assuming Δ(E_γ)=0.3 keV for each E_γ quoted to nearest tenth of a keV and 1 keV otherwise.

[‡] As proposed by 2002Ur02 based on systematics for g.s. and 209.5 level and multipolarities of transitions from higher levels together with band associations. Assignments in Adopted Levels are the same.

§ (A): g.s. band.

(B): Band based on 9/2+.

γ(¹³⁹I)

A₂ and A₄ coefficients are from γγ(θ) data.

E _γ	E(level)	I _γ	Mult. [†]	α	Comments
197.6	1762.0	20 2	M1+E2	0.137 25	α(K)exp=0.20 5 (2002Ur02). α: overlaps M1 and E2. K-conversion coefficient measured by triple γ coin technique and comparing K-x-ray intensity to γ-ray intensity. (198γ)(summed gates)(θ): A ₂ =-0.10 1, A ₄ =+0.10 1.
209 [‡]	418.6	4 2			
209.5	209.5	6 2			
273.8	2035.7	18 2	(D+Q)		(274γ)(summed gates)(θ): A ₂ =+0.03 1, A ₄ =-0.06 2. Sign of A ₄ is inconsistent with ΔJ=1 transition.
351.5	1280.5	9 1			
381.0	816.0	7 1	D		A ₂ =-0.13 3, A ₄ =-0.05 4. Sign of A ₄ is inconsistent with ΔJ=1 transition.
397.4	816.0	64 3	E2	0.01670	A ₂ =+0.12 1, A ₄ =-0.03 2. POL=+0.12 3.
418.6	418.6	80 4	M1+E2	0.0151 9	(419γ)(summed gates)(θ): A ₂ =-0.19 2, A ₄ =-0.004 2. POL=-0.02 1.
435.0	435.0	100 5	E2	0.01277	A ₂ =+0.09 1, A ₄ =-0.02 1. POL=+0.3 1.
464.5	1280.5	42 2	E2	0.01055	(464γ)(397γ)(θ): A ₂ =+0.10 2, A ₄ =+0.04 2. POL=+0.08 3.
471.2	2035.7	6 1	(Q)		(471γ)(summed gates)(θ): A ₂ =+0.10 2, A ₄ =+0.01 2.
481.6	1762.0	25 2	E2	0.00952	(482γ)(464γ)(θ): A ₂ =+0.10 1, A ₄ =+0.05 2. POL=+0.2 1.
493.9	928.9	65 3	E2	0.00886	(494γ)(435γ)(θ): A ₂ =+0.10 1, A ₄ =+0.01 2. POL=+0.2 1.
635.5	1564.5	33 2	E2	0.00449	(635γ)(494γ)(θ): A ₂ =+0.11 2, A ₄ =0.00 2. POL=+0.15 8.
643.8 [‡]	3332.3	2 1			
652.7	2688.5	5 1			
728.8	2490.8	12 2	(Q)		A ₂ =+0.08 2, A ₄ =+0.02 4.
751.6	2316.1	7 2			
827.8	2392.3	3 1			
940.7	2221.2	2 1			

[†] From γγ(θ) and directional linear polarization measurements. In γγ(θ) data, expected A₂=+0.10, A₄=-0.01 for quadrupole (ΔJ=2)-quadrupole (ΔJ=2) cascade and A₂=-0.07 for quadrupole (ΔJ=2)-dipole (ΔJ=1) cascade.

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

Adopted Levels, Gammas

Q(β⁻)=5057 4; S(n)=3744 4; S(p)=10954 6; Q(α)=-342 3 2012Wa38.

S(2n)=9403.8 21, S(2p)=20918 3 (2012Wa38).

2012Va02: precise mass measurement.

2007Ji14, 2006Ks01: theoretical calculations of level properties.

¹³⁹Xe Levels

Cross Reference (XREF) Flags

A ¹³⁹I β⁻ Decay (2.280 s)

B ¹⁴⁰I β⁻n Decay (0.86 s)

C ²⁴⁸Cm SF Decay

D ²⁵²Cf SF Decay

E ²³⁵U(n, Fγ)

E(level) [†]	Jπ [‡]	XREF	T _{1/2} [§]	Comments
0.0	3/2-	ABCDE	39.68 s 14	%β ⁻ =100. μ=-0.304 10 (1989Bo03,2014StZZ). Q=+0.39 2 (1989Bo03,2016St14). RMS charge radius <r ² > ^{1/2} =4.841 fm 10 (2013An02 evaluation). Jπ: spin from atomic beam laser spectroscopy (1989Bo03); parity from log ft<11 for β decay to 7/2+. T _{1/2} : from weighted average of values for five γ rays (175, 218, 289, 296, 393) in the decay of ¹³⁹ Xe (1969Ca03), systematic uncertainty is included in the weighted average. (Individual values in seconds in 1969Ca03: 39.69 3, 39.72 5, 39.81 21, 39.48 13, 39.12 27). Others: 40.8 s 7 (1974Gr29), 39.7 s 8 (1971Kr22), 39.3 s 9 (1970OsZZ), 39.3 s 7 (1968Al06), 41.30 s 15 (1966Ar08, from time decay of β spectrum, not considered in the recommended value due to the presence of several longer-lived impurities in the β decay curve), 40.4 s 13 (1965Pa14), 41 s 2 (1962Wa34), 41 s (1950Di01), ≈30 s (F.A. Heyn et al., Nature 143, 516 (1939)). μ, Q: collinear fast beam laser spectroscopy (1989Bo03). Q=+0.40 in 1989Bo03 re-evaluated to +0.39 in 2016St14.
22.74 ^d 8	(7/2-) ^{@b}	A CDE		
31.70 ^{3e} 20	(5/2-) ^{@b}	A CD		
559.43 ^e 9	(9/2-) ^b	A CD		
593.96 ^d 9	(11/2-) ^a	A CDE		
624.26 9	(5/2-) [@]	A		
670.02 12	(3/2-, 5/2, 7/2-) ^c	A		
678.75 ^f 9	(9/2-)	A C		
1008.27 10	(5/2, 7/2, 9/2)	A		
1059.02 15	(3/2-, 5/2, 7/2) ^c	A		
1086.20 ^f 19	(13/2-) ^b	CD		
1179.34 ^d 12	(15/2-) ^b	CDE		
1193.33 11	(3/2-, 5/2, 7/2)	A		
1194.70 ^e 13	(13/2-)	C		
1312.70 16		A		
1399.47 10	(3/2-, 5/2, 7/2) ^c	A		
1418.02 14	(11/2+)	C		
1444.14 13	(7/2, 9/2) [#]	A		
1448.52 11	(7/2, 9/2) [#]	A		
1493.35 16		A		
1512.35 ^g 17	(13/2+) ^{&b}	CD		
1576.91 ^f 15	(17/2-) ^b	CD		
1684.04 9	(5/2, 7/2, 9/2)	A		
1771.43 9		A		
1809.73 ^d 15	(19/2-) ^b	CDE		
1861.95 ^e 16	(17/2-)	C		
1894.43 15		A		
2014.50 ^g 15	(17/2+) ^{&b}	CD		
2158.70 ^f 17	(21/2-) ^b	CD		
2192.82 19	(19/2-) ^b	CD		
2307.93 13		A		
2500.01 ^d 18	(23/2-) ^b	CD		

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Adopted Levels, Gammas (continued)

 ^{139}Xe Levels (continued)

E(level) [†]	Jπ [‡]	XREF	E(level) [†]	Jπ [‡]	XREF
2574.98 ^g 18	(21/2+)&b	CD	3585.9 ^f 3	(29/2-) ab	CD
2740.18 14		A	3607.7 4		D
2898.45 12		A	3792.81 ^g 23	(29/2+) b	CD
2921.68 ^f 21	(25/2-) ab	CD	4022.9 ^d 3	(31/2-) b	CD
2925.37 21		CD	4232.4 ^f 3	(33/2-) ab	CD
2993.78 24		C	4298.9 4		C
3161.47 ^d 20	(27/2-) b	CD	4412.4 ^g 3	(33/2+) b	D
3211.71 ^g 21	(25/2+)&b	CD	4984.9 [?] 5	(35/2-) b	D
3305.1 3		D	5096.3 ^f 4	(37/2-) b	CD
3547.9 3	(27/2+) b	CD	6091.3 [?] 5	(41/2-) b	D

[†] From least-squares fit to E_γ data, ΔE_γ=0.2 keV assumed when not given. Reduced $\chi^2=2.0$ is somewhat larger than critical $\chi^2=1.5$.

The 849.5 and 969.4 gamma rays deviate by about 3 σ values.

[‡] From $\gamma\gamma(\theta)$ and directional polarization in ^{248}Cm SF decay and assumption that, since fission predominately populates yrast states, the J values generally increase with excitation energy (2002Ur04). Also it is assumed that transitions of unknown multipolarity are dipole or E2; M2 is not allowed from estimated T<10 ns for levels populated in ^{248}Cm SF decay.

[§] From $\gamma(t)$, T_{1/2}<10 ns for excited states in ^{248}Cm SF decay (2002Ur04).

Gammas to (5/2-) and (11/2-).

@ From systematics of N=85 isotones.

& From ΔJ=1 cascade and that the 13/2 state is non-yrast and is populated in fission suggesting opposite parity to the 13/2-.

a 1997Zh23 propose π+= in ^{252}Cf SF decay.

b From 2002Lu08 based on band structure, previous assignments for low lying levels and decay pattern with the assumption of ascending spins with excitation energy. These differ from those suggested by 1997Zh23 in ^{252}Cf SF decay for the 1085.8 and higher states.

c Gammas to 3/2- and (7/2-); ≠3/2+ from log ft<11 from (7/2+) in ^{139}I β- decay.

d (A): Band based on (7/2-).

e (B): Band based on 5/2-.

f (C): Band based on 9/2-.

g (D): Band based on 13/2+.

 $\gamma(^{139}\text{Xe})$

See ^{139}I β- decay for many unplaced gammas.

E(level)	E _γ [†]	I _γ [†]	Mult. [‡]	δ	α	Comments
22.74	(22.8 2)		[E2]		694	Obscured by x rays and 31.7γ in β- decay. Mult.: [E2] leads to an intensity balancing problem for the 22.8 level in β- decay.
31.703	31.70 2	100	M1+E2	≈0.9	≈62.5	Mult.,δ: from ^{139}I β- decay.
559.43	527.81 14	100 3	E2			
	536.80 14	67 2				
593.96	571.13 10	100	E2		0.00625 9	
624.26	592.6 2	100 3				
	601.5 2	76 3				
	624.3 2	6.2 3				
670.02	638.5 2	100 3				
	647.1 [§] 2					
	670.4 2	46.9 16				
678.75	84.80 2	3.45 17	[M1,E2]		2.3 10	
	646.85 25	24.5 9				
	655.9 2	100 3				
1008.27	329.6 2	2.2 2				
	384.0 2	1.8 2				
	448.9 2	2.4 2				
	976.4 2	100 4				
	985.4 2	36 2				
1059.02	389.1 [§] 2	35 1				
	1027.3 2	13.6 5				
	1036.3 2	100 5				
	1059.4 [§] 2	7.7 5				
1086.20	407.8	24 4				E _γ ,I _γ : γ from ^{248}Cm SF decay only.
	491.3 5	100 12	(M1+E2)			E _γ : unweighted average of the two values.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Xe})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	α	Comments
1086.20	525.8 6	12 4			E γ : unweighted average of the two values.
1179.34	585.34 10	100	(E2)		
1193.33	1161.4 2	100 3			
	1170.4 2	37 1			
	1193.3 2	41 1			
1194.70	516.0	17 8			
	600.5	100 33			
	635.5	50 17			
1312.70	634.0 [§] 2	62 4			
	719.1 2	100 4			
	752.9 2	58 4			
1399.47	730.0 2	85 3			
	774.1 [§] 2	100 3			
	1367.4 2	79 3			
	1376.9 2	68 3			
	1399.6 2	44.1 15			
1418.02	739.0	58 25			
	824.2	100 33			
	858.7	83 42			
1444.14	849.5 2	24.6 8			E γ : poor fit, level-energy difference=850.2.
	1412.6 2	100 3			
	1421.9 2	32.3 15			
1448.52	440.0 2	1.2 2			
	769.8 2	26.0 8			
	824.8 2	6.0 2			
	854.4 2	100 4			
	1425.6 2	28.0 8			
1493.35	899.4 2	30.9 23			
	933.9 2	100 2			
1512.35	918.41 17	100	D		
1576.91	397.52 11	100 8	M1+E2	0.0186 12	
	491.3 5	54 8	(E2)		E γ : unweighted average of the two values.
1684.04	675.7 2	4.0 5			
	1005.6 2	26 1			
	1124.5 2	9.0 5			
	1652.5 2	22 1			
	1661.5 2	100 5			
1771.43	87.40 2	50 5			
	763.3 2	100 5			
	1146.9 2	90 8			
	1212.2 2	45 5			
1809.73	232.79 20	12 3			
	630.38 10	100 9	(E2)		
1861.95	667.3	25 13			
	682.5	100 25			
1894.43	1862.8 2	100 3			
	1871.6 2	11 3			
2014.50	152.5	14 4			E γ ,I γ : γ from ^{248}Cm SF decay only.
	502.17 20	14 3			
	835.16 14	100 13	D		
2158.70	348.99 20	47 7	D		I γ : from ^{248}Cm SF decay. Other: 14 6 from ^{252}Cf SF decay seems discrepant.
	581.78 12	100 10	(E2)		
2192.82	383.0 3	45 14			E γ : unweighted average of the two values.
	1013.6 2	100 25			
2307.93	859.4 2	86.4 23			
	1628.7 2	≤ 23			
	1714.1 2	40.9 23			
	1748.8 2	100.0 23			
2500.01	341.3 2	27 10	D		
	690.23 14	100 10	(E2)		
2574.98	416.3	14 7			E γ ,I γ : γ from ^{248}Cm SF decay only.
	560.45 21	100 14	(Q)		

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Xe})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ‡	Comments
2574.98	765.24 20	86 15	D	I γ : from ^{248}Cm SF decay. Other: 200 82 in ^{252}Cf SF decay. E γ : poor fit, level-energy difference=968.8.
2740.18	969.4 2	57.9 13		
	1546.4 2	100 3		
	2115.7 2	89.5 26		
2898.45	1499.5 2	≤ 50		
	2866.5 2	100 5		
	2898.1 2	100 5		
2921.68	763.02 14	100		
2925.37	425.1 3			
	732.63 19	100 10		
	1115.7 3	44 9		
2993.78	835.0	100		
3161.47	661.51 12	100		
3211.71	636.72 18	100 24		
	711.51 22	92 34		
3305.1	805.04 22	100	D	E γ , I γ : γ from ^{252}Cf SF decay only.
3547.9	554.0	48 24		
	626.32 25	100 32		
3585.9	664.21 14	100		
3607.7	682.30 26	100		
3792.81	580.97 18	100 56		E γ , I γ : γ from ^{248}Cm SF decay only.
	631.5	111 56		
4022.9	861.45 18	100		
4232.4	646.52 13	100		
4298.9	713.0	100		
4412.4	619.63 15			
4984.9?	962.0 § 4			
5096.3	863.89 14	100		
6091.3?	995.0 § 4			

† From ^{139}I β^- decay for low-spin ($\leq 9/2$) states and from SF decays for high-spin ($> 9/2$) states. Weighted averages of the values from different studies taken when data are available, with uncertainty of 0.2 keV used for values from ^{248}Cm SF decay where these are not stated.

‡ From $\gamma\gamma(\theta)$ and $\gamma(\text{lin pol})$ in ^{248}Cm SF decay, except as stated. Also comparison to RUL from a comment by 2002Ur04 in ^{238}Cm SF decay that $T_{1/2} < 10$ ns for all excited states, which excludes M2 for $E\gamma < 700$ keV or so.

§ Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(D) Band based on 13/2+.

^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ

Parent ^{139}I : $E=0.0$; $J\pi=(7/2+)$; $T_{1/2}=2.280$ s 11; $Q(\text{g.s.})=7186$ 29; $\%\beta^-$ decay=100.

^{139}I -J, $T_{1/2}$: From ^{139}I Adopted Levels.

^{139}I - $Q(\beta^-)$: From 2012Wa38.

Tentative Decay Scheme due to many transitions unplaced and lack of information about accurate multipolarities of low-energy transitions.

1987RoZW, 1985Ro13, 1985WaZQ: TRISTAN. Measured $E\gamma$, $I\gamma$.

Out of a total 110 γ rays reported, 41 remain unplaced. $I\gamma(\text{unplaced})/I\gamma(\text{placed})=0.16$. The decay scheme (from 1985Ro13), constructed on the basis of energy sums, is therefore treated as tentative, by evaluators.

Others: 1982Al01, 1975Kr17, 1971Kr22.

1992Gr06: measured $\beta\gamma$ -coin; deduced $Q(\beta^-)$ value; plastic scintillation detector telescope.

1975Al11: measured total absorption γ -spectrum and deduced β -strength function.

Delayed neutron measurements (1974Ru07,1974Kr21,1975As04,1976Lu02, 1981Ho07):

1974Ru07: measured neutron spectra up to at least 1600 keV.

1981Ho07: OSIRIS. measured $E\gamma$ for seven transitions, $I\gamma/\text{In}$ (^3He detectors in paraffin shielded by boron-paraffin and cadmium); $I\gamma/\text{In}=6.81$ 6.

Beta spectra: 1973Ad04, 1974Gr29, 1975As04.

Beta-strength function: 1972Pa11, 1974JoZT.

1980KeZQ: LOHENGRIN, OSTIS. Measured $\beta\gamma$ -coin; scin or Ge, Ge(Li).

 ^{139}Xe Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	Comments
0.0	$3/2-$	39.68 s 14	$T_{1/2}$: from Adopted Levels.
22.73 8	(7/2-)		
31.703 20	(5/2-)		
559.40 10	(9/2-)		
593.99 10	(11/2-)		
624.26 10	(5/2-)		
670.02 12	(3/2-, 5/2, 7/2-) §		
678.79 9	(9/2-)		
1008.27 10	(5/2, 7/2, 9/2)		
1059.02 15	(3/2-, 5/2, 7/2) §		
1193.33 11	(3/2-, 5/2, 7/2) §		
1312.70 17			
1399.46 10	(3/2-, 5/2, 7/2) §		
1444.15 13	(7/2, 9/2)		
1448.53 11	(7/2, 9/2)		
1493.35 17			
1684.03 9	(5/2, 7/2, 9/2)		
1771.43 9			
1894.43 15			
2307.94 13			
2740.18 14			
2898.45 12			
3744+x			$E(\text{level})$: set of neutron decaying levels above $S(n)(^{139}\text{Xe}=3744$ 4, where $x<3442$.

† From least-squares fit to $E\gamma$ data. Reduced χ^2 of 2.5 is somewhat larger than critical $\chi^2=1.6$. The 849.5 and 969.4 γ rays deviate by about three times the quoted uncertainty.

‡ From the Adopted Levels. Additional arguments for $J\pi$ assignments from this dataset are given as footnotes.

§ $\neq 3/2+$ from log ft.

^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued) β^- radiations

$\langle E\beta \rangle \geq 2.01$ MeV 29 (1982Al01,Si(Li)) compared to 2.786 MeV 11 from the decay scheme.

1980KeZQ suggested that there is no direct feeding of the g.s. based on agreement of E_β from singles and from

$\beta-528\gamma$. This seems to be confirmed by $\langle E_\beta \rangle$ and would be consistent with $J\pi(^{139}\text{I g.s.})=(7/2+)$ from systematics and $J\pi(^{139}\text{Xe g.s.})=3/2-$.

9.9% 8 feeding to unbound levels above 3.64 MeV. (1983ReZX,1984Ma39).

The $\beta\gamma$ -coin data are from 1985Ro13 and 1992Gr06.

$E\beta^-$	E(level)	$I\beta^{-\dagger}$	Log ft	Comments
(3440-x 30)	3744+x	10.0 3		$I\beta^-$: from Adopted Levels of ^{139}I , $\% \beta^- n=10.0$ 3 which represents total β feeding to neutron decaying levels above the neutron separation energy of ^{139}Xe .
(4290 30)	2898.45	0.36 3	6.9	
(4450 30)	2740.18	1.52 4	6.3	
(4880 30)	2307.94	0.85 3	6.7	
(5290 30)	1894.43	0.32 2	7.3	
(5410 30)	1771.43	0.11 2	7.8	
(5500 30)	1684.03	2.52 10	6.5	
(5690 30)	1493.35	0.44 2	7.3	
(5740 30)	1448.53	6.2 2	6.2	$E\beta^-$: 5520 150 from $\beta\gamma$ -coincidences (1985Ro13). $E\beta^-$: 5352 44 from $\beta(1426\gamma)$ coin (1992Gr06); 5520 150 from $\beta\gamma$ -coincidences (1985Ro13). $E\beta^-$: 5520 150 from $\beta\gamma$ -coincidences (1985Ro13).
(5740 30)	1444.15	1.65 5	6.8	
(5790 30)	1399.46	1.48 5	6.8	
(5870 30)	1312.70	0.33 2	7.5	
(5990 30)	1193.33	0.71 4	7.2	
(6130 30)	1059.02	2.0 1	6.8	
(6180 30)	1008.27	5.5 2	6.4	
(6510 30)	678.79	3.6 3	6.7	
(6520 30)	670.02	0.29 3	7.8	$I\beta^-$: it should be noted that tentative placement of 389γ from 1059 level leads to negative β feeding of -0.34% . It is possible this γ is either multiply placed, or only from the 1448 level.
(6560 30)	624.26	3.2 2	6.7	
(6590 30)	593.99	2.6 4	8.9 ^{1u}	
(6630 30)	559.40	12.3 4	6.2	$E\beta^-$: 6340 120 from $\beta(528\gamma)$ coin; 6210 150 from singles (1985Ro13).
(7150 30)	31.703	≈ 22	≈ 6.1	$I\beta^-$: see comment for β feeding of 22.85 level. Other: $<30\%$ from $\log ft > 5.9$ for first-forbidden transition.
(7160 30)	22.73	≈ 21	≈ 6.1	$I\beta^-$: total β feeding to 22.85 and 31.86 levels is 43% 2 from the present decay scheme with $I\gamma$ normalization=0.0826 70 and $\% \beta^- n=10.0$ 3. This feeding is assumed (by evaluators) as equally divided between the two levels. Other: $<30\%$ from $\log ft > 5.9$ for first-forbidden transition.

[†] Absolute intensity per 100 decays.

¹³⁹I β⁻ Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued)

γ(¹³⁹Xe)

I_γ normalization, I(γ+ce) normalization: From I_γ(571γ)/I_n=0.81 6 (1981Ho07) and %β⁻n=10.0 3 (from Adopted Levels of ¹³⁹I).

Eγ [†]	E(level)	Iγ [†] #	Mult. [‡]	δ	α	I(γ+ce)#	Comments
22.8 2	22.73	0.85	[E2]		690 40	590	I(γ+ce): deduced by the evaluators from β feeding of ≈21% and total γ feeding. Other: I(γ+ce)<292 from I _γ <0.4 deduced from estimate by 1985Ro13 and mult=E2 is low since γ feeding from higher levels gives I(γ+ce)=332 5. In addition, from systematics of neighboring nuclides, strong β feeding is expected to this level.
31.70 2	31.703	8.0 3	M1+E2	≈0.9	≈62.5		α(exp): >27 from intensity balance at 31.86 level, if no β feeding. I(γ+ce): 226 4 from intensity balancing at the 32 level, if no direct β feeding to this level. With 22% β feeding, I(γ+ce)=500. Mult.,δ: from γ intensity balance at 31.9 level, using β feeding of ≈22% and I _γ =8.0 3. Assumption of no β feeding to 31.86 level rules out E1 and implies δ(E2/M1)>0.48.
84.80 2	678.79	2.0 1	[M1, E2]		2.3 10		
87.40 2	1771.43	1.0 1					
^x 165.8 2							
^x 249.5 2		0.6 1					
329.6 2	1008.27	1.1 1					
384.0 2	1008.27	0.9 1					
389.1 §& 2	1059.02	7.6 2					
^x 427.2 2							
440.0 2	1448.53	0.6 1					
448.9 2	1008.27	1.2 1					
^x 467.0 2		1.3 1					
^x 473.0 2		3.0 1					
^x 512.9 2		3.6 1					
527.7 2	559.40	100 3					
536.6 2	559.40	67 2					
571.2 3	593.99	98 3					
592.6 2	624.26	29 1					
601.5 2	624.26	22 1					
624.3 2	624.26	1.8 1					
634.0 §& 2	1312.70	1.6 1					
638.5 2	670.02	6.4 2					
647.1 @& 2	670.02						
	678.79	14.2 @ 5					I _γ : total intensity for doublet=14.2 5. Based on I _γ (647)/I _γ (656)=0.38 15 from SF decay (2002Ur04), almost all the intensity of 647.1γ belongs with the decay of 678 level, and almost none from the decay of 670 level.
656.0 2	678.79	58 2					
670.4 2	670.02	3.0 1					
675.7 2	1684.03	0.8 1					
719.1 2	1312.70	2.6 1					
730.0 2	1399.46	5.8 2					
752.9 2	1312.70	1.5 1					
763.3 2	1771.43	2.0 1					
769.8 2	1448.53	13.0 4					
774.1 §& 2	1399.46	6.8 2					
^x 781.9 2		2.2 1					
^x 808.4 2		0.8 1					
^x 822.8 2		4.0 1					
824.8 2	1448.53	3.0 1					
^x 837.4 2		0.9 1					

Continued on next page (footnotes at end of table)

^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued) $\gamma(^{139}\text{Xe})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger\#$	Comments
849.5 2	1444.15	3.2 1	E γ : poor fit, level-energy difference=850.2.
854.4 2	1448.53	50 2	
859.4 2	2307.94	3.8 1	
^x 869.7 2		2.4 1	
^x 894.4 9		9.2 3	
899.4 2	1493.35	1.3 1	E γ : poor fit, level-energy difference=968.8.
933.9 2	1493.35	4.2 1	
^x 942.5 1		0.7 1	
969.4 2	2740.18	4.4 1	
976.4 2	1008.27	50 2	
985.4 2	1008.27	18 1	
^x 1001.1 3		2.8 1	
1005.6 2	1684.03	5.2 2	
1027.3 2	1059.02	3.0 1	
1036.3 2	1059.02	22 1	
1059.4 ^{s&} 2	1059.02	1.7 1	
^x 1077.0 2		2.0 1	
1124.5 2	1684.03	1.8 1	
^x 1129.9 2		1.8 1	
^x 1137.2 2		0.8 1	
1146.9 2	1771.43	1.8 1	
^x 1149.8 2		5.6 2	
1161.4 2	1193.33	9.2 3	
1170.4 2	1193.33	3.4 1	
^x 1181.7 1		0.8 1	
1193.3 2	1193.33	3.8 1	
1212.2 2	1771.43	0.9 1	
^x 1268.8 2		1.2 1	
^x 1272.2 2		2.0 1	
^x 1280.9 2		1.2 1	
^x 1282.9 2		2.0 1	
^x 1293.2 2		0.9 1	
^x 1304.7 2		6.8 2	
^x 1351.2 2		1.5 1	
1367.4 2	1399.46	5.4 2	
1376.9 2	1399.46	4.6 2	
1399.6 2	1399.46	3.0 1	
^x 1403.7 3		2.6 1	
1412.6 2	1444.15	13.0 4	
1421.9 2	1444.15	4.2 2	
1425.6 2	1448.53	14.0 4	
^x 1431.5 2		5.8 2	
^x 1441.5 2		1.7 1	
^x 1458.2 2		0.8 1	
^x 1468.1 2		2.6 1	
^x 1486.5 2		0.7 1	
1499.5 2	2898.45	≤ 1	
1546.4 2	2740.18	7.6 2	
^x 1577.2 2		1.7 1	
1628.7 2	2307.94	≤ 1.0	
1652.5 2	1684.03	4.4 2	
1661.5 2	1684.03	20 1	
1714.1 2	2307.94	1.8 1	
1748.8 2	2307.94	4.4 1	
^x 1755.9 2		1.8 1	
^x 1786.1 2		1.6 1	
^x 1800.5 2		5.4 2	
^x 1823.5 2		2.4 1	
^x 1829.1 2		3.0 1	
1862.8 2	1894.43	3.6 1	
1871.6 2	1894.43	0.4 1	
^x 1947.0 2		1.9 1	
^x 2023.4 2		3.2 1	

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^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued) $\gamma(^{139}\text{Xe})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^{\ddagger\#}$
2115.7 2	2740.18	6.8 2
^x 2151.4 2		1.8 1
^x 2261.6 2		3.2 1
^x 2429.9 2		2.2 1
^x 2735.5 2		1.4 1
2866.5 2	2898.45	2.0 1
2898.1 2	2898.45	2.0 1
^x 3285.8 2		4.0 1

[†] From 1987RoZW. Uncertainties in energy are stated as 0.02 keV for $E\gamma > 100$ keV and 0.2 keV for $E\gamma < 100$ keV, which to the evaluators seems a reverse statement. Evaluators assign 0.02 keV for $E\gamma < 100$ keV and 0.2 keV for $E\gamma > 100$ keV. Intensity uncertainty is stated as 10% for $I\gamma < 1$ and 3% for $I\gamma > 1$. Evaluators round off the intensity uncertainties as suggested by the significant figures to which the intensities are listed in 1987RoZW.

[‡] From Adopted Gammas.

[§] From the least-squares analysis, alternative placements are possible for some of the γ rays: 389.1 γ could deexcite the 1448 level; 1059.4 γ , the 1684 level; 634.0 γ , the 1193.3 level; and 774.1 γ , the 1444.3 level.

[#] For absolute intensity per 100 decays, multiply by 0.0826 70.

[@] Multiply placed; intensity suitably divided.

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

^x γ ray not placed in level scheme.

^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued)

Decay Scheme

$(7/2^+)$ 0.0 2.280 s
 $^{139}_{53}\text{I}_{86}$
 $Q^- = 7186^{29}$
 $\% \beta^- = 100$

Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided

^{139}I β^- Decay (2.280 s) 1987RoZW,1985Ro13,1985WaZQ (continued)

Decay Scheme (continued)

 ^{140}I β^-n Decay (0.86 s) 1999Li18,1978Kr15,1976Lu02

 Parent ^{140}I : E=0.0; $J\pi=(4-)$; $T_{1/2}=0.86$ s 4; Q(g.s.)=3980 180; $\%\beta^-n$ decay=9.3 10.

 $^{140}\text{I}-J, T_{1/2}$: From ^{140}I Adopted Levels in the ENSDF database (Feb 2006 update).

 $^{140}\text{I}-Q(\beta^-n)$: From 2012Wa38.

 $^{140}\text{I}-\%\beta^-n$ decay: $\%\beta^-n=9.3$ 10 (from ^{140}I Adopted Levels in the ENSDF database, Feb 2006 update).

Measurements of beta-delayed neutrons: 1999Li18, 1980Al15, 1978Kr15, 1977Sh01, 1976Lu02, 1974Kr21, 1972Sc48.

Compilations: 2002Pf04, 1993Ru01, 1984Ma39, 1973To16, 1975Iz03.

 ^{139}Xe Levels

E(level)	$J\pi$	Comments
0.0	3/2-	E(level): assumed that g.s. is populated in this decay.

²⁴⁸Cm SF Decay 2002Ur04

Parent ²⁴⁸Cm: E=0.0; J π =0+; T_{1/2}=3.48 $\times$ 10⁵ y 4; %SF decay=0.32 10.

²⁴⁸Cm-T_{1/2}: From ²⁴⁸Cm Adopted Levels in the ENSDF database (Sept 2014 update).

²⁴⁸Cm-%SF decay: %SF=8.39 16 (²⁴⁸Cm Adopted Levels in the ENSDF database, Sept 2014 update).

2002Ur04: measured E γ , I γ and $\gamma\gamma$, $\gamma\gamma$ (θ), $\gamma\gamma$ (lin pol) using EUROGAM II array consisting of Compton-suppressed Ge detectors.

1994Be25 (several authors are the same as on 2002Ur04): measured E γ , I γ , $\gamma\gamma$ - and multi-fold-coin, coincidences with ¹⁰⁹Mo γ rays, $\gamma\gamma$ (θ); EUROGAM (45 Compton-suppressed large volume Ge and 5 LEP detectors). Identification based on observance of 512 γ , and coincidences with 512 γ ¹⁰⁹Mo γ rays. Three main γ cascades: 571-585-631-690-682; 491-582-763-664-648; and 502-560-637-581 were identified; and J π assignments were made for seven levels starting from 7/2- to 23/2-.

¹³⁹Xe Levels

E(level) [†]	J π [‡]	E(level) [†]	J π [‡]	E(level) [†]	J π [‡]
0.0	3/2-	1576.80 [@] 21	17/2-	3161.4 [#] 3	27/2-
22.71 [#] 14	7/2-	1809.68 [#] 22	19/2-	3211.8 ^{&} 3	25/2+
31.701 ^a 20	5/2-	1861.86 ^a 21	(17/2-)	3547.7 3	
559.32 ^a 14	9/2-	2014.41 ^{&} 21	17/2+	3586.0 [@] 4	(29/2-)
593.93 [#] 16	11/2-	2158.70 [@] 23	21/2-	3792.9 ^{&} 3	(29/2+)
678.48 [@] 14	9/2-	2192.99 24	(19/2-)	4022.8 [#] 4	
1085.93 [@] 17	13/2-	2499.96 [#] 25	23/2-	4232.5 [@] 4	(33/2-)
1179.30 [#] 20	15/2-	2575.06 ^{&} 23	21/2+	4299.0 4	
1194.57 ^a 17	(13/2-)	2921.7 [@] 3	(25/2-)	5096.3 [@] 5	
1417.88 17	(11/2+)	2925.5 4			
1512.12 ^{&} 22	13/2+	2993.7 3			

[†] From least-squares fit to E γ data, assuming $\Delta(E\gamma)$ =0.2 keV for each γ ray.

[‡] As proposed in 2002Ur04 based on multiplicities from $\gamma\gamma$ (θ) and γ (lin pol) data, and band structures. In Adopted Levels, parentheses are added to most assignments.

(A): Band based on 7/2-.

@ (B): Band based on 9/2-.

& (C): Band based on 13/2+.

a (D): Band based on 5/2-.

γ (¹³⁹Xe)

E γ	E(level)	I γ	Mult. [†]	α	Comments
22.8 [‡] 2	22.71				
31.70 [‡] 2	31.701				
152.5	2014.41	1.1 3			
232.8	1809.68	5 1			
341.3	2499.96	3 1	D		(341 γ)(582 γ)(θ): A ₂ =-0.12 4, A ₄ =-0.01 4.
349.0	2158.70	14 2	D		(349 γ)(571 γ +585 γ +630 γ)(θ): A ₂ =-0.09 2, A ₄ =+0.02 2.
383.3	2192.99	1.2 4			
397.5	1576.80	24 2	M1+E2	0.0186 12	(397 γ)(571 γ)(θ): A ₂ =+0.08 1, A ₄ =0.00 1. Pol=-0.10 6 (gated at 585 γ and 581.9 γ).
407.8	1085.93	6 1			
416.3	2575.06	1.0 5			
490.8	1576.80	13 2	(E2)		(491 γ)(528 γ)(θ): A ₂ =+0.08 1, A ₄ =-0.03 5.
491.8	1085.93	25 3	(M1+E2)		(492 γ)(571 γ)(θ): A ₂ =-0.03 1, A ₄ =+0.01 1. Pol=-0.22 11 for 491 doublet (gated at 585 γ).
502.3	2014.41	1.2 4			
516.0	1194.57	1.0 5			
526.4	1085.93	3 1			
527.7	559.32	6 1	(E2)		Mult.: from (491 γ)(528 γ)(θ) consistent with mult=Q for both γ rays.
536.7	559.32	4 1			
554.0	3547.7	1.2 6			E γ : from e-mail reply of Oct. 11, 2002 from one of the authors (W. Urban). E γ =667.0 in Table 1 and Figure 1 of 2000Ur04 is a misprint.
560.7	2575.06	7 1	(Q)		(561 γ)(835 γ)(θ): A ₂ =-0.04 2, A ₄ =+0.02 2.
571.2	593.93	100 5	(E2)		Mult.: from (585 γ)(571 γ)(θ) consistent with mult=Q for both γ rays.
581.0	3792.9	0.9 5			
581.9	2158.70	30 3	(E2)		(582 γ)(397 γ)(θ): A ₂ =-0.10 2, A ₄ =-0.04 4.

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²⁴⁸Cm SF Decay 2002Ur04 (continued)
γ(¹³⁹Xe) (continued)

Eγ	E(level)	Iγ	Mult. [†]	Comments
585.4	1179.30	75 5	(E2)	(585γ)(571γ)(θ): A ₂ =+0.09 1, A ₄ =+0.02 1. Pol=+0.25 6 (gated at 571γ).
600.5	1194.57	6 2		
626.0	3547.7	2.5 8		
630.4	1809.68	33 3	(E2)	(630γ)(571γ)(θ): A ₂ =+0.10 1, A ₄ =+0.01 1. Pol=+0.17 8 (gated at 571γ).
631.5	3792.9	1.0 5		
635.5	1194.57	3 1		
636.8	3211.8	2.9 7		
646.5	4232.5	2.0 4		
646.6	678.48	1.5 5		
655.8	678.48	4 1		
661.5	3161.4	4 1		
664.3	3586.0	5 1		
667.3	1861.86	1.0 5		
682.5	1861.86	4 1		
690.2	2499.96	10 1	Q	(690γ)(571γ)(θ): A ₂ =+0.10 1, A ₄ =0.00 3.
711.8	3211.8	3 1	D	(712γ)(571γ+585γ+630γ)(θ): A ₂ =-0.06 3, A ₄ =+0.02 4.
713.0	4299.0	0.6 3		
732.5	2925.5	0.8 4		
739.0	1417.88	0.7 3		
763.0	2921.7	15 3		
765.4	2575.06	6 1	D	(765γ)(571γ+585γ+630γ)(θ): A ₂ =-0.07 2, A ₄ =0.00 2.
824.2	1417.88	1.2 4		
835.0	2993.7	5 1		
835.2	2014.41	8 1	D	(835γ)(571γ+585γ)(θ): A ₂ =-0.04 1, A ₄ =+0.02 1. Pol=-0.2 2 (gated at 585γ).
858.7	1417.88	1.0 5		
861.4	4022.8	0.8 4		
863.8	5096.3	0.8 4		
918.2	1512.12	5 1	D	(918γ)(571γ)(θ): A ₂ =-0.013 3, A ₄ =+0.01 1.
1013.7	2192.99	2.8 7		

[†] From γγ(θ) and γ(lin pol) data. Mult=Q is for ΔJ=2 transition and mult=D is for ΔJ=1 transition in γγ(θ) data.

[‡] From Adopted Gammas.

²⁵²Cf SF Decay 2002Lu08

Parent ²⁵²Cf: E=0; Jπ=0+; T_{1/2}=2.645 y 8; %SF decay=0.108 7.

²⁵²Cf-T_{1/2}: From ²⁵²Cf Adopted Levels in the ENSDF database (Mar 2005 update).

²⁵²Cf-%SF decay: From 3.50 21 per 100 fissions (1994EnZZ) and %SF=3.092 8 (²⁵²Cf Adopted Levels in the ENSDF database, Mar 2005 update). Other measurement: %SF=0.108(6) (1997Zh23).

2002Lu08: measured Eγ, Iγ, γγ, γγγ and higher fold events using GAMMASPHERE array with 102 Compton-suppressed Ge detectors. Source of 62 μCi sandwiched between two iron foils of 10 mg/cm² thickness was used.

1997Zh23 (from the same group as 2002Lu08): measured Eγ, Iγ, γγ- and triple γ-coincidences using arrays of 20 Compton-suppressed Ge detectors, and GAMMASPHERE (early implementation). All levels in this paper are also given in 2002Lu08, except that one band based on 1086 level has opposite parity to that in 2002Lu08. Evaluators assume that 2002Lu08 completely supersedes 1997Zh23.

¹³⁹Xe Levels

E(level) [‡]	Jπ [§]	Comments
0.0 [†]	3/2-	
22.75 [†] # 14	(7/2-)	
31.700 [†] @ 20	(5/2-)	
559.64@ 12	(9/2-)	
593.88# 16	(11/2-)	
1084.86@ 16	(13/2-)	
1179.18# 17	(15/2-)	
1512.38& 21	(13/2+)	
1576.70@ 18	(17/2-)	
1809.55# 19	(19/2-)	

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²⁵²Cf SF Decay 2002Lu08 (continued)
¹³⁹Xe Levels (continued)

E(level) [‡]	Jπ [§]	Comments
2014.33& 20	(17/2+)	B(E1)/B(E2)=0.52×10 ⁻⁴ 5.
2158.47@ 20	(21/2-)	
2192.29 ^a 23		
2499.83 [#] 21	(23/2-)	B(E1)/B(E2)=0.19×10 ⁻⁴ 3.
2574.58& 22	(21/2+)	
2921.50@ 25	(25/2-)	
2925.06 ^a 25		B(E1)/B(E2)=0.15×10 ⁻⁴ 5.
3161.35 [#] 24	(27/2-)	
3211.20& 23	(25/2+)	
3304.9 3		(27/2+)
3548.0 3	(27/2+)	
3585.7@ 3	(29/2-)	
3607.4 ^a 4		(29/2+)
3792.1& 3	(29/2+)	
4022.8 [#] 3	(31/2-)	
4232.2@ 3	(33/2-)	(33/2+)
4411.8& 4	(33/2+)	
4984.8? 5	(35/2-)	
5096.1@ 4	(37/2-)	(41/2-)
6091.1?@ 6	(41/2-)	

[†] The lowest three levels with Jπ=3/2-, (7/2-) and (5/2-) probably arise from different couplings of νf_{7/2}³ configuration. Higher levels of this band and that of s=i band based on (7/2-) are probably a mixture of νf_{7/2} and νh_{9/2} orbitals and quadrupole phonons.

[‡] From least-squares fit to E_γ data.

[§] As proposed in 2002Lu08 based on decay modes and band structures.

[#] (A): (7/2-) band, simplex s=i, α=-1/2.

@ (B): (5/2-) band, α=+1/2. Positive parity was assigned in 1997Zh23 for levels at 1086 and above.

& (C): (13/2+) band; simplex s=i, α=+1/2.

^a (D): γ sequence.

^γ(¹³⁹Xe)

E _γ [†]	E(level)	I _γ [†]	E _γ [†]	E(level)	I _γ [†]	E _γ [†]	E(level)	I _γ [†]
22.8 [‡] 2	22.75		560.27 17	2574.58	1.1 9	711.34 15	3211.20	1.7 14
31.70 [‡] 2	31.700		571.11 10	593.88	100 20	732.74 19	2925.06	1.8 14
232.78 21	1809.55	2.0 8	580.94 18	3792.1	0.8 6	763.03 14	2921.50	7.9 16
341.3 3	2499.83	1.5 12	581.74 12	2158.47	18 4	765.04 22	2574.58	2.2 9
348.98 22	2158.47	2.5 10	585.32 10	1179.18	71 14	805.04 22	3304.9	1.7 14
382.67 16	2192.29	1.2 10	619.63 15	4411.8		835.14 14	2014.33	4.9 20
397.53 11	1576.70	17 3	626.52 16	3548.0	1.6 13	861.49 18	4022.8	1.0 8
425.1 3	2925.06		630.38 10	1809.55	22 4	863.94 14	5096.1	1.2 10
490.88 14	1084.86		636.65 18	3211.20	2.6 10	918.54 16	1512.38	2.0 8
491.77 14	1576.70		646.53 13	4232.2	1.4 11	962.0 [§] 4	4984.8?	
502.02 22	2014.33	0.4 3	661.52 12	3161.35	3.3 13	995.0 [§] 4	6091.1?	
525.24 14	1084.86	3.0 12	664.16 14	3585.7	4.3 17	1013.4 4	2192.29	1.6 13
527.92 14	559.64	12 2	682.30 26	3607.4	0.9 7	1115.7 3	2925.06	0.8 6
536.94 14	559.64	9 2	690.24 14	2499.83	8.0 16			

[†] From table II of 2002Lu08, except where noted. Energies given in figure 4 of 2002Lu08 are level-energy differences. Systematic uncertainty in E_γ values is stated as 0.1 keV by 2002Lu08. The uncertainties for I_γ values are stated 20% for intense transitions and 80% for weaker γ rays. Evaluators assign ≈20% for I_γ>5, 40% for I_γ=2-5 and ≈80% for I_γ<2. For E_γ values, 2002Lu08 seem to give only the statistical uncertainties. The evaluators have added 0.1 keV systematic uncertainty in quadrature.

[‡] From Adopted Gammas.

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

 $^{235}\text{U}(\text{n},\text{F}\gamma)$ 2012Mu08

2012Mu08: E=thermal neutrons from the CIRUS-BARC reactor facility. Target density=5.1 g/cm³ UAl₃ (17% enriched ²³⁵U). Gamma rays were detected by two clover HPGe detectors equipped with anti-Compton shields, in coincidence mode. Measured E γ , I γ , $\gamma\gamma$ -coin. Deduced levels, J, π , isotopic yield, angular momentum distribution.

 ^{139}Xe Levels

E(level)	J π [†]
0.0	3/2-
23 $\frac{1}{2}$ [‡]	(7/2-)
594 $\frac{1}{2}$ [‡]	(11/2-)
1179 $\frac{1}{2}$ [‡]	(15/2-)
1810 $\frac{1}{2}$ [‡]	(19/2-)

[†] 2012Mu08 gave assignments from 2002Ur04. Here these are from Adopted Levels.

[‡] (A): Band based on 7/2-.

 $\gamma(^{139}\text{Xe})$

E γ	E(level)	I γ [†]
571	594	>100
585	1179	100 5
630	1810	47 7

[†] 2012Mu08 mention uncertainties of 5% to 25% depending on the γ -ray intensity. Evaluators assign 5% for γ rays with I γ ≥50; 15% for I γ =20-50 and 25% for I γ ≤20.

Adopted Levels, Gammas

$Q(\beta^-)=4213\text{ }3$; $S(n)=5885\text{ }10$; $S(p)=8018\text{ }4$; $Q(\alpha)=663\text{ }6$ 2012Wa38.

$S(2n)=10298\text{ }3$, $S(2p)=18923\text{ }9$ (2012Wa38).

1999Am05, 1986Au02: mass measurements.

1992Pr04: measured $Q(\beta^-)$ value for ^{139}Cs β^- decay.

 ^{139}Cs LevelsCross Reference (XREF) Flags

A ^{139}Xe β^- Decay (39.68 s)

B ^{248}Cm SF Decay

C ^{252}Cf SF Decay

E(level) [†]	J π	XREF	T _{1/2} &	Comments
0.0 ^a	7/2+	ABC	9.27 min 5	$\% \beta^- = 100$. $\mu = +2.696\text{ }4$ (1979Bo01, 2014StZZ). $Q = -0.063\text{ }14$ (1979Bo01, 2016St14). RMS charge radius $\langle r^2 \rangle^{1/2} = 4.8422\text{ fm }69$ (2013An02 evaluation). J π : spin from AB (1979Bo01, 1979Ek02), hyperfine laser spectroscopy (1981Th06, 1987Co19); parity from agreement of experimental μ with shell-model calculations. T _{1/2} : from 1969Ca03 (627 γ , 1285 γ , 2–6 MeV β ; scin). Others: 9.27 min 16 (1986Ok03, 627 γ , 1283 γ ; He-jet), 9.76 min 8 (1972Eh02, β , pc), 9.53 min 10 (1970OsZZ, 4 $\pi\beta$, scin), 8.98 min 33 (1970RuZR, NaI), 9.00 min 15 (1966Ar08, $E\beta > 2.4$ MeV, scint. for ^{138}Cs and ^{139}Cs , =18 half-lives). μ, Q : collinear fast beam laser spectroscopy (1979Bo01, 1978Sc27). Value of $-0.075\text{ }11$ in 1979Bo01 re-evaluated by 2013StZZ. Others: $\mu = +2.70\text{ }1$, $Q = -0.06\text{ }3$ (atomic beam laser spectroscopy, 1981Th06); $\mu = +2.70\text{ }3$ (atomic beam, 1979Ek02).
218.633 24	5/2+, 7/2+	ABC	2.23 ns 5	J π : M1+E2 γ to 7/2+; log $ft < 11$ from 3/2– parent gives $\leq 7/2+$; low-lying 5/2+ level in ^{141}Cs and 43Cs suggest (5/2+).
289.75 4	3/2+, 5/2+, 7/2+	A	96 ps 25	J π : E2, M1 γ to 7/2+; log $ft < 11$ from 3/2– parent gives $\leq 7/2+$.
393.59 3	3/2+, 5/2+, 7/2+	A	24 ps 15	J π : E2, M1 γ to 7/2+; log $ft < 11$ from 3/2– parent gives $\leq 7/2+$.
393.65 3	(3/2+, 5/2+, 7/2+)	A	1.71 ns 2	J π : (M1+E2) γ to 5/2+, 7/2+; log $ft < 11$ from 3/2– parent gives $\leq 7/2+$. See also footnote in Levels from ^{139}Xe β^- Decay.
515.11 4	3/2+, 5/2+	A	6 ps +10–6	J π : γ to 7/2+. $\leq 5/2$ from log $f^{lu}_t < 8.5$ for feeding from 3/2– parent. $\pi = +$ from E2, M1 γ to 5/2+, 7/2+.
595.43 ^b 13	(9/2+)	ABC		J π : (M1+E2) γ to 7/2+; yrast-type population in SF decays.
601.61 ^a 25	(11/2+)	BC		J π : $\Delta J = 2$, Q γ to 7/2+; band member.
646.51 6	3/2, 5/2, 7/2+ [‡]	A		
710.12 5		A		
732.36 4	3/2+, 5/2, 7/2+	A		J π : γ to 7/2+; log $ft < 11$ from 3/2– parent gives $\leq 7/2+$.
891.53 6	3/2, 5/2, 7/2+ [‡]	A		
942.60 4	3/2, 5/2, 7/2+ [‡]	A		
1006.52 4	1/2(+), 3/2, 5/2 [§]	A	15 ps 10	
1020.28 6	3/2, 5/2, 7/2+ [‡]	A		
1037.22 9		A		
1070.7 ^b 3	(13/2+)	BC		J π : $\Delta J = 2$, Q γ to (9/2+); γ to (11/2+); band member.
1138.84 5		A		
1146.0 ^a 4	(15/2+)	BC		J π : $\Delta J = 2$, Q γ to (11/2+); band member.
1214.07 10		A		
1395.09 9		A		
1411.6 3		A		
1461.25 7		A		
1498.9 ^b 4	(17/2+)	BC		J π : $\Delta J = 2$, Q γ to (13/2+); γ to (15/2+); band member.
1508.44 7		A		
1510.33 24		A		
1600.02 7		A		
1652.78 5		A		
1693.86 11		A		
1718.05 4		A		
1721.93 24		A		
1735.8 ^a 4	(19/2+)	BC		J π : $\Delta J = 2$, Q γ to (15/2+); (M1+E2) γ to (17/2+); band member.
1738.61 5		A		
1793.18 21		A		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

¹³⁹Cs Levels (continued)

E(level) [†]	J π	XREF	Comments
1816.4? 4	3/2, 5/2, 7/2+ [‡]	A	
1831.21 25		A	
1846.6 ^c 4		C	
2063.74 9	3/2, 5/2, 7/2+ [‡]	A	
2099.59 15		A	
2103.8? 4	3/2, 5/2, 7/2+ [‡]	A	
2119.50? 15		A	
2185.52 5	1/2(+), 3/2, 5/2 [§]	A	
2239.3 ^b 4	(21/2+)	BC	J π : $\Delta J=2$, Q γ to (17/2+); γ to (19/2+); band member.
2304.67 8	3/2, 5/2 [#]	A	
2328.85 6	3/2, 5/2 [#]	A	
2372.86 7	1/2(+), 3/2, 5/2 [§]	A	
2391.1 ^c 5		C	
2423.83 23	3/2, 5/2, 7/2+ [‡]	A	
2432.46 23		A	
2492.4 ^a 4	(23/2+)	BC	J π : γ s to (19/2+) and (21/2+); band member.
2510.45 7	3/2, 5/2 [#]	A	
2585.97 9	1/2(+), 3/2, 5/2 [§]	A	
2620.38 8	1/2(+), 3/2, 5/2 [§]	A	
2727.74 17		A	
2754.03? 17	3/2, 5/2 [#]	A	
2781.6 ^c 5		C	
2797.37 11	1/2(+), 3/2, 5/2 [§]	A	
2852.32? 17	1/2(+), 3/2, 5/2 [§]	A	
2937.01 21	3/2, 5/2 [#]	A	
2967.2 ^b 5	(25/2+)	BC	J π : $\Delta J=2$, Q γ to (21/2+); γ to (23/2+); band member.
2967.60 10	1/2(+), 3/2, 5/2 [§]	A	
2980.2? 3	1/2(+), 3/2, 5/2 [§]	A	
3130.38? 18	3/2(+), 5/2	A	J π : γ to 7/2+; possible allowed or first-forbidden β feeding from 3/2- parent.
3146.7? 3	3/2, 5/2 [#]	A	
3155.99? 23	3/2, 5/2 [#]	A	
3189.8 5		C	
3208.70 15	1/2, 3/2, 5/2 [§]	A	
3337.6 ^a 5	(27/2+)	C	J π : γ to (23/2+); band member.
3343.1 ^c 5		C	
3372.69? 19	1/2, 3/2, 5/2 [§]	A	
3375.39 17	3/2, 5/2 [#]	A	
3496.1 ^b 6	(29/2+)	C	J π : γ to (25/2+); band member.
3504.65? 17	3/2, 5/2 [#]	A	
3745.55 25	1/2, 3/2, 5/2 [§]	A	
3775.84? 12	1/2, 3/2, 5/2 [§]	A	
3815.27? 22	1/2, 3/2, 5/2 [§]	A	
3924.67? 21	1/2, 3/2, 5/2 [§]	A	
4145.1 ^a 6	(31/2+)	C	J π : γ to (27/2+); band member.
4227.9? 3	1/2-, 3/2-, 5/2- [@]	A	
4323.7 ^b 6	(33/2+)	C	J π : γ to (29/2+); band member.
4669.7 ^b 7	(37/2+)	C	J π : γ to (33/2+); band member.

[†] From least-squares fit to E γ values, assuming 0.3 keV uncertainty for E γ when not stated. Uncertainties of 652.28 γ from 942.6 level 996.4 γ from 1214.07 level were doubled to obtain an acceptable fit. Reduced $\chi^2=1.7$ as compared to critical $\chi^2=1.3$.

[‡] 3/2 to 11/2 from γ to 7/2+. $\leq 7/2+$ from $\log ft < 11$ for feeding from 3/2- parent.

[§] $\log f^{lu}_t < 8.5$ for feeding from 3/2- parent, combined with γ to a level with possible J $\pi=5/2+$ in a few cases, which favors 1/2+ over 1/2-.

[#] 3/2 to 11/2 from γ to 7/2+. $\leq 5/2$ from $\log f^{lu}_t < 8.5$ for feeding from 3/2- parent.

[@] $\log ft < 5.9$ for feeding from 3/2- parent.

& For excited states values are from 2011Ro42, measured by $\beta\gamma(t)$ and $\gamma\gamma(t)$, fast timing technique using BaF₂ and LaBr₃ detectors with gating on the HPGe detector. The time spectra were analyzed by shape deconvolution method, and half-life obtained as a slope on the delayed part of the time spectrum and/or by the centroid-shift method, the latter, especially for shorter half-lives up to about 10 ps or so. 2012Ro47 conference report is from the same authors.

^a (A): The g.s. band.

^b (B): Band based on (9/2+). This band has the same parity as the g.s. band, as the 236.9-keV linking transition is (M1+E2) from total conversion coefficient deduced by 2009Li42 from transition intensity balance.

^c (C): γ cascade.

Adopted Levels, Gammas (continued)

$\gamma(^{139}\text{Cs})$						
E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [†]	δ	α	Comments
218.633	218.59 3	100	E2,M1		0.119 5	
289.75	71.0 4	2.20 6	[M1,E2]		4.4 20	
	289.78 7	100 5	E2,M1		0.0486	
393.59	103.75 6	2.77 20	M1(+E2)	<0.87	1.02 21	B(M1)(W.u.)=0.012 +18-8; B(E2)(W.u.)<2.0.
	174.97@ 4	100@ 7	(M1+E2)		0.23 4	
	393.50 6	59 3	E2,M1		0.0199 12	
393.65	174.97@ 4	100@	(M1+E2)		0.23 4	
515.11	121.37@ 8	2.16@ 8				
	121.37@ 8	0.28@ 3				
	225.38 7	13.89 13	[M1,E2]		0.103 9	
	296.53 7	100.0 21	E2,M1		0.0455 8	
	515.44 14	1.70 5				
595.43	595.43 13	100	(M1+E2)	-4.2 +4-5		δ : -4.2 +4-5 or -0.07 2 from $\gamma\gamma(\theta)$ (2009Li42), shell-model predicted value of -3.6 favors higher value. From RUL, large $\delta(Q/D)$ is consistent with M1+E2 rather than E1+M2, assuming level half-life is less than 10 ns.
601.61	601.6		Q			
646.51	356.72 8	84.7 9	$\ddagger$	$\ddagger$	0.105 $\ddagger$ 33	Mult.: $\alpha(K)_{\text{exp}}=0.079\ 25$ is too large for M1 and E2, barely overlaps M2 or E3. α : deduced from $\alpha(K)_{\text{exp}}$.
	646.50 7	100.0 18				
710.12	491.47@ 4	100@				
732.36	338.86 7	32.6 6	D,E2			
	442.7 4	9.4 3	[D,E2]			
	513.88 11	44 5	[D,E2]			
	732.42 6	100.0 12	D,E2			
891.53	181.3 1	11.9 5				
	498.2 5	3.8 5	[D,E2]			
	601.84 7	100 52				
	672.39 18	12.4 5				
	891.76 18	14.8 10				
942.60	427.7 4	4.0 3	[D,E2]			
	549.02@ 4	3.4@ 3				
	549.02@ 4	38.2@ 10				
	652.28 13	14.9 3				E γ : poor fit. Level-energy difference=652.85.
	723.84 6	100.0 13				
	942.61 22	4.4 25				
1006.52	491.47@ 4	32@ 4				
	612.82@ 4	100@ 10				
	612.82@ 4	27.2@ 25				
	716.96 22	3.58 12				
	788.04 8	77.8 13				
1020.28	505.07 8	37.6 6				
	626.89 11	100 18				
	730.4 3	15.9 6				
	801.62 9	62.4 12				
1037.22	305.0 1	14.3 21				
	326.8 4	32.6 21				
	818.29 15	100.0 21				
1070.7	469.1					
	475.3		Q			
1138.84	624.3 7	20.2 12				
	745.16@ 7	100@ 11				
	745.16@ 7	11.9@ 12				
1146.0	544.4		Q			
1214.07	699.6 3	28.3 19				
	996.4 2	100 4				E γ : poor fit. Level-energy difference=995.4.
	1214.9& 4	24 8				
1395.09	388.6 1	39 4				
	879.74 18	100 7				
	1001.7 4	39 4				
	1105.6 3	64 4				

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Cs})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [†]	δ	α	Comments
1395.09	1176.3 6	50 4				
1411.6	896.3 3	100				
1461.25	441.3 7	37.0 22				
	454.46 13	100.0 22				
	518.8 1	19.6 22				
	569.64 22	59 24				
	946.5 3	24 13				
	1067.56 [@] 24	6.5 [@] 22				
	1067.56 [@] 24	57 [@] 5				
	1171.5 4	56.5 22				
1498.9	352.9					
	428.2		Q			
1508.44	565.4 3	18 6				
	775.6 4	17.1 12				
	1114.8 1	27.3 23				
	1115.0 ^a 1	35 ^a 6				
	1289.47 19	100.0 23				
1510.33	914.9 2					
1600.02	1206.45 [@] 10	54 [@] 4				
	1206.45 [@] 10	100 [@] 5				
	1309.4 ^{&} 8	25 16				
1652.78	710.40 18	35.7 11				
	761.04 16	35.7 11				
	1006.25 14	46.9 11				
	1137.52 10	65 9				
	1259.26 9	100 3				
	1362.91 12	57.1 21				
	1434.13 24	45 3				
	1652.8 ^{&} 3	20 5				
1693.86	960.6 5	17 4				
	1178.73 [@] 12	100 [@] 17				
	1299.8 9	15.0 17				
	1404.16 25	38.3 17				
1718.05	579.4 1	18.5 19				
	986.02 11	100 4				
	1324.38 2	69 8				
1721.93	1126.5 2					
1735.8	236.9		(M1+E2)		0.086 12	Mult.: from total conversion coefficient deduced from intensity balance considerations in $\gamma\gamma$ -coincidence analysis in ^{252}Cf SF decay.
	589.8		Q			
1738.61	1344.93 [@] 7	100 [@] 6				
	1344.93 [@] 7	10 [@] 6				
	1449.0 4	13.9 6				
	1520.17 8	71 3				
1793.18	786.7 6	36 9				
	1793.0 5	100 18				
1816.4?	1817.6 ^{&} 9	100				
1831.21	888.6 5	44 4				
	1316.4 4	100 8				
	1437.7 7	74 26				
	1612.4 ^{&} 4	96 19				
1846.6	700.6					
2063.74	924.5 6	41 3				
	1416.5 4	44.3 15				
	1773.84 13	77.1 15				
	2063.90 12	100 3				
2099.59	1367.19 16	100 4				
	1584.7 4	73 24				
2103.8?	2103.7 ^{&} 6	100				
2119.50?	55.7 ^{&} 3	86 23	D(+Q) §	§		
	980.59 ^{&} 18	100 5				
	1099.4 ^{&} 5	50 5				

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Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{Cs})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. †	E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. †
2185.52	446.8 3	9.1 5		2620.38	1022.0& 6	10.6 16	
	585.6 1	4.1 5			1481.5 1	18 3	
	773.4 5	10.2 5			1613.8 1	71 5	
	970.3 4	7.6 5			2227.28 25	100 23	
	1046.31 15	26.9 10		2727.74	1219.33 21	100 18	
	1178.73@ 12	2.5@ 16			2437.8 3	50 9	
	1242.88 8	58.9 11		2754.03?	937.9& 4	43 4	
	1453.32 10	44.2 11			1615.0& 3	100 18	
	1670.33 8	100.0 16			1862.4& 7	46 4	
	1895.98 9	54.3 11			2021.8& 4	64 4	
	1967.3 3	11.2 5			2238.4& 6	93 15	
2239.3	503.5				2464.6& 5	71 11	
	740.4		Q		2535.0& 5	39 11	
2304.67	119.4& 4	11 4			2754.2& 4	43 11	
	1297.85 19	70.5 9		2781.6	390.5		
	2015.11 17	27.7 9			542.3		
	2085.91 10	100.0 18		2797.37	1776.9 4	43 3	
	2304.97 16	46 5			1790.85 18	100 3	
2328.85	589.8 4	13.3 9			1854.5& 5	30 8	
	675.79 16	25.7 9			2403.75 13	61 6	
	820.5& 4	12.4 9			2507.6 6	18 6	
	1115.0 ^a 1	27 ^a 4			2578.9 5	14 4	
	1291.4 4	27 5		2852.32?	1199.43& 23	100 25	
	1309.4 8	52.2 18			2633.75& 22	59 10	
	1386.19 11	81 4		2937.01	1428.70 21	100 3	
	1814.1 4	19 3			2936.2 5	30 9	
	1935.1& ^a 5	18 ^a 3		2967.2	474.8		
	1935.1& ^a 5	18 ^a 3			727.9		Q
	2039.1 4	12.4 9		2967.60	1228.8 5	23.0 17	
	2110.12 13	54 8			1458.98 22	72 27	
	2328.80 9	100 6			1830.2 [#] 6	23.0 17	
2372.86	634.2 1	6.4 11			2025.1 5	16 3	
	719.8& 6	13 6			2451.6 6	13 5	
	1233.8 1	7.5 11			2574.04 12	100 9	
	1857.6 4	21.5 11		2980.2?	1149.2& 3	100 12	
	1979.57 11	100.0 22			1765.2& 6	36 4	
2391.1	544.5				2761.6& 4	48 12	
	655.3&			3130.38?	2736.7& ^a 3	100 ^a 19	
2423.83	1416.94& 20	100 15			2736.7& ^a 3	100 ^a 19	
	2204.6 6	29 15			2911.7& 4	57 15	
	2423.6 4	29 7			3130.6& 6	67 24	
2432.46	832.41 24	46 4		3146.7?	2255.3& 7	100 19	
	1540.1& 7	39 4			3146.6& 3	68 13	
	1700.2 5	100 33		3155.99?	783.1& 5	50 19	
	1786.6& 4	39 15			1036.3& 3	100 9	
2492.4	253.1				3156.3& 4	36 9	
	756.6			3189.8	950.5		
2510.45	772.0 1	13.9 14		3208.70	1608.7 6	42.5 25	
	1490.0 4	51 7			2693.4 5	35 10	
	1503.1 6	50.0 14			2815.03 15	100 10	
	1862.4 7	74 5		3337.6	370.4&		
	1994.2 4	21 3			845.2		
	2116.88 11	79 3		3343.1	375.9		
	2291.61 21	100 7			561.5		
	2510.41 18	68 7		3372.69?	1273.1& 5	38 5	
2585.97	847.45 12	76.7 17			1911.42& 21	100 5	
	1190.6 6	25 10			2430.3& 6	33 10	
	1579.5& 4	58 10			2640.1& 6	29 15	
	1939.5& 3	28 5		3375.39	1543.6& 6	15 3	
	2192.32 13	100 9			1681.1 3	100 44	
	2366.97 22	40 5			1722.6& 6	56 6	
2620.38	926.8 8	9.1 16			3375.51 19	79 9	
	967.3& 5	18.2 15		3496.1	528.9		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{Cs})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$
3504.65?	1711.44& 17	100 20	3745.55	1641.7 3	100 8	3924.67?	2918.3& 3	100 18
	1851.8& 5	34 2		2006.8& 4	71 8	4145.1	807.5	
	2613.7& 7	12 6		2854.2 4	57 11	4227.9?	1803.99& 25	100 10
	2989.4& 4	26 6	3775.84?	1351.6& 4	32.1 19		2832.8& 4	55 10
	3110.8&a 7	14 ^a 8		2769.32& 12	100 8	4323.7	827.6	
	3110.8&a 7	14 ^a 8	3815.27?	2872.65& 25	100 14	4669.7	346.0	
	3214.8& 5	14 4		3168.7& 4	50 9			
	3504.7& 3	24 4	3924.67?	957.3& 4	55 5			
3745.55	1017.7 3	57 8		2903.8& 4	64 14			

[†] From ¹³⁹Xe β⁻ decay for gamma rays from low-spin (J≤9/2) states, and the levels populated only in this decay. For gamma rays from high-spin (J>9/2) states, values are from ²⁵²Cf SF decay. Mult=Q indicates ΔJ=2, quadrupole (most likely E2) transition.

[‡] M2,E3; E1+M2, δ>0.87; or E2+M3, 0.37<δ<0.63. α estimated from α(K)exp in β⁻ decay and possible mult's and δ's.

§ M1(+E2), δ≤0.5 3 or E1(+M2), δ≤0.28 6 from I(γ+ce) and I_γ.

Other member of doublet unplaced in β⁻ decay.

@ Multiply placed; intensity suitably divided.

& Placement of transition in the level scheme is uncertain.

^a Multiply placed; undivided intensity given.

(A) The g.s. band.
(B) Band based on (9/2+).
(C) γ cascade.

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02

Parent ¹³⁹Xe: E=0.0; Jπ=3/2⁻; T_{1/2}=39.68 s 14; Q(g.s.)=5057 4; %β⁻ decay=100.

¹³⁹Xe-J, T_{1/2}: From ¹³⁹Xe Adopted Levels.

¹³⁹Xe-Q(β⁻): From 2012Wa38.

1988Fa06: TRISTAN. Measured E_γ, I_γ, γγ-coincidences, and γγ(θ=0°,35°,55°,90° or 15°,30°,45°,60°,75°,90°).

1980Le03: measured E_γ, I_γ, and γγ-coincidences.

1972Ac02 measured E_γ, I_γ and ce (Si(Li)).

2011Ro42: measured level half-lives by βγ(t) and γγ(t) using fast timing system. ¹³⁹Xe source produced in photofission of ²³⁸U by 50-MeV electron beam from the ALTO facility at Orsay.

Others:

Continued on next page (footnotes at end of table)

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

2014Fi11 (conference article): measured total absorption γ spectrum using Modular Total Absorption Spectrometer (MTAS) at HRIBF-ORNL facility. ¹³⁹Xe produced in ²³⁸U(p,F),E=40 MeV followed by mass separation by magnetic spectrometer. Deduced average electromagnetic energy release of 1126 keV, about 20% higher than obtained from the decay scheme presented here. The results are stated as preliminary.

1999No05: measured E γ , I γ , γ (t), and $\gamma\gamma$ -coincidences (OSIRIS); 120 s collection period with 15 s measurement intervals.

1981ReZZ: measured E β , I β .

1975Al11 measured total absorption γ spectrum and deduced β strength function.

1973Ad04: 1978Wo15, 1978Wu04: measured $\beta\gamma$ -coin.

1973Jo02: measured total absorption γ spectra, β -strength functions.

1967Ho18: decay study of ¹³⁹Xe.

¹³⁹Cs Levels

1988Fa06 updated the level scheme proposed by 1980Le03. The major modifications of 1988Fa06 were: 1) identification of a close-lying doublet at ≈ 394 keV, 2) level at 1186 keV proposed by 1980Le03 was not confirmed, 3) placement of 16 γ 's changed, 4) 26 γ 's placed by 1980Le03 were not placed by 1988Fa06, and 5) J π (¹³⁹Xe g.s.)=3/2- was assumed by 1988Fa06 instead of the 7/2- assumed by 1980Le03. 1988Fa06 suggest that the placement of the 186 level by 1980Le03 is incorrect; however, evaluators note that there is a possible confusion in identification of the 1814 and 1818 γ 's.

1999No05, on the basis of 216.7 γ and 595.5 γ coincidences, suggested a modification of the level scheme. These measurements resulted in a change in placement of the 595.43 γ from deexciting the 2104 level to deexciting a 595 level and the observation of two additional γ 's (914.9 and 1126.5) which were assigned to levels at 1510 and 1722, respectively.

E(level) [†]	J $\pi^{\ddagger}$	T _{1/2} [§]	Comments
0.0	7/2+		% β^- =100.
218.627 24	5/2+, 7/2+	2.23 ns 5	Configuration= $\pi 2d_{5/2}$ (2011Ro42).
289.74 4	3/2+, 5/2+, 7/2+	96 ps 25	
393.59 3	5/2+, 7/2+	24 ps 15	
393.63 3	(3/2+, 5/2+, 7/2+) [#]	1.71 ns 2	
515.11 4	3/2+, 5/2+	6 ps +10-6	
595.43 [@] 13	(9/2+)		
646.51 6	3/2, 5/2, 7/2+		
710.12 5			
732.38 4	3/2+, 5/2, 7/2+		
891.53 6	3/2, 5/2, 7/2+		
942.59 4	3/2, 5/2, 7/2+		
1006.52 4	1/2(+), 3/2, 5/2	15 ps 10	
1020.27 6	3/2, 5/2, 7/2+		
1037.23 9			
1138.86 5			
1214.39 15			
1395.08 9			
1411.6 3			
1461.24 7			
1508.43 7			
1510.33 [@] 24			
1600.02 7			
1652.76 6			
1693.85 11			
1718.29 8			
1721.94 [@] 24			
1738.60 5			
1793.17 21			
1816.47 ^{&} 4	3/2, 5/2, 7/2+		
1831.30 23			
2063.60 11	3/2, 5/2, 7/2+		
2099.61 15			
2103.8? 4	3/2, 5/2, 7/2+		
2119.49? 15			
2185.52 5	1/2(+), 3/2, 5/2		
2304.67 8	3/2, 5/2		
2328.82 6	3/2, 5/2		
2372.86 7	1/2(+), 3/2, 5/2		
2423.83 23	3/2, 5/2, 7/2+		
2432.46 23			

Continued on next page (footnotes at end of table)

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

¹³⁹Cs Levels (continued)

E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]
2510.45 7	3/2, 5/2	2967.62 10	1/2(+), 3/2, 5/2	3504.64? 17	3/2, 5/2
2585.95 9	1/2(+), 3/2, 5/2	2980.3? 3	1/2(+), 3/2, 5/2	3745.54 25	1/2, 3/2, 5/2
2620.39 8	1/2(+), 3/2, 5/2	3130.37? 18	3/2(+), 5/2	3775.83? 12	1/2, 3/2, 5/2
2727.73 17		3146.7? 3	3/2, 5/2	3815.27? 22	1/2, 3/2, 5/2
2754.04? 17	3/2, 5/2	3155.98? 23	3/2, 5/2	3924.67? 21	1/2, 3/2, 5/2
2797.39 11	1/2(+), 3/2, 5/2	3208.68 15	1/2, 3/2, 5/2	4227.9? 3	1/2-, 3/2-, 5/2-
2852.31? 17	1/2(+), 3/2, 5/2	3372.69? 19	1/2, 3/2, 5/2		
2937.00 21	3/2, 5/2	3375.35 16	3/2, 5/2		

[†] From least-squares fit to E_γ data. The uncertainties of 996.4γ from 1214 level and 1115.0γ were doublet to 0.4 keV and 0.2 keV, respectively. Several γ rays with questionable placements were not included in the fitting procedure, when a level was defined by another γ ray with a definite placement. Reduced χ²=1.6 is somewhat larger than critical χ²=1.3.

[‡] From the Adopted Levels.

[§] From 2011Ro42, measured by βγ(t) and γγ(t), fast timing technique between the BaF₂ and LaBr₃ detectors with slow gating on the HPGe detector. The time spectra were analyzed by shape deconvolution method, and half-life obtained as a slope on the delayed part of the time spectrum and/or by the centroid-shift method, the latter, especially for shorter half-lives up to about 10 ps or so.

[#] 1988Fa06 suggest 1/2+ based on lack of γ to 7/2+; however, this is not consistent with the probable dipole nature of the 175γ.

[@] Suggested by 1999No05.

[&] On the basis of a strong 218γ-1816γ coin, 1988Fa06 suggest that the 1816 level proposed by 1980Le03 is not confirmed; however, from the singles data of 1988Fa06 a 1814γ is assigned on the basis the coin, and this could correspond to the 1814γ assigned by 1980Le03 to 2104.

β⁻ radiations

βγ-coincidences from 1973Ad04 and 1978Wu04.

<E_β>=1.72 MeV 6 (1982Al01, Si(Li)) is in excellent agreement with <E_β>=1737 keV 12 from the decay scheme. From total absorption γ spectrum, 2014Fi11 deduce a preliminary value of 1126 keV for the average electromagnetic energy release per decay, which is about 20% higher than expected from the present decay scheme, which suggests that the presently known discrete γ data for the decay ¹³⁹Xe are incomplete.

1973Ad04, 1978Wu04, and 1978Wu04 measured βγ-coincidences (scin,Ge(Li)).

Eβ ⁻	E(level)	Iβ ⁻ †#	Log ft [‡]	Comments
(829@ 4)	4227.9?	0.10 7	5.9 4	
(1132@ 4)	3924.67?	0.16 10	6.1 3	
(1242@ 4)	3815.27?	0.10 8	6.5 4	
(1281@ 4)	3775.83?	0.21 17	6.2 4	
(1311 4)	3745.54	0.40 8	6.0 1	
(1552@ 4)	3504.64?	0.41 20	6.3 2	
(1682 4)	3375.35	0.42 12	6.4 1	
(1684@ 4)	3372.69?	0.14 8	6.9 3	
(1848 4)	3208.68	0.40 6	6.6 1	
(1901@ 4)	3155.98?	0.13 9	7.1 3	
(1910@ 4)	3146.7?	0.09 7	7.3 4	
(1927@ 4)	3130.37?	0.24 17	6.9 3	
(2077@ 4)	2980.3?	0.15 10	7.2 3	
(2089 4)	2967.62	0.81 14	6.5 1	
(2120 4)	2937.00	0.24 4	7.0 1	
(2205@ 4)	2852.31?	0.17 13	7.2 4	
(2260 4)	2797.39	1.10 15	6.5 1	
(2303@ 4)	2754.04?	0.41 17	6.9 2	
(2329 4)	2727.73	0.20 5	7.3 [§] 1	
(2437 4)	2620.39	0.79 13	6.8 1	
(2471 4)	2585.95	0.98 17	6.7 1	
(2547 4)	2510.45	1.84 21	6.5 1	
(2625 4)	2432.46	0.31 9	7.3 [§] 1	
(2633@ 4)	2423.83	≤0.20	≥7.5 [§]	
(2684 4)	2372.86	0.71 10	7.0 1	
(2728 4)	2328.82	2.7 4	6.4 1	
(2752 4)	2304.67	3.0 15	6.4 2	
(2871 4)	2185.52	2.1 15	6.6 4	
(2938@ 4)	2119.49?	0.6 4	7.2 [§] 4	

Continued on next page (footnotes at end of table)

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

β⁻ radiations (continued)

Eβ ⁻	E(level)	Iβ ⁻ †	Log ft‡	Comments
(2957 4)	2099.61	0.26 6	7.6 § 1	
(2993 4)	2063.60	0.5 4	7.3 § 4	
(3226 4)	1831.30	0.32 14	7.7 § 2	
(3241@ 4)	1816.4?	≤0.14	≥8.0 §	
(3318 4)	1738.60	1.29 17	7.1 § 1	
(3339 4)	1718.29	0.57 7	7.5 § 1	
(3363 4)	1693.85	0.35 11	7.7 § 2	
(3404 4)	1652.76	1.7 3	7.0 § 1	
(3457 4)	1600.02	0.38 9	7.7 § 1	
(3549@ 4)	1508.43	0.22 12	7.9 § 3	
(3596 4)	1461.24	0.86 14	7.4 § 1	
(3645@ 4)	1411.6	≤0.18	≥8.2 §	
(3662 4)	1395.08	0.34 7	7.9 § 1	
(3843 4)	1214.39	0.23 7	8.1 § 3	
(4020 4)	1037.23	0.23 4	8.2 § 1	Eβ ⁻ : Measured value=3880 60 (1972LeYH).
(4037 4)	1020.27	1.15 22	7.5 § 1	
(4050 4)	1006.52	8.8 11	6.6 1	
(4114 4)	942.59	1.18 18	7.5 § 1	
(4165 4)	891.53	1.1 7	7.6 § 3	
(4325 4)	732.38	2.2 3	7.4 § 1	
(4347@ 4)	710.12	0.11 6	8.7 § 3	
(4410 4)	646.51	0.33 10	8.2 § 2	Eβ ⁻ : measured value=4380 60 (1972LeYH).
(4462@ 4)	595.43	≤0.28	≥8.3	
(4542 4)	515.11	21.9 24	6.45 5	Eβ ⁻ : measured value=4450 60 (1972LeYH).
(4663 4)	393.63	1.2 5	7.7 § 2	
(4663 4)	393.59	13.9 18	6.7 1	
(4767 4)	289.74	1.9 9	7.6 § 2	
(4838 4)	218.627	4.9 16	7.2 § 2	
(5057 4)	0.0	15 10	8.6 ^{1u} 3	Iβ ⁻ : other: 15 6 (quoted by 1988Fa06 from thesis by 1987RoZW).

† Uncertainties include estimates of uncertainties caused by multiply-placed or uncertain gammas.

‡ Uniqueness from decay scheme.

§ log f^{lu}t>8.5.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

γ(¹³⁹Cs)

α(K)exp, K/L+: from 1972Ac02.

γγ-coincidences shown on drawing are primarily from 1988Fa06 with some from 1980Le03 and 1999No05.

Iγ normalization, I(γ+ce) normalization: from Iγ(218.6γ) relative to Iγ(1283.3γ; ¹³⁹Cs) (measured in an equilibrium

¹³⁹Xe-¹³⁹Cs source), Iγ(1283.3γ) relative to Iγ(165.8γ; ¹³⁹Ba) (corrected for time dependence of ¹³⁹Cs-¹³⁹Ba

activity ratio) and Iγ(165.8γ; ¹³⁹Ba)=23.76% 25 (1980Ge04). Iγ(218.6γ)/Iγ(1283.3γ; ¹³⁹Cs) and Iγ(1283.3γ;

¹³⁹Cs)/Iγ(165.8γ; ¹³⁹Ba) were derived by the evaluators from Iγ normalization(¹³⁹Xe)=0.052 6 and Iγ

normalization(¹³⁹Cs)=0.0077 30 (1980Le03) and Iγ(165.8γ; ¹³⁹Ba).

Eγ†	E(level)	Iγ‡r	Mult.§	δ§	α ^o	I(γ+ce) ^r	Comments
55.7#t 3	2119.49?	1.9@ 5	D(+Q)			10 7	α(exp)≥1.105 23. Mult.,δ: M1(+E2), δ≤0.5 3 or E1(+M2), δ≤0.28 6 from I(γ+ce) and Iγ. I(γ+ce): ≤15.4 14 from intensity balancing at the 2064 level and ≥4.0 11 from α(E1)=1.096 and Iγ. α(exp): upper limit from I(γ+ce) and Iγ; lower limit from α(E1)=1.105.
71.0 4	289.74	3.6 1	[M1,E2]		4.4 20		

Continued on next page (footnotes at end of table)

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

γ(¹³⁹Cs) (continued)

Eγ [†]	E(level)	Iγ ^{‡r}	Mult.§	δ§	α ^o	I(γ+ce) ^r	Comments
103.75 6	393.59	5.6@ 4	M1(+E2)	<0.87	0.99 18		α(K)exp=0.73 13. K/L+ too low and attributed to a contribution by the γ line to ce(L+) (1972Ac02).
119.4#t 4	2304.67	1.2@ 4				27 26	I(γ+ce): ≤51.2 18 from intensity balancing at the 2186 level and ≥1.4 5 from α(E1)=0.134 and Iγ.
121.37&s 8	515.11	8.4s 3					Eγ: level-energy difference=121.47 6.
	515.11	1.1s 1					Eγ: level-energy difference=121.52 5.
174.97abs 4	393.59	202s 13	(M1+E2) c		0.23 4	229ds 15	α(K)exp=0.122 15; K/L+=10 4. α(K)exp,K/L+: for doublet.
	393.63	154s 14	(M1+E2) c		0.23 4	175ds 16	
181.3e 1	891.53	2.5 1					
218.59a 3	218.627	1000	E2,M1		0.113 11		α(K)exp=0.082 12; K/L+=4.1 4. Mult.: α(K)exp gives M1(+E2) with δ<1.25, K/L+ ratio suggests pure E2.
225.38 7	515.11	53.9 5	[M1,E2]		0.103 9		
289.78a 7	289.74	164 7	E2,M1		0.0486		α(K)exp=0.031 6.
296.53a 7	515.11	388 8	E2,M1		0.0455 8		Mult.,δ: δ(E2/M1)>0.65. α(K)exp=0.036 5.
305.0e 1	1037.23	0.7 1					Eγ: from Table I in 1988Fe06, authors' level-scheme Fig. 1 lists 305.5.
326.8n 4	1037.23	1.6 1					
338.86 7	732.38	11.1 2	(M1,E2)		0.0310 15		α(K)exp=0.016 12.
356.72 8	646.51	9.4 1			0.09 4		α(K)exp=0.079 25. Mult.: 1972Ac02 suggest M2,E3, but α(K)=0.519 for M2 and 0.515 for E3 barely overlap the experimental value. High value of α(K)exp may be due to E0 admixture in the 356.7 transition.
388.6e 1	1395.08	1.1 1					α: deduced from α(K)exp.
393.50 6	393.59	120@ 6	E2,M1		0.0204 17		α(K)exp=0.015 3; K/L+=3 1. K/L+ value is a factor of ≈2.5 too low for M1, E2 or E1.
427.7 4	942.59	1.3 1	[D,E2]		0.011 7		
441.3 7	1461.24	1.7 1					
442.7 4	732.38	3.2 1	[M1,E2]		0.0148 16		
446.8n 3	2185.52	1.8 1					
454.46 13	1461.24	4.6 1					
x466.8 3		1.3 1					In coin. with 732γ.
x482.6e 1		0.4 1					
491.47s 4	710.12	6s 1					
	1006.52	26s 3					
498.2 5	891.53	0.8 1	[D,E2]		0.008 5		
505.07 8	1020.27	6.4 1					
513.88 11	732.38	15.0@ 15	[M1,E2]		0.0100 13		
515.44 14	515.11	6.6 2	[M1,E2]		0.0099 13		
518.8e 1	1461.24	0.9 1					
x523.9e 1		0.8 1					In coin. with 818γ.
549.02s 4	942.59	1.1s 1					
	942.59	12.3s 3					
565.4 3	1508.43	1.6p 5					
569.64 22	1461.24	2.7p 11					
579.4e 1	1718.29	1.0 1					
585.6e 1	2185.52	0.8 1					

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$^{139}\text{Xe} \beta^-$ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued) $\gamma(^{139}\text{Cs})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger r}$	Mult. [§]	$\delta^{\S}$	α°	Comments
589.8 4	2328.82	1.5 1				
595.43 13	595.43	5.0 P 15	(M1+E2)	-4.2 +4-5	0.00599	Originally placed as deexciting 2104 level; reassigned by 1999No05.
601.84 7	891.53	21 P 11				
612.82 ^s 4	1006.52	81 ^s 8				
	1006.52	22 ^s 2				
624.3 ⁿ 7	1138.86	1.7 1				
626.89 11	1020.27	17 P 3				
634.2 ^e 1	2372.86	0.6 1				
646.50 7	646.51	11.1 2				
652.5 ^q 2	942.59	4.8 1				
672.39 18	891.53	2.6 1				
675.79 16	2328.82	2.9 1				
699.6 3	1214.39	1.5 1				
710.40 18	1652.76	3.5 1				
716.96 22	1006.52	2.9 1				
719.8 ^{#t} 6	2372.86	1.2 [@] 5				
723.84 6	942.59	32.2 4				
730.4 3	1020.27	2.7 1				
732.42 6	732.38	34.1 4	(M1,E2)		0.0041 7	$\alpha(\text{K})\text{exp}\leq 0.0048$.
745.16 ^s 7	1138.86	8.4 ^s 9				
	1138.86	1.0 ^s 1				
761.04 16	1652.76	3.5 1				
772.0 ^e 1	2510.45	1.0 1				
773.4 ⁿ 5	2185.52	2.0 1				
775.6 4	1508.43	1.5 1				
783.1 ^{#t} 5	3155.98?	1.1 4				
786.7 6	1793.17	0.4 1				
788.04 8	1006.52	63 1				
801.62 9	1020.27	10.6 2				
818.29 ⁿ 15	1037.23	4.9 1				
820.5 ^{ft} 4	2328.82	1.4 1				
832.41 24	2432.46	1.3 1				
847.45 12	2585.95	4.6 1				
^x 868.7 ^e 1		1.0 1				
879.74 18	1395.08	2.8 2				
888.6 5	1831.30	1.2 1				
891.76 18	891.53	3.1 2				
896.3 3	1411.6	2.6 P 13				
^x 908.9 ^e 1		3.9 2				In coin. with 602 γ .
914.9 ^g 2	1510.33					
924.5 6	2063.60	2.9 2				
926.8 ^q 8	2620.39	0.6 1				
937.9 ^{ft} 4	2754.04?	1.2 1				
942.61 22	942.59	1.4 P 8				
946.5 3	1461.24	1.1 P 6				
957.3 ^{ft} 4	3924.67?	1.2 1				
960.6 ^q 5	1693.85	1.0 2				
967.3 ^{hnt} 5	2620.39	1.2 1				
970.3 ⁿ 4	2185.52	1.5 1				
980.59 ^{ft} 18	2119.49?	2.2 1				
^x 980.8 ^e 1		2.2 1				
986.02 ⁿ 11	1718.29	5.4 2				
996.4 ^q 2	1214.39	5.3 2				
1001.7 4	1395.08	1.1 1				
1006.0 ^q 3	1652.76	4.6 1				
1017.7 3	3745.54	1.6 2				
1022.0 ^{ft} 6	2620.39	0.7 1				
1036.3 ^{ft} 3	3155.98?	2.2 2				
1046.31 ⁿ 15	2185.52	5.3 2				
1067.56 ^{bs} 24	1461.24	0.3 ^s 1				
	1461.24	2.6 ^s 2				
1099.4 ^{ft} 5	2119.49?	1.1 1				

Continued on next page (footnotes at end of table)

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued) $\gamma(^{139}\text{Cs})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^{\pm r}$	Comments
1105.6 3	1395.08	1.8 1	
1114.8 ^e 1	1508.43	2.4 2	
1115.0 ^{eu} 1	1508.43	3.1 ^{iu} 5	
	2328.82	3.1 ^{iu} 5	
1126.5 ^g 2	1721.94		
^x 1129.2 ^e 1		1.4 1	In coin. with 602 γ .
1137.52 10	1652.76	6.4 ^p 8	
1149.2 ^{ft} 3	2980.37	2.5 3	
1171.5 4	1461.24	2.6 1	
1176.3 6	1395.08	1.4 1	
1178.73 ^s 12	1693.85	6 ^s 1	
	2185.52	0.5 ^s 3	
^x 1184.6 2			Possible presence in coin. data.
1190.6 6	2585.95	1.5 ^p 6	
1199.43 ^{ft} 23	2852.31?	3.2 ^p 8	
1206.45 ^s 10	1600.02	3.4 ^s 2	
	1600.02	6.3 ^s 3	
1214.9 ^{#t} 4	1214.39	1.3 [@] 4	
1219.33 21	2727.73	3.4 ^p 6	
1228.8 5	2967.62	1.4 1	
1233.8 ^e 1	2372.86	0.7 1	
1242.88 8	2185.52	11.6 2	
1259.26 9	1652.76	9.8 3	
^x 1267.0 ^e 1		0.8 1	In coin. with 218 γ .
1273.1 ^{ft} 5	3372.69?	0.8 1	
1289.47 19	1508.43	8.8 2	
1291.4 ⁿ 4	2328.82	3.1 5	
1297.85 19	2304.67	7.9 1	
1299.8 9	1693.85	0.9 1	
1309.4 ^{#t} 8	1600.02	1.6 [@] 10	
	2328.82	5.9 2	
1316.4 4	1831.30	2.7 2	
1324.38 ⁿ 21	1718.29	3.7 4	
1344.93 ^s 7	1738.60	18 ^s 1	
	1738.60	1.8 ^s 1	
1351.6 ^{ft} 4	3775.83?	1.7 1	
1362.91 12	1652.76	5.6 2	
1367.19 16	2099.61	3.0 1	
1386.19 11	2328.82	9.2 4	
1404.16 25	1693.85	2.3 1	
1416.5 ^q 4	2063.60	3.1 1	
1416.94 ^{#t} 20	2423.83	2.8 [@] 4	
1428.70 ⁿ 21	2937.00	3.3 1	
1434.13 24	1652.76	4.4 3	
1437.7 7	1831.30	2.0 ^p 7	
1449.0 ^q 4	1738.60	2.5 1	
1453.32 10	2185.52	8.7 2	
1458.98 22	2967.62	4.4 ^p 16	
1481.5 ^e 1	2620.39	1.2 2	
1490.0 4	2510.45	3.7 5	
1503.1 ⁿ 6	2510.45	3.6 1	
1520.17 8	1738.60	12.7 5	
1540.1 ^{fqt} 7	2432.46	1.1 1	
1543.6 ^{ft} 6	3375.35	0.5 1	
1579.5 ^{ft} 4	2585.95	3.5 6	
1584.7 ^f 4	2099.61	2.2 ^p 7	
1608.7 ^q 6	3208.68	1.7 1	
^x 1611.6 ^e 1		1.6 2	In coin. with 218 γ and 290 γ .
1612.4 ^{#t} 4	1831.30	2.6 5	
1613.8 ^e 1	2620.39	4.7 3	
1615.0 ^{#t} 3	2754.04?	2.8 [@] 5	
^x 1635.2 ^e 1		1.3 1	
1641.7 3	3745.54	2.8 2	

Continued on next page (footnotes at end of table)

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued) $\gamma(^{139}\text{Cs})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger r}$	Comments
1652.8#t 3	1652.76	2.0@ 5	
x1653.6e 1		4.6 6	
x1665.4e 1		0.8 1	
x1666.2fm 6		0.8 1	
1670.33 8	2185.52	19.7 3	
1681.1 3	3375.35	3.4P 15	
1700.2q 5	2432.46	2.8P 9	
1711.44ft 17	3504.64?	5.0P 10	
1722.6ft 6	3375.35	1.9 2	
x1765.0e 1		0.9 1	
1765.2ft 6	2980.3?	0.9 1	
x1769.0e 1		0.7 1	In coin. with 218 γ .
1773.84 13	2063.60	5.4 1	
1776.9n 4	2797.39	3.3 2	
1786.6#t 4	2432.46	1.1@ 4	
1790.85 18	2797.39	7.7 2	
1793.0 5	1793.17	1.1 2	
1803.99ft 25	4227.9?	2.0 2	
x1804.1e 1		2.0 2	
1814.1jn 4	2328.82	2.2 3	
1817.6fjq 9	1816.4?	2.7 3	
x1818.5e 1		2.7 3	
x1830.2qs 6		0.6s 1	
1830.2&qs 6	2967.62	1.4s 1	
1851.8ft 5	3504.64?	1.7 1	
x1852.3e 1		1.7 1	In coin. with 732 γ .
x1853.3e 1		3.4 2	In coin. with 218 γ .
1854.5#t 5	2797.39	2.3@ 6	
1857.6 4	2372.86	2.0 1	
1862.4 7	2510.45	5.3 3	
	2754.04?	1.3 1	
1895.98 9	2185.52	10.7 2	
1911.42ft 21	3372.69?	2.1 1	
x1911.7e 1		2.1 1	In coin. with 175 γ .
1935.1ftu 5	2328.82	2.0u 3	
	2328.82	2.0u 3	
x1939.5e 1		1.7 3	
1939.5ft 3	2585.95	1.7 3	
1967.3 3	2185.52	2.2 1	
1979.57k 11	2372.86	9.3 2	
1994.2n 4	2510.45	1.5 2	
2006.8ft 4	3745.54	2.0 2	
x2007.6e 1		2.0 2	In coin. with 296 γ .
2015.11 17	2304.67	3.1 1	
2021.8ft 4	2754.04?	1.8 1	
2025.1 5	2967.62	1.0 2	
2039.1 4	2328.82	1.4 1	
2063.7q 2	2063.60	7.0 2	
2085.91 10	2304.67	11.2 2	
x2099.48n 20		2.8 2	In coin. with 218 γ .
2103.7#t 6	2103.8?	1.0@ 3	
2110.12 13	2328.82	6.1P 9	
2116.88k 11	2510.45	5.7 2	
2192.32 13	2585.95	6.0 5	
2204.6 6	2423.83	0.8@ 4	
2227.28 25	2620.39	6.6 15	
2238.4lt 6	2754.04?	2.6 4	
x2249.7 4		1.2@ 3	
2255.3lt 7	3146.7?	1.6 3	
2291.61 21	2510.45	7.2@ 5	
2304.97 16	2304.67	5.2@ 5	
2328.80 9	2328.82	11.3@@ 7	
2366.97 22	2585.95	2.4 3	

Continued on next page (footnotes at end of table)

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

γ(¹³⁹Cs) (continued)

Eγ [†]	E(level)	Iγ ^{‡r}	Eγ [†]	E(level)	Iγ ^{‡r}
2403.75 13	2797.39	4.7 4	2815.03 15	3208.68	4.0 4
2423.6 4	2423.83	0.8@ 2	2832.8 ^{lt} 4	4227.9?	1.1 2
2430.3 ^{lt} 6	3372.69?	0.7 2	2854.2 4	3745.54	1.6 3
2437.8 3	2727.73	1.7 3	2872.65 ^t 25	3815.27?	2.2 3
2451.6 6	2967.62	0.8 3	^x 2886.6 4		1.5@ 3
2464.6 ^{lt} 5	2754.04?	2.0 3	2903.8 ^{lt} 4	3924.67?	1.4 3
2507.6 6	2797.39	1.4 4	2911.7 ^t 4	3130.37?	1.2 3
2510.41 18	2510.45	4.9@ 5	2918.3 ^{lt} 3	3924.67?	2.2 4
2535.0 ^{lt} 5	2754.04?	1.1 3	2936.2 5	2937.00	1.0 3
2574.04 12	2967.62	6.1 5	^x 2941.8 3		1.4@ 3
2578.9 5	2797.39	1.1 3	2989.4 ^{lt} 4	3504.64?	1.3 3
2613.7 ^{lt} 7	3504.64?	0.6 3	^x 3028.6 4		1.2@ 3
2633.75 ^{lt} 22	2852.31?	1.9 3	3110.8 ^{ltu} 7	3504.64?	0.7 ^u 4
2640.1 ^{lt} 6	3372.69?	0.6 3		3504.64?	0.7 ^u 4
^x 2673.4 5		1.0@ 3	3130.6 ^t 6	3130.37?	1.4 5
2693.4 5	3208.68	1.4 4	3146.6 ^{lt} 3	3146.7?	1.1 2
2736.7 ^{tu} 3	3130.37?	2.1 ^u 4	3156.3 ^{lt} 4	3155.98?	0.8 2
	3130.37?	2.1 ^u 4	3168.7 ^t 4	3815.27?	1.1 2
2754.2 ^{lt} 4	2754.04?	1.2 3	3214.8 ^{lt} 5	3504.64?	0.7 2
2761.6 ^{lt} 4	2980.3?	1.2 3	3375.51 19	3375.35	2.7 3
2769.32 ^{lt} 12	3775.83?	5.3 4	^x 3424.8 5		1.3@ 4
^x 2790.89 14		4.8@ 4	3504.7 ^{lt} 3	3504.64?	1.2 2

[†] From 1980Le03, except as noted. Eγ data of 1980Le03 were adopted by evaluators instead of the relatively more precise values of 1988Fa06 since they resulted in a more consistent least-squares analysis.

[‡] From 1988Fa06 for Eγ<2190, except as noted, and 1980Le03 for Eγ≥2190. Intensities for multiply-placed gammas were divided by 1988Fa06 on the basis of γγ-coincidence data.

§ From α(K)exp and K/L ratios.

Not observed by 1988Fa06.

@ From 1980Le03.

& Discrepant with result from least-squares analysis.

a Eγ=174.862 6, 218.751 10, 289.821 25, 296.611 12 (1979Bo26. Curved-crystal spect) not adopted by evaluators due to uncertainty in nuclide assignments (assignments made by comparison of Eγ with data in 1977Bl12).

b Least-squares analysis suggests 174.84 5 and 175.36 9 for the members of 174.97 doublet and 1067.29 11 and 1067.66 8 for the members of the 1067.56 doublet.

c Primarily E1 or M1 from K/L+ for the doublet. From α(K)exp one member of doublet appears to be E1+M2 and the other M1+E2.

d Estimate from Iγ, α(K)exp, and K/L+.

e From 1988Fa06. Maximum uncertainty of 0.1 keV given.

f Placement from 1980Le03. Not placed by 1988Fa06.

g From 1999No05.

h Placement suggested by evaluators based on level energy differences and γγ-coincidence. Unplaced by 1988Fa06.

i Discrepancy between Fig. 1 and Table I of 1988Fa06 on division of intensities.

j See comment on 1817 level.

k Member of 394 doublet fed not indicated by 1988Fa06. Final level assigned by evaluators based on the least-squares analysis.

l Placement considered uncertain by evaluators since placement of γ rays with Eγ<2200 were not confirmed by 1988Fa06 and there are no γγ-coincidence data.

m Placed as deexciting 2852 level by 1980Le03. However, existence of 1886 daughter not confirmed by 1988Fa06.

n Placements of the following γ rays proposed by 1980Le03 were modified on the basis of γγ-coincidence data by 1988Fa06: 967.3γ from 1186 level; 446.8γ and 2099.5γ from 2100 level; 1814.1γ from 2104 level; 326.8γ from 2120 level; 773.4γ from 2373 level; 1776.9γ from 2424 level; 986.0γ from 2586 level; 624.3γ from 2728 level; 1428.7γ and 1994.2γ from 2937 level; 818.3γ from 3147 level; 970.3γ, 1324.4γ and 1503.1γ from 3156 level; 1046.3γ from 3375 level; and 1291.4γ from 4228 level.

o Theoretical values from BrIcc v2.3b (16-Dec-2014) 2008Ki07, "Frozen Orbitals" approximation. When δ(E2/M1) is not given, value overlaps that for pure M1 and for pure E2.

P Unweighted average of discrepant Iγ measurements from 1988Fa06 and 1980Le03 for the following transitions:

Eγ	1980Le03	1988Fa06	Eγ	1980Le03	1988Fa06	Eγ	1980Le03	1988Fa06
565.4	1.1 3	2.0 1	946.5	1.7 4	0.5 1	1584.7	2.8 4	1.5 1
569.6	1.6 3	3.8 2	1137.5	7.1 5	5.6 3	1681.1	1.9 4	4.9 2
595.4	3.5 4	6.5 1	1190.6	0.9 4	2.1 1	1700.2	1.9 4	3.6 2
601.8	9.3 7	32.1 5	1199.4	2.4 4	4.0 1	1711.4	4.1 4	6.0 7
626.9	14.0 12	20.3 4	1219.3	2.8 4	4.0 2	2110.1	5.2 4	7.0 2
896.3	3.8 5	1.3 1	1437.7	1.3 5	2.7 2			
942.6	2.1 4	0.6 1	1459.0	2.8 5	5.9 2			

Footnotes continued on next page

¹³⁹Xe β⁻ Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

γ(¹³⁹Cs) (continued)

^qUnweighted average of values from 1983Le03 and 1988Fa06 since the two seem discrepant. Uncertainty of 0.1 keV used in 1988Fa06 data

1980Le03	1988Fa06 (ΔE<0.1)	1980Le03	1988Fa06 (ΔE<0.1)	1980Le03	1988Fa06 (ΔE<0.1)
<u>x652.58 13</u>	<u>652.7</u>	<u>x1021.4 6</u>	<u>1022.5</u>	<u>x1699.8 3</u>	<u>1700.7</u>
x926.0 6	927.6	1416.94 20	1416.1	1816.7 4	1818.5
961.1 4	960.2	1448.7 3	1449.4	x1831.5 4	1829.0
X996.19 11	996.6	x1540.8 5	1539.4	x2063.90 12	2063.5
x1006.25 14	1005.7	x1609.3 4	1608.1		

^r For absolute intensity per 100 decays, multiply by 0.056 6.

^s Multiply placed; intensity suitably divided.

^t Placement of transition in the level scheme is uncertain.

^u Multiply placed; undivided intensity given.

^x γ ray not placed in level scheme.

Decay Scheme

$^{139}_{54}\text{Xe}_{85}$ 39.68 s
 $Q=5057^4$
 β^- 100%
 Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given

$^{139}_{54}\text{Xe}_{85}$ 39.68 s
 $Q=5057^4$
 β^- 100%
 Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given

1/2-, 3/2-, 5/2-
 1/2, 3/2, 5/2
 3/2, 5/2
 1/2, 3/2, 5/2
 1/2, 3/2, 5/2
 3/2, 5/2
 1/2, 3/2, 5/2
 3/2, 5/2
 1/2(+), 3/2, 5/2
 1/2(+), 3/2, 5/2
 1/2(+), 3/2, 5/2
 3/2, 5/2, 7/2+
 1/2(+), 3/2, 5/2
 3/2, 5/2, 7/2+
 3/2, 5/2, 7/2+
 1/2(+), 3/2, 5/2
 3/2, 5/2, 7/2+
 3/2, 5/2, 7/2+
 3/2+, 5/2, 7/2+
 3/2+, 5/2+, 7/2+
 5/2+, 7/2+
 3/2+, 5/2+, 7/2+
 5/2+, 7/2+
 7/2+

2832.8 0.022
 1803.99 0.112
 2018.3 0.12
 2003.8 0.078
 987.3 0.067
 3168.7 0.062
 2762.68 0.123
 1351.6 0.30
 2834.3 0.035
 1946.8 0.090
 1511.7 0.112
 1017.7 0.157
 3504.7 0.067
 3114.8 0.039
 3110.8 0.039
 3038.4 & 0.089
 2613.7 0.039
 1851.8 0.034
 1711.44 0.035
 3375.51 0.151
 1722.6 0.28
 1651.1 0.106
 1543.6 0.09
 2640.1 0.08
 2430.3 0.034
 1911.42 0.039
 1273.1 0.045
 2815.03 0.022
 2683.4 0.038
 1608.7 0.038
 3156.3 0.035
 1036.3 0.045
 783.1 0.063
 2246.6 0.062
 3190.6 0.062
 2911.7 0.080
 2711.7 0.08
 2736.7 & 0.12
 2736.7 & 0.12

4227.9
 3924.67
 3815.27
 3775.83
 3745.54
 3504.64
 3375.35
 3372.69
 3208.68
 3155.98
 3146.7
 3130.37
 2967.62
 2852.31
 2727.73
 2585.95
 2423.83
 2372.86
 2119.49
 2103.8
 2099.61
 1831.30
 1793.17
 1738.60
 1693.85
 1652.76
 1600.02
 1461.24
 1395.08
 1214.39
 1020.27
 1006.52
 942.59
 891.53
 732.38
 646.51
 515.11
 393.63
 393.59
 289.74
 218.627
 0.0

$^{139}_{55}\text{Cs}_{84}$ 9.69 h

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

Decay Scheme (continued)

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

Decay Scheme (continued)

$3/2^-$ 0.0 39.68 s
 $^{139}_{54}\text{Xe}_{85}$
 $Q^- = 5057^4$
 $\% \beta^- = 100$

Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

Decay Scheme (continued)

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

Decay Scheme (continued)

$^{139}_{54}\text{Xe}_{85}$ 39.68 s
 $Q^- = 5057^4$
 $\% \beta^- = 100$

Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given

$^{139}_{55}\text{Cs}_{84}$

^{139}Xe β^- Decay (39.68 s) 1988Fa06,1980Le03,1972Ac02 (continued)

Decay Scheme (continued)

$3/2^-$ 0.0 39.68 s
 $^{139}_{54}\text{Xe}_{85}$
 $Q^- = 5057^4$
 $\% \beta^- = 100$

Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given

 $^{139}_{55}\text{Cs}_{84}$

²⁴⁸Cm SF Decay 1999No05

Parent ²⁴⁸Cm: E=0.0; J π =0+; T_{1/2}=3.48×10⁵ y 6; %SF decay=0.081 52.

²⁴⁸Cm-T_{1/2}: From ²⁴⁸Cm Adopted Levels in the ENSDF database (Sept 2014 update).

²⁴⁸Cm-%SF decay: from 0.97 62 per 100 fissions (1994EnZZ) and %SF=8.39 16 (²⁴⁸Cm Adopted Levels in the ENSDF database, Sept 2014 update).

1999No05: Measured E γ and $\gamma\gamma$ - and $\gamma\gamma\gamma$ -coincidences (EUROGAM).

From their data, 1999No05 note that the most pronounced fission partners for the 218.6 γ -408.6 γ -618.4 γ -387.5 γ -503.0 γ cascade assigned by 1998Hw04 to ¹³⁹Cs in ²⁵²Cf SF decay are ¹⁰³Nb and ¹⁰⁵Nb instead of the expected ¹⁰⁵Nb and ¹⁰⁷Nb normalization. A strong 96.9 γ was also observed and a double gate on this line with the 127 γ from ^{103,105}Nb yielded ¹⁰⁵Nb and ¹⁴²Cs γ 's. A 408.6 γ -218.6 γ gate yielded 205.6 γ , 404.7 γ , and 544.9 γ which had been assigned to ¹⁴²Cs by 1998Hw04 in ²⁵²Cf SF decay. Therefore, 1999No05 conclude that this cascade should be assigned to ¹⁴²Cs and the 218.6 γ occurs for both the ¹³⁹Cs and ¹⁴²Cs nuclides.

¹³⁹Cs Levels

E(level) [†]	J π [‡]	E(level) [†]	J π [‡]	E(level) [†]
0.0 §	7/2+	1070.4 [#] 3	(13/2+)	2239.1 [#] 5
218.6 3	(5/2+)	1145.8 § 4	(15/2+)	2491.8 § 5
595.4 [#] 3	(9/2+)	1498.8 [#] 4		2966.7 [#] 6
601.6 § 3	(11/2+)	1735.5 § 4		

[†] From least-squares fit to E γ data, assuming 0.3 keV uncertainty for each E γ value.

[‡] As proposed in 1999No05 based on band structures.

§ (A): g.s. yrast band.

(B): Side band.

$\gamma(^{139}\text{Cs})$

Coincidences are from double gates on 475.2 γ -740.3 γ and 127.9 γ (¹⁰⁵Nd)-740.3 γ .

E γ	E(level)	E γ	E(level)	E γ	E(level)
218.6	218.6	475.2	1070.4	601.5	601.6
236.6	1735.5	544.3	1145.8	727.6	2966.7
428.2	1498.8	589.9	1735.5	740.3	2239.1
468.5	1070.4	595.5	595.4	756.3	2491.8

²⁵²Cf SF Decay 2009Li42

Parent ²⁵²Cf: E=0; J π =0+; T_{1/2}=2.645 y 8; %SF decay=0.056 9.

²⁵²Cf-T_{1/2}: From ²⁵²Cf Adopted Levels in the ENSDF database, March 2005 update.

²⁵²Cf-%SF decay: From 1.8 3 per 100 fissions (1994EnZZ) and %SF=3.092 8 (²⁵²Cf Adopted Levels in the ENSDF database, March 2005 update).

2009Li42 (also 2010Li24): measured Doppler corrected E γ , I γ , $\gamma\gamma$ coin, $\gamma\gamma$ (θ) using Gammasphere array.

Others:

1998Hw04: a level scheme of ¹³⁹Cs containing seven γ rays. All, except the 218 γ , have been reassigned to ¹⁴²Cs.

From studies of ²⁴⁸Cm SF decay and ¹³⁹Xe β^- decay, 1999No05 concluded that the 218.6-408.6-618.4-387.5-503.0 cascade belonged to ¹⁴²Cs instead of ¹³⁹Cs. 1999No05 also noted that the 218.6 γ belonged to both the ¹³⁹Cs and ¹⁴²Cs nuclides.

1972Ho08 reported three γ rays.

¹³⁹Cs Levels

E(level) [†]	J π [‡]	Comments
0.0 §	7/2+	
218.6 10	(5/2+)	
595.4 [#] 9	9/2+	J π : 9/2 or 11/2 based on yrast structure, the latter is ruled out based on A ₂ value. π is determined based on the conversion coefficient of 236.9 γ .
601.6 § 9	11/2+	
1070.7 [#] 10	13/2+	
1146.0 § 12	15/2+	
1498.9 [#] 12	17/2+	
1735.8 § 13	19/2+	

Continued on next page (footnotes at end of table)

²⁵²Cf SF Decay 2009Li42 (continued)

¹³⁹Cs Levels (continued)

E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]
1846.6@ 14		2967.2# 15	25/2+	4145.1§ 20	(31/2+)
2239.3# 13	21/2+	3189.8 17		4323.7# 21	(33/2+)
2391.1@ 15		3337.6§ 17	(27/2+)	4669.7# 23	(37/2+)
2492.4§ 14	(23/2+)	3343.1@ 16			
2781.6@ 15		3496.1# 18	(29/2+)		

[†] From least-squares fit to Eγ data, assuming 0.3 keV uncertainty for each γ ray.

[‡] As proposed in 2009Li42 based on multiplicities from γγ(θ) data and band structures.

§ (A): Band based on 7/2+, α=1.

(B): Band based on 9/2+, α=0.

@ (C): γ cascade.

γ(¹³⁹Cs)

Eγ	E(level)	Mult. [†]	δ	α	Comments
218.6	218.6				
236.9	1735.8	(M1+E2)		0.089 6	α(exp)=0.086 12 (2009Li42). Mult.: from total conversion coefficient deduced from intensity balance considerations in γγ-coincidence analysis (2009Li42).
253.1	2492.4				
346.0	4669.7				
352.9	1498.9				
370.4‡	3337.6				
375.9	3343.1				
390.5	2781.6				
428.2	1498.9	Q			(428γ)(475γ)(θ): A ₂ =+0.11 1, A ₄ =0.00 2.
469.1	1070.7				
474.8	2967.2				
475.3	1070.7	Q			(475γ)(595γ)(θ): A ₂ =-0.10 1, A ₄ =-0.01 2.
503.5	2239.3				
528.9	3496.1				
542.3	2781.6				
544.4	1146.0	Q			(544γ)(602γ)(θ): A ₂ =+0.09 2, A ₄ =+0.01 3.
544.5	2391.1				
561.5	3343.1				
589.8	1735.8	Q			(590γ)(544γ)(θ): A ₂ =+0.10 4, A ₄ =0.00 7.
595.4	595.4	(M1+E2)	-4.2 +4-5		δ: -4.2 +4-5 or -0.07 2 from γγ(θ) (2009Li42), shell-model predicted value of -3.6 favors higher value. From RUL, large δ(Q/D) is consistent with M1+E2 rather than E1+M2, assuming level half-life is less than 10 ns.
601.6	601.6	Q			
655.3‡	2391.1				
700.6	1846.6				
727.9	2967.2	Q			(728γ)(740γ)(θ): A ₂ =+0.11 3, A ₄ =-0.01 4.
740.4	2239.3	Q			(740γ)(428γ)(θ): A ₂ =+0.11 2, A ₄ =-0.02 3.
756.6	2492.4				
807.5	4145.1				
827.6	4323.7				
845.2	3337.6				
950.5	3189.8				

[†] From γγ(θ) data, except as stated.

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

Adopted Levels, Gammas

$Q(\beta^-)=2314.6\ 23$; $S(n)=4723.4\ 34$; $S(p)=9316\ 9$; $Q(\alpha)=-922\ 4\ 2012\text{Wa}38$.

$S(2n)=13335.15\ 6$, $S(2p)=17108.5\ 3\ (2012\text{Wa}38)$.

1999Am05: mass measurement (Penning trap).

Other reactions:

1989Kr15: $^{139}\text{La}(\text{pol } n, p)\ E=\text{res.}$ Compiled and analyzed data for parity violation effects.

 ^{139}Ba Levels**Cross Reference (XREF) Flags**

A $^{139}\text{Cs}\ \beta^-$ Decay (9.27 min)

B ^{252}Cf SF Decay

C $^{136}\text{Xe}(\alpha, n\gamma)$

D $^{138}\text{Ba}(n, \gamma)\ E=\text{thermal}$

E $^{138}\text{Ba}(n, \gamma), (n, n)$: Resonances

F $^{138}\text{Ba}(\text{pol } p, p), (\text{pol } p, p')$: IAR

G $^{138}\text{Ba}(d, p)$

H $^{138}\text{Ba}(\alpha, ^3\text{He})$

E(level) [†]	J π	XREF	T _{1/2}	Comments
0.0 [@]	7/2-	ABCD FG	82.93 min [§] 9	$\% \beta^- = 100$. $\mu = -0.973\ 5\ (1988\text{We}07, 2014\text{StZZ})$. $Q = -0.573\ 13\ (1988\text{We}07, 2016\text{St}14)$. RMS charge radius $\langle r^2 \rangle^{1/2} = 4.8513\ \text{fm}\ 49\ (2013\text{An}02\ \text{evaluation})$. J π : spin from Collinear Fast Beam Laser Spectroscopy (CFBLS) (1983Mu12), π from L(d,p)=3. E(level): parent of 16182, 7/2- IAR in ^{139}La . μ, Q : CFBLS (1988We07); Q includes Sternheimer correction. Other: $\mu = -0.975\ 17$, $Q = -0.50\ 4\ (CFBLS, 1983\text{Mu}12)$.
627.318 22	3/2-	A CD FG		XREF: F(631.0).
1082.01 4	(1/2)-	A D FG		J π : L(d,p)=1; γ to 7/2-; parent of 16812, 3/2- IAR in ^{139}La . XREF: F(1087.0).
1283.32 3	(9/2)-	A C FGH		J π : L(d,p)=1; parent of 17268, 1/2- IAR in ^{139}La . XREF: F(1305).
1308.21 [@] 5	(11/2-)	ABC		J π : L(d,p)=5; parent of 17486, 9/2- IAR in ^{139}La .
1420.67 4	(5/2)-	A D FG		J π : γ to 7/2-; γ from (13/2)+; possible band member. XREF: F(1435).
1539.01 10	(13/2)+	ABC FGH		J π : L(d,p)=3; parent of 17616, 5/2- IAR in ^{139}La . XREF: F(1575).
1619 10	(9/2)-	FGH		J π : L(d,p)=6; parent of 17756, 13/2+ IAR in ^{139}La . XREF: F(1641).
1620.73 6	(7/2-, 9/2+)	A		J π : L(d,p)=5; parent of 17822, 9/2- IAR in ^{139}La .
1680.78 4	(7/2)-	A D FG		J π : γ s to 7/2- and (11/2-); γ from 5/2+. XREF: F(1692).
1698.69 5	(5/2)-	A D FG		J π : L(d,p)=3; parent of 17873, 7/2- IAR in ^{139}La . XREF: F(1711).
1748.27 5	3/2-	A D FG		J π : L(d,p)=3; parent of 17892, 5/2- IAR in ^{139}La . XREF: F(1780).
1817.78 4	(1/2-, 3/2, 5/2-)	A F		J π : L(d,p)=1; γ to 7/2-. XREF: F(1842).
1828.45 [@] 10	(15/2-)	BC		J π : γ s to 1/2- and 5/2-.
1851.03 6	(11/2-, 9/2, 7/2-)	A C		J π : $\Delta J=2$, Q transition to (11/2-); γ to (13/2)+. J π : γ rays to 7/2- and (11/2-); possible β feeding from 7/2+ parent; population in ($\alpha, n\gamma$) favors high spin.
1877.38 4	(5/2- to 11/2-)	A		J π : γ s to 7/2- and (9/2)-; β feeding from 7/2+ parent.
1887.54 5	(5/2-, 7/2, 9/2-)	A g		J π : γ s to (5/2)- and (9/2)-.
1895.48 6	1/2, 3/2, 5/2+	D g		J π : primary γ from 1/2+.
1933.48 5	(7/2)-	A FG		XREF: F(1943).
1946.04 18	(3/2-, 5/2+)	D		J π : L(d,p)=3; parent of 18124, 7/2- IAR in ^{139}La .
1949.13 6	(5/2)-	A FG		J π : primary γ from 1/2+; γ to 7/2-. XREF: F(1963).
1951.54 15		D		J π : γ s to 3/2- and 7/2-. L(d,p)=3; parent of 18144, 5/2- IAR in ^{139}La for 1949 level. These may belong to 1951 level as well.
1976.89 [@] 14	(17/2-)	BC	0.40 ns 25	J π : γ to 7/2- suggests 3/2- to 11/2-. See also comment for 1949 level.
1998.25 6	(7/2-, 9/2, 11/2-)	A		J π : $\Delta J=1\ (M1)\ \gamma$ to (15/2-); band member. T _{1/2} : from $\gamma(t)$ in ($\alpha, n\gamma$).
2020.89 10	(5/2-, 7/2-)	A		J π : γ s to 7/2- and (11/2-). J π : γ s to 3/2- and 9/2-.

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Adopted Levels, Gammas (continued) ^{139}Ba Levels (continued)

E(level) [†]	J π	XREF	Comments
2037.97 5	(3/2-, 5/2, 7/2-)	A	J π : γ s to 3/2- and 7/2-.
2079.06 14	(7/2-, 9/2, 11/2-)	A	J π : γ s to 7/2- and (11/2-).
2089.89 6	(5/2-, 7/2-)	A	J π : γ s to 3/2- and 9/2-.
2091.7@ 4	(19/2-)	BC	J π : γ to (17/2-); possible band member.
2100.08 11	(5/2-, 7/2-)	A FG	XREF: F(2115)G(2106). J π : L(d,p)=(3); γ s to 3/2- and 7/2-. Parent of 19297, 7/2- IAR in ^{139}La . In (d,p) and (p,p'), the level may also correspond to the 2100.85 level.
2110.85 6	(5/2- to 11/2-)	A	J π : γ s to 7/2- and (9/2-); β feeding from 7/2+ parent. See also comment for 2100.07 level.
2129.20 5	3/2-	D FG	XREF: F(2158). J π : L(d,p)=1; γ to 7/2-.
2157.00 8	3/2-, 5/2+	A D g	J π : primary γ from 1/2+; γ to 7/2-. L(d,p)=1 for a 2153 10 group corresponds to 2156.99 and/or 2158.77 levels.
2158.85 6	3/2-, 5/2+	A D g	J π : primary γ from 1/2+; log ft<11 from 7/2+. See also comment for 2156.99 level.
2166.72 19	(7/2-)	A f	XREF: f(2182). J π : γ s to 3/2- and (11/2-).
2173.95 5	(5/2-, 7/2-)	A f	XREF: f(2182). J π : γ s to 3/2- and 9/2-; possible parent of 18363, 5/2- IAR in ^{139}La .
2185.58 7	1/2-, 3/2-	D FG	XREF: F(2186). J π : L(d,p)=1.
2218.93 7	(3/2-, 5/2, 7/2-)	A	J π : γ s to 3/2- and 7/2-.
2229.79 9	(5/2- to 11/2-)	A	J π : γ s to 7/2- and (9/2-).
2249.85 24	(5/2- to 11/2-)	A	J π : γ s to 7/2- and (9/2-).
2304.88 8	(5/2-, 7/2-)	A FG	XREF: F(2335). J π : L(d,p)=(3); possible parent of 18516, (5/2-) IAR in ^{139}La .
2349.81 3	5/2-, 7/2-	A G	XREF: G(2361). J π : L(d,p)=3.
2375.80 8	(5/2-, 7/2, 9/2-)	A g	J π : γ s to 5/2- and 9/2-. L(d,p)=3 for a 2378 10 group corresponds to 2375.8 and/or 2380.70 levels.
2380.70 7	(3/2- to 11/2-)	A g	J π : γ to 7/2-; possible β feeding from 7/2+ parent. See also comment for 2375.80 level.
2435.28 9	1/2-, 3/2-	D FG	XREF: F(2446). J π : L(d,p)=1; possible parent of 18630, (3/2-) IAR in ^{139}La .
2461.67 7	(5/2-, 7/2, 9/2-)	A	J π : γ s to 5/2- and 9/2-.
2479.3 4		B	J π : γ to (19/2-) suggests 15/2- to 23/2-.
2480.76 5	(3/2-)	D g	J π : primary γ from 1/2+; γ to 7/2-. L(d,p)=1 for a 2478 group corresponds to 2480.7 and/or 2485.5 levels.
2485.59 25	1/2, 3/2, 5/2+	D g	J π : primary γ from 1/2+. See also comment for 2480.7 level.
2524.30 11	(7/2-, 9/2, 11/2-)	A g	
2529.69 16	(3/2- to 9/2-)	A g	J π : γ s to 7/2- and (5/2-).
2531.83 5	(3/2-, 5/2, 7/2-)	A g	J π : γ s to 3/2- and 7/2-.
2543 10	(5/2-, 7/2-)	G	J π : L(d,p)=(3). E(level): from energy matching, this level could correspond to 2549.7 level, the implied J π values are exclusive.
2549.72 16	(3/2-)	D	J π : γ to 7/2-; primary γ from 1/2+.
2569.87 13	(3/2-)	D G	J π : L(d,p)=(1); γ to 7/2-.
2605.74 4	(3/2- to 9/2-)	A	J π : γ s to 7/2- and (5/2-).
2649.38 7	(3/2-, 5/2, 7/2-)	A	J π : γ s to 3/2- and 7/2-.
2667		G	
2681.2 4		B	J π : γ to (19/2-) suggests 15/2- to 23/2-.
2739 10		G	
2743.5? 4		C	E(level), J π : probably a high-spin level and different from the 2739 level in (d,p).
2797 10		G	
2847.75 7	(5/2- to 11/2-)	A	J π : γ s to 7/2- and (9/2-).
2857 15	(1/2-, 3/2-)	G	E(level): from energy matching, this level could correspond to 2847.75 level, however the two sets of implied J π values are exclusive. J π : L(d,p)=(1).
2909 15		G	
2939 15		G	
2994.43 9	(5/2-, 7/2, 9/2-)	A g	J π : γ s to (5/2)- and (9/2)-.
2997.31 8	(7/2-, 9/2)	A g	J π : 6.2 $\leq$ log ft $\leq$ 7.5 via 7/2+ parent; γ s to (9/2)- and (11/2-).

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Adopted Levels, Gammas (continued) ^{139}Ba Levels (continued)

E(level) [†]	J π	XREF	Comments
3024.8 2	(1/2-, 3/2-)	D G	XREF: D(?)G(3023). J π : L(d,p)=(1).
3080 10	11/2+, 13/2+	GH	J π : L(d,p)=6.
3088.6 4		B	J π : γ to (19/2-) suggests 15/2- to 23/2-.
3100 10		G	
3122.7 [#] 4	(21/2-)	B	J π : γ to (19/2-); possible bandhead.
3168.20 21	(1/2-, 3/2-)	D G	J π : L(d,p)=(1); primary γ from 1/2+.
3177 10		a G	XREF: a(3200).
3210 10	(1/2-, 3/2-)	G	J π : L(d,p)=(1).
3231 10		a G	XREF: a(3200).
3259.2 3	1/2, 3/2, 5/2+	D G	J π : primary γ from 1/2+.
3270.28 19	(5/2, 7/2, 9/2)	A G	J π : possible β feeding from 7/2+ parent.
3336 10		G	
3344.3 4		B	J π : probably >15/2, since populated in ^{252}Cf SF decay.
3381.9 4		B	J π : probably >15/2, since populated in ^{252}Cf SF decay.
3385.10 21	(1/2-, 3/2-)	D G	XREF: G(3379). J π : L(d,p)=(1); primary γ from 1/2+.
3401.39 14	5/2-, 7/2-	A G	J π : L(d,p)=3.
3418.79 14	(5/2, 7/2, 9/2)	A	J π : possible β feeding from 7/2+ parent.
3434.44 21	(5/2, 7/2, 9/2)	A	J π : possible β feeding from 7/2+ parent.
3464.40 7	(5/2-, 7/2-)	A G	J π : L(d,p)=(3); γ s to 3/2- and 7/2-.
3480 10		G	
3499 10		G	
3524 10		G	
3563 10		G	
3592 10		G	
3603 10		G	
3641 10		G	
3665.66 8	5/2, 7/2, 9/2	A g	J π : γ to 7/2-; allowed or first-forbidden β from 7/2+ parent.
3674.62 14	(5/2, 7/2-)	A g	J π : γ to 3/2-; allowed or first-forbidden β from 7/2+ parent.
3701.95 14	(5/2-, 7/2, 9/2-)	A G	J π : γ s to (5/2)- and (9/2)-.
3724.19 14	(5/2, 7/2-)	A G	J π : γ to 3/2-; allowed or first-forbidden β from 7/2+ parent.
3769.21 11	(5/2, 7/2, 9/2)	A G	J π : possible β feeding from 7/2+ parent.
3820.05 24	(5/2, 7/2, 9/2)	A G	XREF: G(3811). J π : possible β feeding from 7/2+ parent.
3839.73 15	(5/2, 7/2, 9/2)	A G	J π : possible β feeding from 7/2+ parent.
3853.93 16	(5/2, 7/2, 9/2)	A	J π : possible β feeding from 7/2+ parent.
3887.9 3	(5/2, 7/2, 9/2)	A	J π : possible β feeding from 7/2+ parent.
3890.9 [#] 4	(25/2-)	B	J π : γ to (21/2-); band member.
3912.27 21	(5/2, 7/2, 9/2)	A	J π : 6.2 $\leq\log ft\leq 7.5$ via 7/2+ parent.
3930 10		G	
3950.84 12	(5/2)+	A G	J π : $\log ft=5.3$ from 7/2+ parent; γ to 3/2-.
3971 10		G	
4010 10		G	
4046.9 4		B	J π : probably >15/2, since populated in ^{252}Cf SF decay.
4616.3 [#] 4	(29/2-)	B	J π : γ to (25/2-); possible band member.
(4723.51 4)	1/2+	D	J π : s-wave capture in 0+ g.s. of ^{138}Ba . E(level): S(n)=4723.43 4 (2012Wa38).
4724.07	1/2-, 3/2- $\frac{7}{2}$	E	
4725.36	[3/2]- $\frac{7}{2}$	E	
4725.42	1/2-, 3/2- $\frac{7}{2}$	E	
4728.10	[1/2]- $\frac{7}{2}$	E	
4731.25	1/2+ $\frac{7}{2}$	E	
4733.28	[1/2]- $\frac{7}{2}$	E	
4737.34	[3/2]- $\frac{7}{2}$	E	
4742.94		E	
4743.15		E	
4746.65		E	
4746.80		E	
4747.44	1/2-, 3/2- $\frac{7}{2}$	E	
4749.41		E	
4752.41		E	
4753.02		E	

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Adopted Levels, Gammas (continued) ^{139}Ba Levels (continued)

E(level) [†]	J π	XREF	Comments
4753.99	1/2+ $\frac{7}{2}$	E	
4754.41	1/2-, 3/2- $\frac{7}{2}$	E	
4755.77		E	
4757.67		E	
4763.32	3/2- $\frac{7}{2}$	E	
4766.01		E	
4766.85		E	
4770.51		E	
4770.61		E	
4771.74		E	
4772.56	[3/2]- $\frac{7}{2}$	E	
4773.40	1/2+ $\frac{7}{2}$	E	
4773.41		E	
4776.29	[3/2]- $\frac{7}{2}$	E	
4777.97		E	
4778.22	[1/2]- $\frac{7}{2}$	E	
4781.92		E	
4782.34	1/2+ $\frac{7}{2}$	E	
4783.66	[3/2]- $\frac{7}{2}$	E	
4784.38		E	
4785.74	3/2- $\frac{7}{2}$	E	
4789.61		E	
4791.83	3/2- $\frac{7}{2}$	E	
4791.94		E	
4792.22		E	
4795.42		E	
4795.92		E	
4797.12	[1/2]- $\frac{7}{2}$	E	
4800.64		E	
4802.32	1/2+ $\frac{7}{2}$	E	
4804.30		E	
4804.51		E	
4806.52		E	
4810.18		E	
4811.89	[3/2]- $\frac{7}{2}$	E	
4813.97		E	
4814.52		E	
4817.95		E	
4819.26		E	
4819.52		E	
4820.47		E	
4822.11		E	
4822.48		E	
4822.61		E	
4823.33		E	
4823.71		E	
4824.44		E	
4825.04		E	
4825.99	[1/2]- $\frac{7}{2}$	E	
4826.55		E	
4828.12	1/2+ $\frac{7}{2}$	E	
4829.84	[3/2]- $\frac{7}{2}$	E	
4830.70		E	
4831.49		E	
4831.79		E	
4832.03		E	
4832.63		E	
4834.58	1/2+ $\frac{7}{2}$	E	
4835.33	[3/2]- $\frac{7}{2}$	E	
4838.26		E	
4839.08	3/2- $\frac{7}{2}$	E	
4839.23	1/2+ $\frac{7}{2}$	E	
4839.70		E	

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Adopted Levels, Gammas (continued) ^{139}Ba Levels (continued)

E(level) [†]	J π	XREF	Comments
4846.11		E	
4847.62		E	
4849.20	[1/2] ⁻ $\frac{5}{2}$	E	
4849.53		E	
4849.86		E	
4852.14	3/2 ⁻ $\frac{5}{2}$	E	
4852.34		E	
4854.60		E	
4855.32		E	
4856.16		E	
4856.91		E	
4859.45	1/2 ⁺ $\frac{5}{2}$	E	
4861.31		E	
4861.48	[3/2] ⁻ $\frac{5}{2}$	E	
4862.58		E	
4863.34		E	
4864.68		E	
4865.61		E	
4866.94		E	
4869.12		E	
4869.35		E	
4869.96		E	
4872.75		E	
4873.71	3/2 ⁻ $\frac{5}{2}$	E	
4874.84		E	
4877.18		E	
4879.37		E	
4880.70	[3/2] ⁻ $\frac{5}{2}$	E	
4883.25		E	
4883.75		E	
4885.24		E	
4885.76		E	
4887.47		E	
4889.05		E	
4889.22		E	
4890.49		E	
4890.86	[3/2] ⁻ $\frac{5}{2}$	E	
4891.59		E	
4894.15	[3/2] ⁻ $\frac{5}{2}$	E	
4895.66	3/2 ⁻ $\frac{5}{2}$	E	
4897.70		E	
4898.11		E	
4899.08		E	
4901.81	[3/2] ⁻ $\frac{5}{2}$	E	
4903.68	1/2 ⁺ $\frac{5}{2}$	E	
4906.18		E	
4907.90		E	
4909.62		E	
4910.51		E	
4911.68		E	
4912.10	[1/2] ⁻ $\frac{5}{2}$	E	
4913.00		E	
4913.80		E	
4914.38		E	
4916.29		E	
4916.80	1/2 ⁺ $\frac{5}{2}$	E	
4918.35		E	
4919.68		E	
4920.53		E	
4920.91		E	
4921.78		E	
4956.6 [#] 4	(31/2 ⁻)	B	J π : γ to (27/2 ⁻); possible band member.

Footnotes continued on next page

Adopted Levels, Gammas (continued)

¹³⁹Ba Levels (continued)

† Primary γ rays from (n, γ) were included in the least-squares analysis with the capture-state energy held fixed.

‡ From 2006MuZX, based on the analysis of s-wave (L=0, $J\pi=1/2^+$) and p-wave (L=1, $J\pi=1/2^-$ or $3/2^-$) neutron resonance data.

§ From unweighted average of 83.09 min 9 (2012Da17, γ counting for several samples and γ rays counted for more than 5 half-lives, long-lived source used as reference); 83.25 min 8 (2012Da04, γ counting, several samples counted over $\approx$ 4 half-lives, long-lived source used as reference); 82.57 min 12 (2008Ni02, average of 82.60 min 8 and 82.54 min 8 from K x-ray and 165 γ counting for two samples); 83.06 min 28 (1980Ge04, γ counting over seven half-lives, details provided); 82.71 min 18 (1972Em01, β counting for 2.4T_{1/2} G-M detector); 82.9 min 2 (1962Fr04, β counting); 82.9 min 1 (1958Bu04, 2π counting for 6-10 half-lives). Other values which seem either imprecise or discrepant: 84.547 min 15 (1989Ab05, γ counting over 0.7 half-life; no details given); 84.44 min 22 (1985An25, γ counting over six half-lives); 84.63 min 34 (1972Eh02, β counting, proportional counter); 85.2 min 8 (1969Su01); 85 min 1 (1960Wi10, 1953Pa25); 84.0 min 2 (1957Ba16, 4π counting for nine half-lives); 85.0 min 5 (1950Di04); 85.6 min (1937Po03), 85 min 3 (1960Ke06) and 84 min 1 (1948Sh27). Weighted average of all the values (but with uncertainty of 0.08 min in 1989Ab05 value) above is 83.44 min 19 with reduced $\chi^2=20$, showing the discrepant nature of the dataset.

(A): γ sequence based on (21/2-).

@ (B): γ sequence based on 7/2-, g.s.

$\gamma(^{139}\text{Ba})$

See β^- decay and (n, γ) E=thermal for unplaced γ rays.

E(level)	E $\gamma^\dagger$	I $\gamma^\dagger$	Mult.‡	$\alpha^\S$	Comments
627.318	627.24 3	100			
1082.01	454.66 6	100			
1283.32	1283.23 5	100			
1308.21	1308.13 6	100	(Q)		
1420.67	793.28 7	9.6 7			
	1420.66 6	100 6			
1539.01	230.76 9	100	(D)		
1620.73	312.31 21	1.9 4			
	1620.74 6	100 5			
1680.78	260.6 4	1.2 4	[M1, E2]	0.0707 12	
	1680.72 6	100 5			
1698.69	1698.66 7	100			
1748.27	666.07 11	63 3			
	1120.89 10	100 5			
	1748.5 3	28 3			
1817.78	396.9 3	8.6 24			
	735.68 9	34.8 28			
	1190.42 6	100 6			
1828.45	289.39 10	1.0			γ from ²⁵² Cf SF decay only.
	520.29 10	100	Q		
1851.03	542.71 15	23 3			
	567.72# 5	100# 8			
	1850.7 4	10 3			
1877.38	196.51 18	2.5 4			
	594.02 5	20.7 13			
	1877.45 7	100 6			
1887.54	188.88 20	3.6 7			
	466.70 12	9.2 10			
	604.22 6	19.3 13			
	1887.57 7	100 6			
1895.48	1268.2	100			
1933.48	1306.09 11	43 4			
	1933.48 7	100 6			
1946.04	1318.5 2	70 8			
	1946.9 4	100 23			
1949.13	1321.77 6	100 6			
	1949.26 14	14.2 16			
1951.54	1951.53 15	100			
1976.89	148.44 10	100	(M1)	0.325	B(M1)(W.u.)=0.013 8. Mult.: $\Delta J=1$, dipole from $\gamma(\theta)$ in ($\alpha, n\gamma$); band assignment suggests M1.
1998.25	690.04 9	30 3			
	714.90 6	100 6			
	1998.46 15	40 4			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Ba})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ‡	$\alpha^{\S}$	Comments
2020.89	737.60 12	33 4			
	1393.2 3	12 3			
	2020.76 25	100 34			
2037.97	357.01 16	9.1 15			
	616.91 21	16 3			
	1410.58 7	100 6			
	2038.10 11	28.2 24			
2079.06	770.56 19	40 7			
	2079.33 19	100 12			
2089.89	806.32 21	9.0 16			
	1462.43 19	26 5			
	2089.91 9	100 7			
2091.7	114.8 3	100	[M1]	0.672 11	$E\gamma$: unweighted average.
2100.08	419.3 3	20 6			
	1472.6 5	25 11			
	2100.13 17	100 13			
2110.85	233.45 22	1.4 4			
	430.20 16	5.5 5			
	827.52 7	16.7 11			
	2110.91 9	100 6			
2129.20	708.4 1	58 6			
	1047.4 1	100 5			
	1501.81 19	86 9			
	2129.2 1	57 7			
2157.00	339.4 4	14 6			
	1529.3 3	63 14			
	2156.94 13	100 11			
2158.85	738.4 2	56 3			γ from (n, γ) only.
	1077.01 17	100 7			
	1531.3 3	76 9			
2166.72	858.4 3	89 23			
	883.5 3	100 28			
	2166.7 4	94 28			
2173.95	890.54 8	36.7 25			
	1546.63 13	15.1 18			
	2173.98 7	100 6			
2185.58	1103.2 2	86 6			
	1558.3 2	100 10			
2218.93	401.08 22	19 4			
	538.35 24	25 6			
	598.17 18	22 4			
	798.01 14	49 7			
	1591.73 11	100 9			
	2218.91 23	40 6			
2229.79	946.46 8	100 7			
	2229.9 3	14 3			
2249.85	966.6 3	100 25			
	2249.7 4	67 17			
2304.88	1677.44 10	100 8			
	2304.97 16	34 4			
2349.81	249.89 18	1.8 4			
	416.49 22	2.2 5			
	531.98 4	38.6 21			
	601.48 5	11.6 7			
	651.08 7	8.3 7			
	668.97 8	7.5 7			
	929.18 6	41.6 22			
	1722.55 9	13.5 9			
	2349.92 6	100 6			
2375.80	558.1 3	12 4			
	955.19 19	42 6			
	1092.23 12	60 3			
	2375.95 11	100 9			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Ba})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$
2380.70	2380.66 7	100	2649.38	832.2 3	7.3 26	3701.95	1768.19 21	95 15
2435.28	687.6 5	11.2 14		2022.1 5	39 26		1814.6 4	85 25
	1353.1 2	100 10		2649.32 7	100 6		2003.4 3	100 20
2461.67	528.20 10	54 19	2681.2	589.51 10	100		2418.9 4	85 20
	1040.93 22	47 5	2743.5?	1204.5@ 3	100	3724.19	3096.4 4	33 9
	1178.35 9	100 9	2847.75	849.7 3	10 3		3724.20 15	100 9
2479.3	387.65 10	100		1564.63 13	30 4	3769.21	3769.16 11	100
2480.76	295@ 5	<46		2847.63 8	100 6	3820.05	3819.99 24	100
	352@ 5	<46	2994.43	613.4 3	19 6	3839.73	1818.5 3	84 20
	1060.1 3			1573.84 15	32 4		3839.78 17	100 8
	1853.31 9	100 7		1711.09 11	100 8	3853.93	3853.87 16	100
	2480.68 12	30 6	2997.31	1063.7 4	12 6	3887.9	3887.8 3	100
2485.59	1403.4 4	100		1316.4 4	15 5	3890.9	768.18 10	100
2524.30	434.23 20	49 11		1689.04 25	23 5	3912.27	3912.21 21	100
	1216.14 19	74 13		1713.6 4	18 5	3950.84	1600.7 5	39 15
	1240.93 25	54 11		2997.32 9	100 7		1793.63 17	43 6
	2524.47 22	100 16	3088.6	996.86 10	100		2330.2 6	20 9
2529.69	1108.93 18	51 8	3122.7	1031.05 10	100		3323.66 15	100 10
	2529.9 3	100 28	3259.2	2176.1		4046.9	702.61@	
2531.83	1110.9 4	6.4 12		2632.5			958.33 10	100
	1904.50 7	29.5 17	3270.28	1249.41 22	100 19	4616.3	725.33 10	100
	2531.84 7	100 7		3270.2 3	67 10	(4723.51)	1338.4 2	0.98 11
2549.72	1129.3 3	21 6	3344.3	255.71 10	100		1464.3 3	0.70 11
	1468@		3381.9	902.56 10	100		1555.3 2	1.00 11
	1921.8 4	100 11	3401.39	2774.04 13	100		1698.6@& 2	2.3& 3
	2550.8 5	90 21	3418.79	1737.9 3	76 8		2152.5 4	1.09 9
2569.87	1150.1 8	18 6		3418.77 15	100 9		2173.96 23	1.00 11
	1488.9 9	64 9	3434.44	973.0 4	58 20		2237.8 3	1.8 4
	2569.68 13	100 9		1344.4 4	55 16		2242.67 6	6.8 4
2605.74	375.91@ 7	16.0 12		2352.6 6	100 36		2288.19 9	4.3 5
	448.76 12	12.4 15	3464.40	933.0 3	12 4		2537.88 6	6.6 4
	505.4 3	3.8 12		1159.30 17	24 4		2564.66 5	3.4 5
	515.86 7	21.3 18		1353.92 19	20 4		2594.29 4	11.3 5
	567.72# 5	15# 3		2836.88 16	25.2 26		2777.5 7	0.77 23
	656.58 13	12.7 15		3464.34 9	100 6		2828.00 4	2.89 23
	672.21 15	7.8 12	3665.66	1059.9 3	11 4		2975.3 9	5.38 9
	728.38 9	16.6 15		3665.61 8	100 6		3641.47 5	37 3
	788.3 4	3.6 12	3674.62	1500.5 3	49 12		4096.14 4	100 5
	924.96 8	27.2 21		1563.9 4	34 10	4956.6	340.38 10	100
	1185.21 17	12.1 18		3047.29 16	100 10			
	2605.75 6	100 6	3701.95	267.6 3	65 20			

† Values represent averages when available from different datasets, except as noted.

‡ From $\gamma(\theta)$ in $(\alpha, n\gamma)$.§ Theoretical values using BrIcc code. If $\delta(E2/M1)$ is not given, value overlaps those for pure M1 and pure E2.

Multiply placed; intensity suitably divided.

@ Placement of transition in the level scheme is uncertain.

& Multiply placed; undivided intensity given.

Adopted Levels, Gammas (continued) **^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09**

Parent ^{139}Cs : $E=0.0$; $J\pi=7/2+$; $T_{1/2}=9.27$ min 5; $Q(\text{g.s.})=4213$ 3; $\%\beta^-$ decay=100.

$^{139}\text{Cs}-J, T_{1/2}$: From ^{139}Cs Adopted Levels.

$^{139}\text{Cs}-Q(\beta^-)$: From 2012Wa38.

1980Le03: measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin; deduced levels, $Q(\beta)$.

1973Ad04 (also 1972LeYH): measured $E\beta$, $\beta\gamma$ -coin; deduced $Q(\beta)$.

Decay scheme is basically as proposed by 1980Le03 with following modifications suggested in 1981Pe04 NDS evaluation:

1. The placement of the 619.7 γ deexciting a 2159 level was removed.
2. The placement of 1539.09 γ deexciting the 1539 level was removed.
3. A level at 2606 was added. 1980Le03 apparently assumed that the 1539 level observed by 1973Ad04 differed from the 1539, $L=5$ level observed in (d,p). 1981Pe04 assumed that the levels were the same, which seems to be confirmed by $^{136}\text{Xe}(\alpha, n\gamma)$ work of 1987Pr06. 1981Pe04 introduced a second level at 2606 apparently on the basis of the existence of the 1067 γ feeding the 1539 level; however, since this γ was not placed on the basis of $\gamma\gamma$ -coincidences, evaluators have not adopted the second 2606 level.

1997Gr09 (also 1994He33, 1992Gr18) measured summed γ -ray spectrum (TAGS, total absorption γ -ray spectrometer; NaI(Tl) well) and $\beta\gamma$ -coincidences (Si-NaI(Tl) well). The spectra were analyzed based on the response functions for monoenergetic neutrons and electrons computed with a Monte Carlo code. The β -feeding distributions as a function of the excitation energy of the state were deduced. Analysis of the ^{139}Cs β^- spectra was based on ^{139}Cs β^- decay scheme in 1989Bu12 evaluation and $I\beta^-(\text{g.s.})=85.0\%$ 34 (1992Gr21, 1997Gr09). The decay scheme in 1989Bu12 was modified by the adjustment of $I\beta^-$'s, the addition of a state at 3200 keV, and the lowering of the 1283 state to 1273; this resulted in excellent agreement between the measured and simulated spectra. The agreement of $I\beta$ values between the simulation and 1989Bu12 NDS evaluation is also good, particularly below 2600 keV.

Others: 1978Wu04, 1970RuZR, 1969Ca03, 1966Zh02.

 ^{139}Ba Levels

E(level)	$J\pi^\dagger$	Comments
0.0	7/2-	
627.319 22	3/2-	
1082.04 5	(1/2)-	
1283.32 3	(9/2)-	
1308.21 5	(11/2)-	
1420.67 4	(5/2)-	
1538.97 11	(13/2)+	
1620.73 6	(7/2-, 9/2+)	
1680.78 4	(7/2)-	
1698.69 5	(5/2)-	
1748.29 5	3/2-	

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^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued) ^{139}Ba Levels (continued)

E(level)	$J\pi^\dagger$	Comments
1817.78 4	(1/2-, 3/2, 5/2-)	
1851.03 6	(11/2-, 9/2, 7/2-)	
1877.38 4	(5/2- to 11/2-)	
1887.54 5	(5/2-, 7/2, 9/2-)	
1933.48 5	(7/2)-	
1949.13 6	(3/2-, 5/2+)	
1998.25 6	(7/2-, 9/2, 11/2-)	
2020.89 10	(5/2-, 7/2-)	
2037.97 5	(3/2-, 5/2, 7/2-)	
2079.06 14	(7/2-, 9/2, 11/2-)	
2089.89 6	(5/2-, 7/2-)	
2100.08 11	(5/2-, 7/2-)	
2110.85 6	(5/2- to 11/2-)	
2157.00 8	3/2-, 5/2+	
2158.87 16	3/2-, 5/2+	
2166.72 19	(7/2-)	
2173.95 5	(5/2-, 7/2-)	
2218.93 7	(3/2-, 5/2, 7/2-)	
2229.79 9	(5/2- to 11/2-)	
2249.85 24	(5/2- to 11/2-)	
2304.88 8	(5/2-, 7/2-)	
2349.81 3	5/2-, 7/2-	
2375.80 8	(5/2-, 7/2, 9/2-)	
2380.70 7	(3/2- to 11/2-)	
2461.67 7	(5/2-, 7/2, 9/2-)	
2524.30 11	(7/2-, 9/2, 11/2-)	
2529.69 16	(3/2- to 9/2-)	
2531.83 5	(3/2-, 5/2, 7/2-)	
2605.74 4	(3/2- to 9/2-)	
2649.38 7	(3/2-, 5/2, 7/2-)	
2847.75 7	(5/2- to 11/2-)	
2994.43 9	(5/2-, 7/2, 9/2-)	
2997.31 8	(7/2-, 9/2)	
3200?		E(level): Pseudo level introduced from TAGS analysis (1997Gr09). May correspond to the 3177 or 3231 states in (d,p). $J=5/2, 7/2, 9/2$ implied from $\log ft=7.2$ suggests that this level probably does not correspond to $L=(1)$, $J\pi=(1/2-, 3/2-)$ 3163 and/or 3210 levels in (d,p).
3270.28 19	(5/2, 7/2, 9/2)	
3401.39 14	5/2-, 7/2-	
3418.79 14	(5/2, 7/2, 9/2)	
3434.45 21	(5/2, 7/2, 9/2)	
3464.40 7	(5/2-, 7/2-)	
3665.66 8	5/2, 7/2, 9/2	
3674.62 14	(5/2, 7/2-)	
3701.95 14	(5/2-, 7/2, 9/2-)	
3724.19 14	(5/2, 7/2-)	
3769.21 11	(5/2, 7/2, 9/2)	
3820.05 24	(5/2, 7/2, 9/2)	
3839.73 15	(5/2, 7/2, 9/2)	
3853.93 16	(5/2, 7/2, 9/2)	
3887.9 3	(5/2, 7/2, 9/2)	
3912.27 21	(5/2, 7/2, 9/2)	
3950.84 12	(5/2)+	

 † From the Adopted Levels.

¹³⁹Cs β⁻ Decay (9.27 min) 1980Le03,1997Gr09 (continued)

β⁻ radiations

1975Al11 measured total absorption γ spectrum and deduced β strength function. See also 1973Jo02.

1992Gr21 measured Iβ⁻(g.s.); 4πγ-β (NaI(Tl) well-Si); while 1997Gr09 (also 1994He33) measured total absorption gamma spectrum (TAGS).

βγ-coincidences are from 1973Ad04, 1972LeYH, and 1970RuZR (Si,NaI).

<E_β>=1.73 MeV 5 (1982Al01. Si(Li)) in poor agreement with <E_β>=1.659 MeV 2 from decay scheme.

Eβ ⁻	E(level)	Iβ ⁻ †§	Log ft	Comments
(262 3)	3950.84	0.099 22	5.3 1	Iβ=0.017 (1997Gr09).
(301 3)	3912.27	0.012 3	6.4 1	Iβ=0.011 (1997Gr09).
(325 3)	3887.9	0.0078 21	6.7 1	Iβ=0.007 (1997Gr09).
(359 3)	3853.93	0.019 4	6.5 1	Iβ=0.021 (1997Gr09).
(373 3)	3839.73	0.033 8	6.3 1	Iβ=0.017 (1997Gr09).
(393 3)	3820.05	0.011 3	6.9 1	Iβ=0.010 (1997Gr09).
(444 3)	3769.21	0.044 10	6.4 1	Iβ=0.22 (1997Gr09).
(489 3)	3724.19	0.034 8	6.7 1	Iβ=0.043 (1997Gr09).
(511 3)	3701.95	0.061 14	6.5 1	Iβ=0.085 (1997Gr09).
(538 3)	3674.62	0.053 12	6.6 1	Iβ=0.085 (1997Gr09).
(547 3)	3665.66	0.15 3	6.2 1	Iβ=0.38 (1997Gr09).
(749 3)	3464.40	0.19 4	6.6 1	Iβ=0.153 (1997Gr09).
(779 3)	3434.45	0.038 13	7.3 2	Iβ=0.036 (1997Gr09).
(794 3)	3418.79	0.069 15	7.1 1	Iβ=0.21 (1997Gr09).
(812 3)	3401.39	0.029 7	7.5 1	Iβ=0.085 (1997Gr09).
(943 3)	3270.28	0.025 6	7.8 1	Iβ=0.162 (1997Gr09).
(1013# 3)	3200?	0.145	7.2	Iβ ⁻ : from the TAGS analysis (1997Gr09).
(1216 3)	2997.31	0.14 3	7.5 1	Iβ=0.170 (1997Gr09).
(1219 3)	2994.43	0.117 25	7.6 1	Iβ=0.170 (1997Gr09).
(1365 3)	2847.75	0.14 3	7.7 [‡] 1	Iβ=0.21 (1997Gr09).
(1564 3)	2649.38	0.24 7	7.7 [‡] 1	Iβ=0.28 (1997Gr09).
(1607 3)	2605.74	0.56 11	7.3 1	Iβ=0.47 (1997Gr09).
(1681 3)	2531.83	0.54 11	7.4 1	Iβ=0.54 (1997Gr09).
(1683 3)	2529.69	0.12 4	8.1 [‡] 2	Iβ=0.170 (1997Gr09).
(1689 3)	2524.30	0.077 17	8.3 [‡] 1	Iβ=0.128 (1997Gr09).
(1751 3)	2461.67	0.12 3	8.2 [‡] 1	Iβ=0.128 (1997Gr09).
(1832 3)	2380.70	0.17 4	8.1 [‡] 1	Iβ=0.170 (1997Gr09).
(1837 3)	2375.80	0.15 3	8.1 [‡] 1	Iβ=0.141 (1997Gr09).
(1863 3)	2349.81	1.21 25	7.3 1	Iβ=1.19 (1997Gr09).
(1908 3)	2304.88	0.092 20	8.4 [‡] 1	Iβ=0.21 (1997Gr09).
(1963 3)	2249.85	0.028 8	9.0 [‡] 1	Iβ=0.043 (1997Gr09).
(1983 3)	2229.79	0.092 32	8.5 [‡] 2	Iβ=0.062 (1997Gr09).
(1994 3)	2218.93	0.13 3	8.4 [‡] 1	Iβ=0.102 (1997Gr09).
(2039 3)	2173.95	0.29 6	8.0 [‡] 1	Iβ=0.24 (1997Gr09).
(2046 3)	2166.72	0.036 10	8.9 [‡] 1	Iβ=0.032 (1997Gr09).
(2054 3)	2158.87	0.047 12	8.8 [‡] 1	Iβ=0.058 (1997Gr09).
(2056 3)	2157.00	0.021 10	9.2 [‡] 2	Iβ=0.017 (1997Gr09).
(2102 3)	2110.85	0.77 16	7.7 [‡] 1	Iβ=0.62 (1997Gr09).
(2113 3)	2100.08	0.048 13	8.9 [‡] 1	Iβ=0.041 (1997Gr09).
(2123 3)	2089.89	0.105 24	8.6 [‡] 1	Iβ=0.094 (1997Gr09).
(2134 3)	2079.06	0.058 13	8.8 [‡] 1	Iβ=0.051 (1997Gr09).
(2175 3)	2037.97	0.19 4	8.3 [‡] 1	Iβ=0.162 (1997Gr09).
(2192 3)	2020.89	0.16 6	8.4 [‡] 2	Iβ=0.153 (1997Gr09).
(2215 3)	1998.25	0.110 23	8.6 [‡] 1	Iβ=0.111 (1997Gr09).
(2264 3)	1949.13	0.23 5	8.3 [‡] 1	Iβ=0.21 (1997Gr09).
(2280 3)	1933.48	0.25 6	8.3 [‡] 1	Iβ=0.170 (1997Gr09).
(2325 3)	1887.54	0.27 6	8.3 [‡] 1	Iβ=0.20 (1997Gr09).
(2336 3)	1877.38	0.36 8	8.2 [‡] 1	Iβ=0.30 (1997Gr09).
(2362 3)	1851.03	0.13 3	8.6 [‡] 1	Iβ=0.170 (1997Gr09).
(2395# 3)	1817.78	<0.024	>9.4 [‡]	Iβ=0.060 (1997Gr09).
(2465 3)	1748.29	0.026 9	10.6 ^{1u} 2	Iβ=0.026 (1997Gr09).
(2514 3)	1698.69	0.107 24	8.8 [‡] 1	Iβ=0.094 (1997Gr09).
(2532 3)	1680.78	0.37 8	8.3 [‡] 1	Iβ=0.21 (1997Gr09).
Eβ ⁻ : 1981De25 obtained Eβ ⁻ =2790 500 in βγ-coin.				
(2592 3)	1620.73	0.40 9	8.3 [‡] 1	Iβ=0.34 (1997Gr09).
(2674# 3)	1538.97	0.031 7	9.5 [‡] 1	Iβ=0.21 (1997Gr09).
(2792 3)	1420.67	0.36 9	8.5 [‡] 1	Iβ=0.21 (1997Gr09).
(2905 3)	1308.21	0.22 5	8.8 [‡] 1	Iβ=0.12 (1997Gr09).

Continued on next page (footnotes at end of table)

¹³⁹Cs β⁻ Decay (9.27 min) 1980Le03,1997Gr09 (continued)

β⁻ radiations (continued)

Eβ ⁻	E(level)	Iβ ^{-†§}	Log ft	Comments
(2930 3)	1283.32	6.2 13	7.4 [‡] 1	Iβ=5.2 (1997Gr09). Eβ ⁻ : 1981De25 obtained Eβ ⁻ =2888 40 in βγ-coin.
(3131# 3)	1082.04	<0.04	>9.7 [‡]	Iβ=0.0 (1997Gr09).
(3586# 3)	627.319	<0.02	>11.7 ^{1u}	Iβ=0.0 (1997Gr09). Eβ ⁻ : 1981De25 obtained Eβ ⁻ =3600 150 in βγ-coin.
(4213 3)	0.0	84.5 31	6.88 [‡] 2	Iβ ⁻ : other: 85.0 34 (1992Gr21,1997Gr09) and 80 5 from statistical analysis of β spectra using the relative Iβ of 1980Le03 (1986HeZY). Eβ ⁻ : 4213 5 from 1981De25 (β's, βγ-coin; mag spect, Ge).

[†] Deduced from γ-intensity balances. The values from TAGS measurement (1997Gr09) are given under comments.

[‡] log f^t_u>8.5.

[§] Absolute intensity per 100 decays.

[#] Existence of this branch is questionable.

γ(¹³⁹Ba)

Iγ normalization: weighted average of 0.068 16 from ΣIγ(to g.s.)=15.0 34 (Iβ⁻(g.s.)=85.0% 34 from 1992Gr21) and 0.083 32 from Iγ(1283.3γ) relative to Iγ(165.8γ; ¹³⁹Ba) (corrected for time dependence of ¹³⁹Cs-¹³⁹Ba activity ratio) and Iγ(165.8γ; ¹³⁹Ba)=23.76% 25 (1980Ge04). Iγ(1283.3γ)/Iγ(165.8γ; ¹³⁹Ba) derived by evaluators from Iγ normalization=0.0077 30 (1980Le03) and Iγ(165.8γ; ¹³⁹Ba)=22% 1 (1976GlZV).

Eγ [†]	E(level)	Iγ ^{†&}	Mult.	α
188.88 20	1887.54	0.11 2		
196.51 18	1877.38	0.12 2		
230.76 9	1538.97	0.43 4		
233.45 22	2110.85	0.13 3		
249.89 18	2349.81	0.14 3		
260.6 4	1680.78	0.10 3	[M1,E2]	0.0707 12
267.6 3	3701.95	0.13 4		
312.31 21	1620.73	0.11 2		
339.4 4	2157.00	0.08 3		
357.01 16	2037.97	0.19 3		
375.91 ^{‡b} 7	2605.74	0.54 4		
396.9 3	1817.78	0.22 6		
401.08 22	2218.93	0.14 3		
^x 404.61 25		0.11 3		
416.49 22	2349.81	0.17 4		
419.3 3	2100.08	0.13 4		
430.20 16	2110.85	0.50 4		
434.23 20	2524.30	0.19 4		
448.76 12	2605.74	0.42 5		
454.66 6	1082.04	1.82 11	[M1,E2]	0.0148 20
466.70 12	1887.54	0.28 3		
505.4 3	2605.74	0.13 4		
515.86 7	2605.74	0.72 6		
528.20 10	2461.67	0.50 17		
531.98 4	2349.81	2.97 16		
538.35 24	2218.93	0.18 4		
542.71 15	1851.03	0.32 4		
558.1 3	2375.80	0.12 4		
567.72 ^a 5	1851.03	1.37 ^a 11		
	2605.74	0.50 ^a 11		
594.02 5	1877.38	0.98 6		
598.17 18	2218.93	0.16 3		
601.48 5	2349.81	0.89 5		
604.22 6	1887.54	0.59 4		
613.4 3	2994.43	0.21 6		
616.91 21	2037.97	0.33 6		
^x 619.7 [§] 3		0.22 6		
627.24 3	627.319	21.4 11		
651.08 7	2349.81	0.64 5		
656.58 13	2605.74	0.43 5		

Continued on next page (footnotes at end of table)

^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued) $\gamma(^{139}\text{Ba})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger\&$	$E\gamma^\dagger$	E(level)	$I\gamma^\dagger\&$
666.07 11	1748.29	0.40 4	1573.84 15	2994.43	0.35 4
668.97 8	2349.81	0.58 5	1591.73 11	2218.93	0.73 6
672.21 15	2605.74	0.27 4	1600.7 5	3950.84	0.27 10
690.04 9	1998.25	0.30 3	1620.74 6	1620.73	5.8 3
714.90 6	1998.25	0.99 6	1677.44 10	2304.88	1.24 9
728.38 9	2605.74	0.56 5	1680.72 6	1680.78	8.4 4
735.68 9	1817.78	0.89 7	1689.04 25	2997.31	0.27 5
737.60 12	2020.89	0.60 6	1698.66 7	1698.69	2.46 14
770.56 19	2079.06	0.23 4	1711.09 11	2994.43	1.09 8
$\times$ 773.5 3		0.13 4	1713.6 4	2997.31	0.22 6
788.3 4	2605.74	0.12 4	1722.55 9	2349.81	1.04 7
793.28 7	1420.67	1.05 7	1737.9 3	3418.79	0.42 4
798.01 14	2218.93	0.36 5	1748.6 3	1748.29	0.21 4
806.32 21	2089.89	0.17 3	1768.19 21	3701.95	0.19 3
827.52 7	2110.85	1.52 10	1793.63 17	3950.84	0.30 4
832.2 3	2649.38	0.17 6	1814.6 4	3701.95	0.17 5
849.7 3	2847.75	0.14 4	1818.5 3	3839.73	0.21 5
858.4 3	2166.72	0.16 4	1850.7 4	1851.03	0.14 4
883.5 3	2166.72	0.18 5	1877.45 7	1877.38	4.73 25
890.54 8	2173.95	1.02 7	1887.57 7	1887.54	3.05 17
924.96 8	2605.74	0.92 7	1904.50 7	2531.83	1.71 10
929.18 6	2349.81	3.20 17	1933.48 7	1933.48	3.39 18
933.0 3	3464.40	0.18 5	1949.26 14	1949.13	0.46 5
946.46 8	2229.79	1.37 10	1998.46 15	1998.25	0.40 4
955.19 19	2375.80	0.40 6	2003.4 3	3701.95	0.20 4
966.6 3	2249.85	0.24 6	2020.76 25	2020.89	1.8 6
973.0 4	3434.45	0.18 6	2022.1 5	2649.38	0.9 6
1040.93 22	2461.67	0.44 4	2038.10 11	2037.97	0.59 5
1059.9 3	3665.66	0.21 7	2079.33 19	2079.06	0.58 7
1063.7 4	2997.31	0.14 7	2089.91 9	2089.89	1.89 12
$\times$ 1067.06# 19		0.33 6	2100.13 17	2100.08	0.65 8
1076.94 17	2158.87	0.36 7	2110.91 9	2110.85	9.1 5
1092.23 12	2375.80	0.58 3	2156.94 13	2157.00	0.57 6
1108.93 18	2529.69	0.56 8	2166.7 4	2166.72	0.17 5
1110.9 4	2531.83	0.37 7	2173.98 7	2173.95	2.78 15
1120.89 10	1748.29	0.65 6	2218.91 23	2218.93	0.29 4
1159.30 17	3464.40	0.37 5	2229.9 3	2229.79	0.19 4
1178.35 9	2461.67	0.93 8	2249.7 4	2249.85	0.16 4
1185.21 17	2605.74	0.41 6	$\times$ 2269.5 3		0.20 4
1190.42 6	1817.78	2.56 15	2304.97 16	2304.88	0.42 5
1216.14 19	2524.30	0.29 5	2330.2 6	3950.84	0.14 6
1240.93 25	2524.30	0.21 4	$\times$ 2339.4 5		0.39 9
1249.41 22	3270.28	0.21 4	2349.92 6	2349.81	7.7 4
1283.23 5	1283.32	100 5	2352.6 6	3434.45	0.31 11
1306.09 11	1933.48	1.47 13	2375.95 11	2375.80	0.96 8
1308.13 6	1308.21	5.2 3	2380.66 7	2380.70	2.60 15
1316.4 4	2997.31	0.18 5	2418.9 4	3701.95	0.17 4
1321.77 6	1949.13	3.25 18	$\times$ 2422.16 18		0.40 5
1344.4 4	3434.45	0.17 5	2524.47 22	2524.30	0.39 6
1353.92 19	3464.40	0.30 5	2529.9 3	2529.69	1.1 3
$\times$ 1386.85 24		0.26 5	2531.84 7	2531.83	5.8 4
1393.2 3	2020.89	0.21 5	2605.75 6	2605.74	3.38 19
1410.58 7	2037.97	2.09 12	2649.32 7	2649.38	2.32 13
1420.66 6	1420.67	11.0 6	$\times$ 2673.98 18		0.48 6
1462.43 19	2089.89	0.50 8	2774.04 13	3401.39	0.41 4
1472.6 5	2100.08	0.16 7	2836.88 16	3464.40	0.38 4
1500.5 3	3674.62	0.20 5	2847.63 8	2847.75	1.38 8
1529.3 3	2157.00	0.36 8	$\times$ 2978.99 24		0.18 2
1531.2 3	2158.87	0.30 8	2997.32 9	2997.31	1.19 8
$\times$ 1539.09@ 14		0.40 4	3047.29 16	3674.62	0.41 4
1546.63 13	2173.95	0.42 5	3096.4 4	3724.19	0.12 3
1563.9 4	3674.62	0.14 4	$\times$ 3171.57 23		0.25 3
1564.63 13	2847.75	0.42 5	3270.2 3	3270.28	0.14 2

Continued on next page (footnotes at end of table)

^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued) $\gamma(^{139}\text{Ba})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger\&$	$E\gamma^\dagger$	E(level)	$I\gamma^\dagger\&$
3323.66 15	3950.84	0.69 7	3769.16 11	3769.21	0.62 4
^x 3364.23 11		1.10 8	3819.99 24	3820.05	0.15 2
3418.77 15	3418.79	0.55 5	3839.78 17	3839.73	0.25 2
3464.34 9	3464.40	1.51 9	3853.87 16	3853.93	0.27 2
^x 3645.70 13		0.38 3	3887.8 3	3887.9	0.11 2
3665.61 8	3665.66	1.89 11	3912.21 21	3912.27	0.17 2
3724.20 15	3724.19	0.36 3			

[†] From 1980Le03, except as noted.

[‡] 1981Pe04 suggested placement from a second 2606 level.

[§] 1981Pe04 removed this γ from its position in the decay scheme of 1980Le03 (2159, $\leq 7/2^-$, to 1539, 11/2+,13/2+) since such a transition would have M2,E3 multipolarity.

[#] Removed from its position in the decay scheme of 1980Le03 (2606, 3/2-,5/2,7/2- to 1539, 11/2+,13/2+) since such a transition would have M2,E3 multipolarity or higher. 1981Pe04 suggested that this γ deexcites a second 2606 level.

[@] 1981Pe04 removed this γ from its position in the decay scheme of 1980Le03 (1539, 11/2+,13/2+ to g.s., 7/2-) since such a transition would have M2,E3 multipolarity.

[&] For absolute intensity per 100 decays, multiply by 0.071 14.

^a Multiply placed; intensity suitably divided.

^b Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued)

Decay Scheme

Intensities: I(γ +ce) per 100 parent decays
@ Multiply placed; intensity suitably divided

^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued)

Decay Scheme (continued)

Intensities: I(γ +ce) per 100 parent decays
@ Multiply placed; intensity suitably divided

$^{139}_{55}\text{Cs}_{84}$ 9.27 min
7/2+ 0.0
% β^- =100
 Q^- =4213³

¹³⁹Cs β⁻ Decay (9.27 min) 1980Le03,1997Gr09 (continued)

Decay Scheme (continued)

7/2⁺ 0.0 9.27 min
¹³⁹Cs₈₄
 %β⁻=100
 Q⁻=4213³

Intensities: I(γ+ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided

^{139}Cs β^- Decay (9.27 min) 1980Le03,1997Gr09 (continued)

Decay Scheme (continued)

Intensities: I(γ +ce) per 100 parent decays
 @ Multiply placed; intensity suitably divided

$^{139}_{56}\text{Cs}_{84}$ 9.27 min
 $Q^- = 4213^3$
 $\% \beta^- = 100$

^{252}Cf SF Decay 2001Lu16

Parent ^{252}Cf : $E=0.0$; $J\pi=0+$; $T_{1/2}=2.645$ y 8; %SF decay= 4.3×10^{-3} 28.

$^{252}\text{Cf}-T_{1/2}$: From ^{252}Cf Adopted Levels in the ENSDF database (March 2005 update).

^{252}Cf -%SF decay: From 0.0014 9 per fission (nudat 2.6) and %SF=3.092 8 (^{252}Cf Adopted Levels in the ENSDF database, March 2005 update).

2001Lu16 (also 2003Ha49,2002Ha46): measured $E\gamma$, $I\gamma$ and $\gamma\gamma$ using GAMMASPHERE array comprised of 100 escape-suppressed Ge detectors. Coincidence resolving time ≈ 1 μs . Comparisons made with the known structure of ^{135}Te isotone.

 ^{139}Ba Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\ddagger$
0.0 #	7/2-	2479.376 22		3890.96 § 5	(25/2-)
1307.884 # 17	11/2-	2681.23 4		4046.92 8	
1538.75 3	13/2+	3088.59 6		4616.29 § 6	(29/2-)
1828.143 # 20	(15/2-)	3122.78 § 3	(21/2-)	4956.67 § 6	(31/2-)
1976.586 # 20	(17/2-)	3344.30 6			
2091.723 # 21	(19/2-)	3381.94 4			

† From $E\gamma$ s, assigning $\Delta(E\gamma)=0.1$ keV systematic error for each γ ray (as proposed by 2001Lu16).

‡ As proposed in 2001Lu16 based on band structures.

§ (A): γ sequence based on (21/2-).

(B): γ sequence based on 7/2-, g.s.

 $\gamma(^{139}\text{Ba})$

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma$	Mult. ‡	α	$I(\gamma+\text{ce})$
115.137 6	2091.723	10.9 §	[M1]	0.662	18.1
148.443 5	1976.586	29.1 §	[M1]	0.325	38.6
230.87 3	1538.75	7.2			
255.710 21	3344.30	0.8			
289.39 4	1828.143	0.6			
340.378 24	4956.67	1.1			
387.653 5	2479.376	1.7			
520.258 9	1828.143	60.9 §	[E2]	0.0088	61.4
589.51 3	2681.23	1.5			
702.61 #	4046.92				
725.33 3	4616.29	1.9			
768.18 3	3890.96	2.4			
902.56 3	3381.94	0.9			
958.33 6	4046.92	0.9			
996.86 5	3088.59	7.3			
1031.049 21	3122.78	5.9			
1307.877 17	1307.884	100 §	[E2]	0.00106	100

† Uncertainty is statistical. 2001Lu16 propose 0.1 keV systematic uncertainty for each γ ray.

‡ Expected to be dipoles and quadrupoles (E2) since the coincidence resolving time is approximately 1 μs . An E3 transition from a possible 25/2+ to 19/2- level was looked for but not found as is the case in ^{135}Te isotone.

§ Intensity quoted by 2001Lu16 is corrected for internal conversion for assumed multipolarity as specified.

Placement of transition in the level scheme is uncertain.

¹³⁶Xe($\alpha, n\gamma$) 1987Pr06

E=20, 22 MeV. Measured excitation functions (E α =20-27 MeV), E γ , I γ , $\gamma\gamma$ -coin, $\gamma(\theta=25^\circ-155^\circ, 9 \text{ angles})$, and $\gamma(t)$.

¹³⁹Ba Levels

E(level)	J $\pi^\dagger$	T _{1/2}	Comments
0.0	7/2-		
627.2 3	3/2-		
1283.2 3	(9/2-)		
1308.1 3	11/2-		
1538.9 5	13/2+		
1828.7 $\frac{1}{2}$ 5	(15/2-)		J π : stretched Q γ to 1308, 11/2- level.
1850.9 5	(11/2-)		
1977.1 $\frac{1}{2}$ 6	(17/2)	0.40 ns 25	J π : stretched D γ to (15/2-). T _{1/2} : from $\gamma(t)$.
2091.6 $\frac{1}{2}$ 6			
2743.4? $\frac{1}{2}$ 6			

† As proposed in 1987Pr06 based on $\gamma(\theta)$ data for some of the transitions, and earlier assignments for low-lying states.
Predictions of particle-core coupling model are also used.

$\frac{1}{2}$ Established on the basis of $\gamma\gamma$ -coin spectra with gates on 1308.1 γ and 230.8 γ .

 $\gamma(^{139}\text{Ba})$

Assigned to ¹³⁹Ba on the basis of $\gamma\gamma$ -coin.

E $\gamma^\dagger$	E(level)	I $\gamma^\ddagger$	Mult. §	Comments
114.5# 3	2091.6	3# 2		
148.4 3	1977.1	21 2	D	A ₂ =-0.26 8; A ₄ =+0.10 12.
230.8 3	1538.9	23 2	(D)	A ₂ =-0.18 13; A ₄ =+0.04 23.
520.6 3	1828.7	72 13	Q	A ₂ =+0.77 30; A ₄ =-0.61 40.
567.7 3	1850.9	31 6		
627.2 3	627.2	51 8		
1204.5 3	2743.4?	54 26		
1283.2 3	1283.2	33 16		
1308.1 3	1308.1	325 30	(Q)	A ₂ =+0.45 7; A ₄ =-0.05 11.

† Upper limit on ΔE given.

$\ddagger$ At E α =20 MeV and $\theta=90^\circ$, unless otherwise stated.

§ From $\gamma(\theta)$ data.

Deduced from 520.6 γ -gated coin spectrum. Intensity at E(α)=22 MeV.

$^{138}\text{Ba}(\text{n},\gamma)$ E=thermal 1991Bo47,1990Is07,1969Mo13

1991Bo47 measured γ 's, $\gamma\gamma$ -coincidences; HPGe's.

1990Is07 measured γ 's; pair spectrometer (HPGe, NaI(Tl)). Natural target. See 1990Is07 for many unplaced transitions observed.

1969Mo13 measured γ 's and $\gamma\gamma$ -coincidences (Ge(Li),NaI).

2007ChZX: measured $E\gamma$ and elemental cross sections for natural targets using Budapest reactor facility. Consult also EGAF database at IAEA-NDS webpage and/or LBNL (isotopes project) websites. A total of nine secondary and five primary gamma rays are reported in the measurements at Budapest. Except for the intensity of 1047.7 γ , all other $E\gamma$ and $I\gamma$ data are in reasonable agreement with those from 1991Bo47.

Other: 1969IrZZ.

All data are from 1991Bo47, except as noted. Comparisons made with data in 2007ChZX.

 ^{139}Ba Levels

E(level)	$J\pi^\dagger$	Comments
0.0	$7/2^-$	
627.30 7	$3/2^-$	
1081.96 7	$(1/2^-)$	
1420.66 10	$(5/2^-)$	
1679.9 4	$(7/2^-)$	
1698.61 20	$(5/2^-)$	
1748.14 23	$3/2^-$	
1895.45 8	$1/2, 3/2, 5/2^+$	
1946.02 18	$(3/2^-, 5/2^+)$	
1951.54 15		
2129.17 7	$3/2^-$	
2155.4 4	$3/2^-, 5/2^+$	
2158.82 8	$3/2^-, 5/2^+$	
2185.55 9	$1/2^-, 3/2^-$	
2435.25 11	$1/2^-, 3/2^-$	
2480.74 7	$(3/2^-)$	
2485.56 25	$1/2, 3/2, 5/2^+$	
2549.71 17	$(3/2^-)$	
2569.86 13	$(3/2^-)$	
3024.8 2	$(1/2^-, 3/2^-)$	
3168.17 21	$(1/2^-, 3/2^-)$	
3259.1 3	$1/2, 3/2, 5/2^+$	
3385.07 21	$(1/2^-, 3/2^-)$	
(4723.48 7)	$1/2^+$	$J\pi$: s-wave capture in 0^+ g.s. of ^{138}Ba . $E(\text{level})$: S(n)=4723.43 4 (2012Wa38).

† From Adopted Levels.

¹³⁸Ba(n,γ) E=thermal 1991Bo47,1990Is07,1969Mo13 (continued)

γ(¹³⁹Ba)

The γγ coincidences are primarily taken from 1991Bo47 with some additions from 1969Mo13.

Iγ normalization: From ΣIγ(to g.s.)=100 (1991Bo47).

Eγ	E(level)	Iγ ^j	Comments
295† [‡] k 5	2480.74	<1.0	
352† [‡] k 5	2480.74	<1.0	
454.67† 10	1081.96	29.0 ^g 14	Eγ=454.78 5, σ=0.0858 22 (2007ChZX).
627.26† 10	627.30	100 5	Eγ=627.30 5, σ=0.293 6 (2007ChZX).
666.2 [§] h 7	1748.14	1.44 7	Eγ=665.98 7, σ=0.0053 3 (2007ChZX), but placed from a 1293.3 level, not known from any other study.
^x 686.7 5		0.22 2	
687.6 5	2435.25	0.16 2	
708.4 1	2129.17	1.29 [#] 12	
^x 731.9 5		0.15 2	
738.4 2	2158.82	0.54 3	
^x 744.7 2		0.23 2	
^x 749.5 2		0.45 3	
^x 755.4 3		0.09 1	
^x 758.7@ 2		0.12 1	
^x 765.7@ 2		0.11 1	
793.4 3	1420.66	0.26 2	
^x 822.6 4		0.13 1	
^x 866.9&			
^x 890.2 3		0.16 1	
^x 1036.5 3			
^x 1037.9&			
1047.3 1	2129.17	2.23 11	Eγ=1047.74 5, σ=0.0319 10 (2007ChZX). Note that relative intensity deduced from 2007ChZX is about a factor of 5 higher than that from 1991Bo47.
^x 1054.4 3			
1060.1 3	2480.74		
1077.1 2	2158.82	0.96 6	
^x 1082.7 3		0.22 2	
^x 1090.0 3		0.28 3	
1103.2 2	2185.55	1.68 11	Eγ=1103.43 10, σ=0.0043 4 (2007ChZX).
1120.8 9	1748.14	2.28 12	
1129.3 3	2549.71	0.08 2	
^x 1131.5 3		0.16 2	
1150.1 8	2569.86	0.06 2	
^x 1152.2 4		0.42 4	
^x 1186.8 2		0.67 4	
^x 1204.9 3		0.69 4	
^x 1215.8 4		0.14 2	
^x 1220.4 3		0.24 2	
^x 1236.1 3		0.49 5	
^x 1237.1 4		0.38 4	
^x 1250.6 3		0.49 6	
^x 1254.3 4		0.24 4	
1268.2 2	1895.45	1.81 18	
^x 1299.2 3		0.41 4	
1318.5 2	1946.02	0.55 6	
^x 1321.7 4		0.32 3	
^x 1328.3 4		0.41 4	
1338.4 2	(4723.48)	0.55 6	
1353.1 2	2435.25	1.43 14	
^x 1365.1 4		0.13 2	
^x 1378.8 3		0.44 6	
1403.4 4	2485.56	0.35 8	
^x 1406.2 3		1.13 15	
^x 1418.4 3		0.61 6	
1420.57 ^h 25	1420.66	2.71 18	Eγ=1420.41 7, σ=0.0089 5 (2007ChZX).
^x 1459.2 8		0.23 3	
1464.3 3	(4723.48)	0.39 6	
(1468)	2549.71		
^x 1470.8 6		0.44 5	
^x 1484.5 7		0.22 3	

Continued on next page (footnotes at end of table)

¹³⁸Ba(n,γ) E=thermal 1991Bo47,1990Is07,1969Mo13 (continued)

γ(¹³⁹Ba) (continued)

E _γ	E(level)	I _γ ^j	Comments
1488.8 9	2569.86	0.21 3	
1501.81 ⁱ 19	2129.17	1.92 ^d 20	
^x 1505.6@			
^x 1515.5 3		0.44 4	
1531.4 3	2158.82	0.73 8	
^x 1542.2 5		0.18 2	
1555.3 2	(4723.48)	0.56 6	
1558.3 2	2185.55	1.96 20	E _γ =1558.11 9, σ=0.0078 5 (2007ChZX).
^x 1562.0@			
^x 1569.2 5		0.24 6	
^x 1572.3 ^f 3		0.64 6	
^x 1618.6 3		0.37 4	
1679.9 4	1679.9	0.44 [#] 16	
1698.6 ^l 2	1698.61	1.28 ^l 16	
	(4723.48)	1.28 ^l 16	
^x 1720.1 3		0.60 9	
^x 1732.2 3		0.38 8	
1748.3 3	1748.14	0.61 6	
^x 1785.7 5		0.24 3	
^x 1807.1 3		0.38 7	
^x 1817.6 ^a			
^x 1841.9 4		0.20 2	
1853.31 ^b 9	2480.74	2.20 ^d 14	E _γ =1853.21 13, σ=0.0074 6 (2007ChZX).
1921.8 4	2549.71	0.39 4	
1946.9 4	1946.02	0.79 18	
1951.53 ^b 15	1951.54	1.3 ^b 4	E _γ =1951.7 5, σ=0.0016 5 (2007ChZX).
^x 2033.8 6		0.21 8	
^x 2038.4 4		0.43 10	
^x 2074.9 4		0.23 4	
^x 2081.4@ 4		0.38 4	
^x 2099.5 4		0.22 3	
^x 2109.0 7		0.44 6	
^x 2126.3 4		0.39 4	
2129.2 1	2129.17	1.28 14	
^x 2135.9@			
^x 2140.2 7		0.19 2	
2152.5 4	(4723.48)	0.61 5	
2155.4 4	2155.4	0.50 4	
2173.96 ^b e 23	(4723.48)	0.56 6	
2176.1	3259.1		
2237.8 3	(4723.48)	0.98 21	
2242.67 ^b 6	(4723.48)	3.81 ^c 20	E _γ =2242.50 15, σ=0.0103 13 (2007ChZX).
^x 2278.7ab ^f 5			
2288.19 9	(4723.48)	2.4 ^g 3	
2480.68 ^b 12	2480.74	0.66 ^g 12	
^x 2515.5 10		0.46 7	
^x 2522.5 [†] k 15		8.5 15	
^x 2532.3 3		0.55 5	
2537.88 ^b 6	(4723.48)	3.68 ^d 21	E _γ =2537.64 13, σ=0.0103 7 (2007ChZX).
2550.8 5	2549.71	0.35 8	
2564.66 ⁱ 5	(4723.48)	1.9 ^g 3	
2569.68 ^f i 13	2569.86	0.33 3	
2594.29 ^b 4	(4723.48)	6.35 ^d 26	E _γ =2594.00 10, σ=0.0185 8 (2007ChZX).
2632.5	3259.1		
2777.5 7	(4723.48)	0.43 13	
^x 2800.6 5		0.31 8	
2828.00 ^b f 4	(4723.48)	1.62 13	
^x 2833.7 4		0.51 15	
^x 2874.4 5		0.36 10	
^x 2883.4@			
2975.3 9	(4723.48)	3.01 5	
^x 3432.4 ^b e 3		0.54 ^b 12	
3641.47 ^b 5	(4723.48)	20.7 ^g 19	E _γ =3641.22 13, σ=0.0560 16 (2007ChZX).

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¹³⁸Ba(n,γ) E=thermal 1991Bo47,1990Is07,1969Mo13 (continued)

γ(¹³⁹Ba) (continued)

Eγ	E(level)	I _γ ^j	Comments
^x 3685.5 ^{&}			
^x 3856.5 ^{&}			
4096.14 ^{b 4}	(4723.48)	56.0 28	Eγ=4095.77 15, σ=0.154 4 (2007ChZX).
[†] From 1969Mo13. [‡] Observed only in γγ-coincidences by 1969Mo13. [§] Placed as deexciting the 1293 state by 1969Mo13. [#] Background subtracted (1991Bo47). [@] γγ-cascade summing to 3641.5 keV (1991Bo47). ^{&} γγ-cascade summing to 4723.4 keV (1991Bo47). ^a γγ-cascade summing to 4096.1 keV (1991Bo47). ^b From 1990Is07. I _γ converted from absolute to relative using I _γ normalization and 10% uncertainty from Δσ(n,γ) added in quadrature by the evaluators. ^c Weighted av of 3.85 40 (1991Bo47) and 3.80 22 (1990Is07). ^d I _γ (1502γ)=4.0 13/100 n captures (1990Is07) and <10 (1969Mo13), I _γ (1854γ)=3.2 13/100 n captures (1990Is07), I _γ (2538γ)=4.6 3/100 n captures (1990Is07), and I _γ (2594γ)=6.8 2/100 n captures (1990Is07). ^e In 1990Is07, a 3432γ is placed from the capture state to a level at 1291 keV, and the 2147γ as a ground-state transition. Here 3432γ is unplaced and 2147γ placed from the capture state. ^f Not assigned to a specific Ba isotope by 1990Is07. ^g Unweighted averages of values given in 1990Is07 (first value) and 1969Mo13 (second value) taken in the following cases. The I _γ values from 1990Is07 converted from absolute to relative using I _γ normalization and 10% uncertainty from Δσ(n,γ) added in quadrature by the evaluators: 455γ: 29.0 14 and 27.0 20. 2288γ: 2.05 25 and 2.71 22. 2481γ: 0.79 13 and 0.54 12. 2565γ: 1.60 15 and 2.28 11. 3641γ: 18.8 12 and 22.6 23. ^h Weighted averages taken in the following cases: 666γ: 666.1 8 (1991Bo47) and 666.5 15 (1969Mo13). 1420γ: 1420.8 2 (1991Bo47), 1420.01 33 (1990Is07) and 1420.1 10 (1969Mo13). ⁱ Unweighted averages taken in the following cases: 1502γ: 1502.0 2 (1991Bo47) and 1501.62 16 (1990Is07). 2288γ: 2288.1 1 (1991Bo47) and 2288.26 6 (1990Is07). 2565γ: 2564.7 1 (1991Bo47) and 2564.61 8 (1990Is07). 2570γ: 2569.8 3 (1991Bo47) and 2569.55 23 (1990Is07). ^j Absolute intensity per 100 neutron captures. ^k Placement of transition in the level scheme is uncertain. ^l Multiply placed; undivided intensity given. ^x γ ray not placed in level scheme.			

¹³⁸Ba(n,γ)(n,n): Resonances 2006MuZX

1997Be37: ¹³⁹Ba(n,γ) E<200 keV. Measured σ_γ and deduced resonance parameters (TOF).

Other: 1988Mil9.

All data are from evaluation by 2006MuZX.

¹³⁹Ba Levels

E(level) [†]	Jπ	L	gΓ _n Γ _γ /Γ (meV)	Comments
4723.25?	1/2+	0		E(level): fictitious level.
4724.07	1/2-, 3/2-	1	4.91 14	E(n)(lab)=-0.1775 keV, Γ _γ =(55) meV.
4725.36	[3/2]-	1	37 1	E(n)(lab)=0.648 keV, gΓ _n =0.0050 eV 2.
4725.42	1/2-, 3/2-	1	0.8 1	E(n)(lab)=1.948 keV, gΓ _n =0.101 eV 8, Γ _γ =29 meV 10.
4728.10	[1/2]-	1	31 1	E(n)(lab)=2 keV.
4731.25	1/2+	0	66 2	E(n)(lab)=4.704 keV, gΓ _n =0.81 eV 6, Γ _γ =32 meV 3.
4733.28	[1/2]-	1	35 2	E(n)(lab)=7.876 keV, gΓ _n =6.172 eV 53, Γ _γ =67 meV 5.
4737.34	[3/2]-	1	59 3	E(n)(lab)=9.918 keV, gΓ _n =0.36 eV 4, Γ _γ =39 meV 2.
4742.94			45 2	E(n)(lab)=14.01 keV, gΓ _n =0.57 eV 6, Γ _γ =33 meV 2.
4743.15			62 3	E(n)(lab)=19.65 keV.
4746.65			73 3	E(n)(lab)=19.86 keV.
4746.80			13 2	E(n)(lab)=23.39 keV.
4747.44	[3/2]-	1	48 6	E(n)(lab)=23.54 keV.
4749.41			39 3	E(n)(lab)=24.19 keV, gΓ _n =6.71 eV 34, Γ _γ =24 meV 3.
4752.41			60 4	E(n)(lab)=26.17 keV.
4753.02			7 2	E(n)(lab)=29.19 keV.
4753.99	1/2+	0	54 20	E(n)(lab)=29.81 keV.
4754.41	[1/2]-	1	25 3	E(n)(lab)=30.78 keV, gΓ _n =207.2 eV 21, Γ _γ =54 meV 20.
4755.77			4 1	E(n)(lab)=31.21 keV, gΓ _n =3.55 eV 54, Γ _γ =25 meV 3.
4757.67			3 1	E(n)(lab)=32.58 keV.
4763.32	3/2-	1	69 24	E(n)(lab)=34.49 keV.
4766.01			33 4	E(n)(lab)=40.18 keV, gΓ _n =89.6 eV 34, Γ _γ =35 meV 12.
4766.85			32 40	E(n)(lab)=42.89 keV.
4770.51			9 3	E(n)(lab)=43.74 keV.
4770.61			64 6	E(n)(lab)=47.42 keV.
4771.74			34 4	E(n)(lab)=47.53 keV.
4772.56	[3/2]-	1	59 6	E(n)(lab)=48.66 keV.
4773.40	1/2+	0	28 14	E(n)(lab)=49.49 keV, gΓ _n =6.1 eV 13, Γ _γ =30 meV 3.
4773.41			73 10	E(n)(lab)=50.34 keV, gΓ _n =270 eV 4, Γ _γ =28 meV 14.
4776.29	[3/2]-	1	47 5	E(n)(lab)=50.35 keV.
4777.97			20 5	E(n)(lab)=53.25 keV, gΓ _n =12 eV 2.
4778.22	[1/2]-	1	21 5	E(n)(lab)=54.94 keV.
4781.92			218 15	E(n)(lab)=55.19 keV, gΓ _n =42.8 eV 32, Γ _γ =21 meV 5.
4782.34	1/2+	0	53 18	E(n)(lab)=58.92 keV.
4783.66	[3/2]-	1	59 7	E(n)(lab)=59.34 keV, gΓ _n =73.2 eV 36, Γ _γ =53 meV 18.
4784.38			82 8	E(n)(lab)=60.67 keV, gΓ _n =11.0 eV 21, Γ _γ =30 meV 4.
4785.74	3/2-	1	61 28	E(n)(lab)=61.4 keV.
4789.61			10 4	E(n)(lab)=62.77 keV, gΓ _n =114 eV 8, Γ _γ =31 meV 14.
4791.83	3/2-	1	66 8	E(n)(lab)=66.66 keV.
4791.94			120 25	E(n)(lab)=68.9 keV, gΓ _n =0.46 keV 8, Γ _γ =33 meV 4.
4792.22			16 7	E(n)(lab)=69.01 keV.
4795.42			16 6	E(n)(lab)=69.29 keV.
4795.92			62 8	E(n)(lab)=72.52 keV.
4797.12	[1/2]-	1	28 13	E(n)(lab)=73.02 keV.
4800.64			65 9	E(n)(lab)=74.23 keV, gΓ _n =0.190 keV 9, Γ _γ =28 meV 13.
4802.32	1/2+	0	97 19	E(n)(lab)=77.77 keV.
4804.30			34 16	E(n)(lab)=79.47 keV, gΓ _n =0.233 keV 7, Γ _γ =97 meV 19.
4804.51			226 19	E(n)(lab)=81.46 keV.
4806.52			68 8	E(n)(lab)=81.67 keV.
4810.18			32 7	E(n)(lab)=83.7 keV.
4811.89	[3/2]-	1	80 10	E(n)(lab)=87.38 keV.
4813.97			37 7	E(n)(lab)=89.11 keV, gΓ _n =(20) eV, Γ _γ =40 meV 5.
4814.52			234 20	E(n)(lab)=91.2 keV.
4817.95			72 9	E(n)(lab)=91.76 keV.
4819.26			106 12	E(n)(lab)=95.21 keV.
4819.52			61 9	E(n)(lab)=96.53 keV.
4820.47			49 8	E(n)(lab)=96.79 keV.
4822.11			38 8	E(n)(lab)=97.75 keV.
				E(n)(lab)=99.4 keV.

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¹³⁸Ba(n,γ),(n,n): Resonances 2006MuZX (continued)

¹³⁹Ba Levels (continued)

E(level) [†]	Jπ	L	gΓ _n Γ _γ /Γ (meV)	Comments
4822.48			56 10	E(n)(lab)=99.77 keV.
4822.61			72 11	E(n)(lab)=99.91 keV.
4823.33			88 11	E(n)(lab)=100.63 keV.
4823.71			51 9	E(n)(lab)=101.01 keV.
4824.44			54 9	E(n)(lab)=101.75 keV.
4825.04			153 16	E(n)(lab)=102.35 keV.
4825.99	[1/2]-	1	20 7	E(n)(lab)=103.31 keV, gΓ _n =21 eV 7, Γ _γ =20 meV 7. gΓ _n =21.000 eV listed in 2006MuZX, evaluators assume a misprint.
4826.55			189 54	E(n)(lab)=103.87 keV.
4828.12	1/2+	0	67 19	E(n)(lab)=105.46 keV, gΓ _n =367 eV 14, Γ _γ =67 meV 19.
4829.84	[3/2]-	1	56 7	E(n)(lab)=107.19 keV, gΓ _n =33 eV 7, Γ _γ =26 meV 4.
4830.70			70 9	E(n)(lab)=108.05 keV.
4831.49			77 11	E(n)(lab)=108.85 keV.
4831.79			46 10	E(n)(lab)=109.15 keV.
4832.03			51 10	E(n)(lab)=109.39 keV.
4832.63			162 18	E(n)(lab)=110 keV.
4834.58	1/2+	0	29 7	E(n)(lab)=111.96 keV, gΓ _n =211 eV 11, Γ _γ =29 meV 7.
4835.33	[3/2]-	1	84 22	E(n)(lab)=112.72 keV, gΓ _n =24 eV 7, Γ _γ =42 meV 10.
4838.26			40 11	E(n)(lab)=115.67 keV.
4839.08	3/2-	1		E(n)(lab)=116.5 keV, gΓ _n =0.38 keV 4.
4839.23	1/2+	0	90 42	E(n)(lab)=116.65 keV, gΓ _n =383 eV 25.
4839.70			127 20	E(n)(lab)=117.12 keV.
4846.11			98 40	E(n)(lab)=123.58 keV.
4847.62			54 11	E(n)(lab)=125.1 keV.
4849.20	[1/2]-	1	35 10	E(n)(lab)=126.69 keV, gΓ _n =52 eV 8, Γ _γ =35 meV 10.
4849.53			54 12	E(n)(lab)=127.02 keV.
4849.86			80 14	E(n)(lab)=127.35 keV.
4852.14	3/2-	1	83 34	E(n)(lab)=129.65 keV, gΓ _n =0.54 keV 4, Γ _γ =42 meV 17.
4852.34			48 30	E(n)(lab)=129.85 keV.
4854.60			47 11	E(n)(lab)=132.13 keV.
4855.32			71 13	E(n)(lab)=132.85 keV.
4856.16			39 11	E(n)(lab)=133.7 keV.
4856.91			114 16	E(n)(lab)=134.46 keV.
4859.45	1/2+	0	85 15	E(n)(lab)=137.01 keV, gΓ _n =1.60 keV 5, Γ _γ =85 meV 15.
4861.31			74 14	E(n)(lab)=138.89 keV.
4861.48	[3/2]-	1	55 13	E(n)(lab)=139.06 keV, gΓ _n =134 eV 19, Γ _γ =26 meV 7.
4862.58			49 12	E(n)(lab)=140.17 keV.
4863.34			100 16	E(n)(lab)=140.93 keV.
4864.68			55 11	E(n)(lab)=142.28 keV.
4865.61			39 10	E(n)(lab)=143.22 keV.
4866.94			50 11	E(n)(lab)=144.56 keV.
4869.12			62 15	E(n)(lab)=146.76 keV.
4869.35			66 15	E(n)(lab)=146.99 keV.
4869.96			68 14	E(n)(lab)=147.6 keV.
4872.75			94 18	E(n)(lab)=150.41 keV.
4873.71	3/2-	1	151 60	E(n)(lab)=151.38 keV, gΓ _n =0.34 keV 3, Γ _γ =76 meV 30.
4874.84			110 20	E(n)(lab)=152.52 keV.
4877.18			51 16	E(n)(lab)=154.87 keV.
4879.37			78 18	E(n)(lab)=157.08 keV.
4880.70	[3/2]-	1	182 60	E(n)(lab)=158.42 keV, gΓ _n =0.45 keV 3, Γ _γ =91 meV 30.
4883.25			63 16	E(n)(lab)=160.99 keV.
4883.75			91 17	E(n)(lab)=161.49 keV.
4885.24			54 15	E(n)(lab)=162.99 keV.
4885.76			57 15	E(n)(lab)=163.52 keV.
4887.47			44 15	E(n)(lab)=165.24 keV.
4889.05			181 31	E(n)(lab)=166.83 keV.
4889.22			96 26	E(n)(lab)=167 keV.
4890.49			68 17	E(n)(lab)=168.28 keV.
4890.86	[3/2]-	1	69 17	E(n)(lab)=168.65 keV, gΓ _n =38 eV 20, Γ _γ =35 meV 9.
4891.59			137 22	E(n)(lab)=169.39 keV.
4894.15	[3/2]-	1	139 63	E(n)(lab)=171.97 keV, gΓ _n =105 eV 22, Γ _γ =70 meV 32.
4895.66	3/2-	1	259 49	E(n)(lab)=173.49 keV, gΓ _n =103 eV 19.
4897.70			77 20	E(n)(lab)=175.54 keV.

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¹³⁸Ba(n,γ),(n,n): Resonances 2006MuZX (continued)

¹³⁹Ba Levels (continued)

E(level) [†]	Jπ	L	gΓ _n Γ _γ /Γ (meV)	Comments
4898.11			68 19	E(n)(lab)=175.96 keV.
4899.08			100 22	E(n)(lab)=176.93 keV.
4901.81	[3/2]-	1	80 18	E(n)(lab)=179.68 keV, gΓ _n =90 eV 26, Γ _γ =40 meV 9.
4903.68	1/2+	0	80 18	E(n)(lab)=181.57 keV, gΓ _n =0.40 keV 4, Γ _γ =80 meV 18.
4906.18			144 24	E(n)(lab)=184.09 keV.
4907.90			41 16	E(n)(lab)=185.82 keV.
4909.62			86 21	E(n)(lab)=187.55 keV.
4910.51			176 27	E(n)(lab)=188.45 keV.
4911.68			86 20	E(n)(lab)=189.63 keV.
4912.10	[1/2]-	1	35 17	E(n)(lab)=190.05 keV, gΓ _n =89 eV 27, Γ _γ =35 meV 17.
4913.00			83 20	E(n)(lab)=190.96 keV.
4913.80			54 18	E(n)(lab)=191.76 keV.
4914.38			69 19	E(n)(lab)=192.35 keV.
4916.29			39 32	E(n)(lab)=194.27 keV.
4916.80	1/2+	0	56 31	E(n)(lab)=194.78 keV, gΓ _n =0.82 keV 4, Γ _γ =56 meV 31.
4918.35			30 23	E(n)(lab)=196.35 keV.
4919.68			44 17	E(n)(lab)=197.69 keV.
4920.53			50 19	E(n)(lab)=198.54 keV.
4920.91			89 22	E(n)(lab)=198.92 keV.
4921.78			35 16	E(n)(lab)=199.8 keV.

[†] S(n)(¹³⁹Ba)+E(n)(c.m.), where S(n)=4723.43 4 (2012Wa38), E(n)(c.m.) is deduced from listed E(n)(lab).

¹³⁸Ba(pol p,p),(pol p,p'): IAR 1989Ny02

E=9.4–12.4 MeV. All data are from the resonance analysis of 1989Ny02 of ¹³⁹La isobaric analog resonances. See ¹³⁸Ba(pol p,p),(pol p,p') IAR under ¹³⁹La for details and comparison to the data of 1977Cl02.

¹³⁹Ba Levels

E(level) [†]	Jπ	Comments
0.0	7/2-	E(level): 16182, 7/2- in ¹³⁹ La is assigned as IAR of ¹³⁹ Ba g.s.
631.0 7	3/2-	E(level): from 16812, 3/2- IAR in ¹³⁹ La.
1087.0 5	1/2-	E(level): from 17268, 1/2- IAR in ¹³⁹ La.
1305 2	9/2-	E(level): from 17486, 9/2- IAR in ¹³⁹ La.
1435.0 6	5/2-	E(level): from 17616, 5/2- IAR in ¹³⁹ La.
1575 7	13/2+	E(level): from 17756, 13/2+ IAR in ¹³⁹ La.
1641 8	9/2-	E(level): from 17823, 9/2- IAR in ¹³⁹ La.
1692 2	7/2-	E(level): from 17873, 7/2- IAR in ¹³⁹ La.
1711 1	5/2-	E(level): from 17892, 5/2- IAR in ¹³⁹ La.
1780 5	3/2-	E(level): from 17962, 3/2- IAR in ¹³⁹ La.
1842	(9/2-)	E(level): from possible 18024, (9/2-) IAR in ¹³⁹ La.
1943 6	7/2-	E(level): from 18124, 7/2- IAR in ¹³⁹ La.
1963 3	5/2-	E(level): from 18144, 5/2- IAR in ¹³⁹ La.
2115 4	7/2-	E(level): from 18297, 7/2- IAR in ¹³⁹ La.
2158 2	3/2-	E(level): from 18339, 3/2- IAR in ¹³⁹ La.
2182 2	5/2-	E(level): from 18363, 5/2- IAR in ¹³⁹ La.
2186 2	1/2-	E(level): from 18368, 1/2- IAR in ¹³⁹ La.
(2335 [‡])	(5/2-)	E(level): from 18517, (5/2-) IAR in ¹³⁹ La.
(2446 [‡])	(3/2-)	E(level): from 18630, (3/2-) IAR in ¹³⁹ La.

[†] Except for the ground and first two excited states, excitation energies derived in the analysis are generally 12 to 32 keV higher than the energies of the corresponding levels in Adopted Levels. Above 2 MeV or so, it is difficult to make unique assignments of IARs in ¹³⁹La to parent levels in ¹³⁹Ba due to high level density.

[‡] Resonances corresponding to these states were not fitted in the analysis but are necessary for a good fit to the data (1989Ny02).

¹³⁸Ba(d,p) ¹⁹⁶⁸Ra18,1973Ip01,1977St33

1967Wi08: E=12 MeV. Measured $\sigma(\theta)$ using ΔE -E Si detectors, level energies with 5 keV uncertainty.
1968Ra18: E=5-7.5 MeV. Measured $\sigma(\theta)$; FWHM=9. Magnetic spectrometer.
1970Vo04: E=12 MeV. Measured $\sigma(\theta)$; FWHM=13-15. DWBA, magnetic spectrometer.
1973Ip01: E=19 MeV. Measured $\sigma(\theta \leq 172.5^\circ, 7.5^\circ \text{ steps})$; FWHM=18. DWBA, magnetic spectrometer.
1974Bo32: E=19 MeV. Measured $\sigma(\theta \leq 172.5^\circ, 7.5^\circ \text{ steps})$; FWHM=18. DWBA. Systematic search for L=6 transitions in (d,p) reactions for N=83 nuclei.
1977St33: E=5-8.5 MeV. Measured $\sigma(\theta=50^\circ, 90^\circ, 140^\circ, 170^\circ)$; surface-barrier detectors, FWHM=15. DWBA.
1997HiZZ: (pol d,p) E=22 MeV, measured $\sigma(\theta)$, vector and tensor analyzing powers, J-dependence of T_{20} , finite range DWBA analysis.
Cross section data listed here are from 1973Ip01. Other: 1970Vo04.

¹³⁹Ba Levels

E(level) [†]	L [‡]	(2J+1)S [‡]	Comments
0.0	3@	7.04\$@	(2J+1)S: 7.60 (1973Ip01), 4.15 (1970Vo04, without cutoff), 5.60 (1970Vo04, with cutoff), 6.08 (1967Wi08), 8.0 (1968Ra18). d σ /d Ω (max)=10.8 mb/sr (15°).
630 5	1@	2.08\$@	(2J+1)S: 2.02 (1973Ip01). d σ /d Ω (max)=10.3 mb/sr (7.5°).
1081 7	1@	0.84@	d σ /d Ω (max)=4.24 mb/sr (7.5°). (2J+1)S: 0.88 (1973Ip01).
1283 7	5@	6.2@	d σ /d Ω (max)=1.09 mb/sr (30°). (2J+1)S: 5.70 (1973Ip01).
1419 7	3@	1.68@	d σ /d Ω (max)=3.24 mb/sr (15°). (2J+1)S: 1.83 (1973Ip01).
1539 10	6	7.17\$	d σ /d Ω (max)=0.90 mb/sr (37.5°).
1619 10	5	2.17	d σ /d Ω (max)=0.40 mb/sr (30°).
1680 10	3	0.81	d σ /d Ω (max)=1.54 mb/sr (7.5°).
1697 7	3@	1.02@	(2J+1)S: 1.12 (1973Ip01). d σ /d Ω (max)=2.13 mb/sr (22.5°).
1745 10	(1)	0.21#	d σ /d Ω (max)=1.00 mb/sr (7.5°).
1893 10			
1930 10	3	0.35	d σ /d Ω (max)=0.65 mb/sr (15°).
1943 10	3	0.45	d σ /d Ω (max)=0.94 mb/sr (15°).
2106 10	(3)	0.52	d σ /d Ω (max)=1.11 mb/sr (15°).
2127 7	1	0.62#	d σ /d Ω (max)=2.99 mb/sr (7.5°).
2153 10	1&	0.20#&	(2J+1)S: 0.56 (1973Ip01) for L=3. d σ /d Ω (max)=1.17 mb/sr (15°).
2182 10	1	0.41#	E(level): unresolved doublet (1973Ip01). d σ /d Ω (max)=1.78 mb/sr (7.5°).
2300 10	(3)	0.32	d σ /d Ω (max)=0.78 mb/sr (15°).
2361 10	3	0.47	d σ /d Ω (max)=1.00 mb/sr (15°).
2378 10	3	0.48	d σ /d Ω (max)=1.02 mb/sr (15°).
2433 10	1	0.10#	d σ /d Ω (max)=0.66 mb/sr (15°).
2478 10	1	0.49#	d σ /d Ω (max)=2.13 mb/sr (7.5°).
2527 10			
2543 10	(3)&	0.1&	
2566 10	(1)&	0.09#&	
2667 10			
2739 10			
2797 10			
2857 15	(1)&	0.05#&	
2909 15			
2939 15			
2993 10			
3023 10	(1)&	0.07#&	
3080 10	6	2.4\$	E(level),L,(2J+1)S: from 1974Bo32.
3100 10			
3163 10	(1)&	0.08#&	
3177 10			
3210 10	(1)&	0.12#&	
3231 10			
3249 10			
3270 10			
3336 10			
3379 10	(1)&	0.1#&	

Continued on next page (footnotes at end of table)

¹³⁸Ba(d,p) 1968Ra18,1973Ip01,1977St33 (continued)

¹³⁹Ba Levels (continued)

E(level) [†]	L [‡]	(2J+1)S [‡]	E(level) [†]	E(level) [†]
3397 10	3&	0.54&	3603 10	3842 10
3465 10	(3)&	0.29&	3641 10	3930 10
3480 10			3674 10	3944 10
3499 10			3699 10	3971 10
3524 10			3727 10	4010 10
3563 10			3767 10	
3592 10			3811 10	

[†] From 1968Ra18 (ΔE=10), 1970Vo04 (ΔE=5 and 15), and 1977St33 (ΔE=7), except as noted.

[‡] From 1973Ip01, except as noted. The (2J+1)S values given are for L=1/2, unless otherwise stated. L-values are also given 1970Vo04, 1968Ra18 and 1967Wi08. The spectroscopic factors were obtained by comparing the experimental cross sections with the DWBA theoretical values, the latter calculated using DWUCK computer code, and multiplied by a normalization factor of 1.5.

[§] For L+1/2.

[#] Average of values for L+1/2 and L-1/2.

[@] From 1977St33.

[&] From 1970Vo04. Authors present (2J+1)S values with and without cutoff values, those without cutoff are given here.

¹³⁸Ba(α,³He) 2008Ka01

2008Ka01: E=51 MeV beam provided by Yale tandem accelerator. The reaction products were analyzed with an Enge magnetic split-pole spectrometer. The ³He ions were isolated by a gas-filled ionization chamber and plastic scintillator at the focal plane of the Enge spectrometer and using E-ΔE technique. Angular distributions were measured at 6°, 11°, 20° and 30°. Resolution (FWHM)=70 keV. DWBA analysis of σ(θ) data.

Absolute cross sections have typical uncertainty of ~7% while relative values are accurate to 5%.

This work focuses on measurement of i_{13/2} and h_{9/2} single-neutron strengths for N=83 nuclides. From cross section data, matrix elements were also deduced for f_{7/2}⊗2+ (vibration) and f_{7/2}⊗3- (vibration) configuration mixings. For L=6, configurations of (0+ core)⊗i_{13/2} and (3- core)⊗f_{7/2}; and for L=5, configurations of (0+ core)⊗h_{9/2} and (2+ core)⊗f_{7/2} have been used for two-level mixing calculations to extract the mixing matrix elements from the measured spectroscopic factors and excitation energies.

¹³⁹Ba Levels

E(level) [†]	L	C ² S [‡]	Comments
1283.32	5	0.70	dσ/dΩ=0.35 mb/sr at 20°, 0.20 mb/sr at 30°.
1539.01	6	0.60	dσ/dΩ=0.75 mb/sr at 20°, 0.44 mb/sr at 30°.
1619 10	5	0.41	dσ/dΩ=0.18 mb/sr at 20°, 0.11 mb/sr at 30°.
3080 10	6	0.17	dσ/dΩ=0.27 mb/sr at 6°, 0.21 mb/sr at 11°, 0.12 mb/sr at 20°, 0.08 at 30°.

[†] From Adopted Levels. The values were not determined independently in 2008Ka01. Centroid energies (keV): 1407 10 for h_{9/2}, 1879 24 for i_{13/2}.

[‡] Typical uncertainties are 10% based on relative cross sections and analysis using a variety of optical parameters listed by 2008Ka01. Summed [C²S]=1.11 16 for h_{9/2}, 0.77 11 for i_{13/2}.

Adopted Levels, Gammas

Q(β⁻)=-278.7; S(n)=8778.0 26; S(p)=6255.7 23; Q(α)=-2071.7 25 2012Wa38.
S(2n)=16230.3 28, S(2p)=15260.7 23 (2012Wa38).
Other reactions:
2015Kh02: ¹³⁹La(³He,X)¹³⁸La/¹³⁹La, E=38 MeV; measured E_γ, I_γ; deduced γ-ray strength functions, and nuclear level densities.
1997Sa05: ¹³⁹La(pol n,n'), E=0.5-1 eV. Measured parity-violating spin rotation angle near p-wave resonance and deduced parity mixing matrix element.
1996Ha05: ¹³⁹La(π⁺,K⁺)¹³⁹La E=1.06 GeV/c. measured hypernuclei mass spectra. Deduced Λ hypernuclei spectroscopic properties.
1996Ha47: ¹³⁹La(π⁺,K⁺)¹³⁹La E=1.06 GeV/c. measured Λ hypernuclei excitation energy spectra. Deduced binding energy mass number dependence.
1995Aj01: ¹³⁹La(π⁺,K⁺)¹³⁹La E=1.06 GeV/c. measured σ(θ); superconducting kaon spectrometer. FWHM=2 MeV. Deduced s_Λ, p_Λ, d_Λ, f_Λ, and g_Λ binding energies.
1994Al35: polarized La(pol n,X), E=0.5-10 eV; measured transmission; deduced J(3 eV res)=11/2 from sign of ε=(N₊-N₋)/(N₊+N₋).
2006MuZX: evaluation of neutron resonances.

¹³⁹La Levels

Cross Reference (XREF) Flags

A ¹³⁹ Ba β ⁻ Decay (82.93 min)	G ¹³⁸ La(d,p)	M Coulomb Excitation
B ¹³⁹ Ce ε Decay (137.641 d)	H ¹³⁹ La(γ,γ'): E=1.2-4.1 MeV	N ¹⁴⁰ Ce(μ ⁻ ,nγ)
C ¹³⁸ Ba(pol p,p),(pol p,p'): IAR	I ¹³⁹ La(γ,γ'): E=6.0-8.6 MeV	O ¹⁴⁰ Ce(d, ³ He)
D ¹³⁸ Ba(³ He,d),(α,t)	J ¹³⁹ La(γ,γ'): E=5.4-11.5 MeV	P ²³⁸ U(¹² C,Fγ)
E ¹³⁸ Ba(⁷ Li, ⁶ He)	K ¹³⁹ La(n,n'γ),(n,n')	
F ¹³⁸ La(n,γ),(n,n): Resonances	L ¹³⁹ La(d,d'),(α,α')	

E(level) [†]	Jπ [‡]	XREF	T _{1/2} or Γ	Comments
0.0 ^f	7/2 ⁺	AB DE GHI JKLMNOP	stable	μ=+2.7830455 9 (1977Kr12,2014StZZ). Q=+0.200 6 (2007Ja16,2016St14). RMS charge radius <r ² > ^{1/2} =4.8550 fm 49 (2013An02 evaluation). Jπ: spin from ABMR (1971Ch02) and optical spectroscopy (1934An02); π from L(³ He,d)=L(d, ³ He)=4. μ: NMR, optical spectroscopy using ² H standard (1977Kr12). Others: 2.7832 2 (NMR,1951Sh33), 2.7780 9 (1949Di13), +2.76 (1940Wi08). Q: 2007Ja16 carried out a theoretical calculation of electric field gradients using relativistic model and measured nuclear quadrupole coupling constants from molecular beam magnetic resonance (D.S. Rudinoff et al., Jour. Mol. Spectr. 218, 169 (2003)). Others: +0.20 1 (collinear fast beam laser spectroscopy (1982Ho02,1982Ba08); +0.26 or +0.28 (1971Ch02), +0.229 (1962Ko22), +0.21 1 (1958Mu08), +0.23 1 (1957Ti30), +0.3 1 (1955Lu59). Recent hyperfine structure studies: 1994Wa31, 1990Pr03, and 1990Sh13. Jπ: M1 γ to 7/2 ⁺ . L=2 in (³ He,d) or (d, ³ He). T _{1/2} : weighted av of β ⁻ decay (1.48 ns 3 (1966Be42), 1.50 ns 10 (1956De57), 1.50 ns 10 (1955Ge38)) and ε decay (1.60 ns 4 (1970Ko38), 1.48 ns 3 (1967Ma07), 1.47 ns 6 (1965Ge04), 1.47 ns 5 (1962Be31)). See β ⁻ and ε decay for details.
165.85778 11	5/2 ⁺	AB DE HI KLMNOP	1.50 ns 3	
1209.0 3	1/2 ⁺ §	DE K o		
1216? 1		H o		
1219.047 10	9/2 ⁺ #	A HI KLMN	0.58 ps 9	T _{1/2} : from B(E2) in Coulomb excitation and adopted Jπ and γ properties.
1256.797 10	(5/2 ⁺)	A I KLMN		Jπ: 5/2 ⁺ , 7/2 ⁺ from γ(θ) and excit in Coul. ex. 5/2 ⁺ from comparison of compound-nucleus calculation to γ excit in (n,n'γ).

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Adopted Levels, Gammas (continued)
¹³⁹La Levels (continued)

E(level) [†]	Jπ [‡]	XREF	T _{1/2} or Γ	Comments
1381.408 <i>g</i> 12	(9/2+)	A HI K N P		Jπ: γ to 5/2+. 9/2+ from comparison of compound-nucleus calculation to γ excit in (n,n'γ). 1970Mo30 suggest 7/2 based on 5034γ(θ) in (γ,γ'); however, γ(θ) also appears consistent with 9/2.
1420.3 3	(11/2)-	D I OP		Jπ: L=5 in (³ He,d) and (d, ³ He), where 11/2 was assumed for spectroscopic factors with possible involvement of h _{11/2} orbital; 291.3γ from (13/2+) in ²³⁸ U(¹² C,Fγ) unlikely to be M2 for 9/2-.
1420.490 7	(7/2)+	A E HI KLMN		Jπ: M1+E2 γ to 7/2+; dipole γ from 9/2-; excit and γ(θ) in Coul. ex. Note that 11/2+ proposed in (n,n'γ) (1987Ab17) from excitation function data is inconsistent.
1476.489 7	(9/2+)	A I K		Jπ: 5/2+,7/2,9/2+ from γ's from 9/2 resonance and to 5/2+. 9/2+ from comparison of compound-nucleus calculation to γ excit in (n,n'γ).
1536.388 7	7/2+ [#]	A GHI K	0.044 ps 7	T _{1/2} : from B(E2) in Coulomb excitation and adopted Jπ and γ properties.
1537.69 <i>f</i> 10	(11/2+)	KLM P		Jπ: from comparison of compound-nucleus calculation to γ excit in (n,n'γ).
1558.72 3	3/2+,5/2+ [§]	A DE K O		Jπ: 3/2+ from comparison of compound-nucleus calculation to γ excit in (n,n'γ). 5/2+ from comparison of DWBA to σ(θ) in (⁷ Li, ⁶ He).
1578.163 14	5/2+,7/2+ [#]	A HI KLM		Jπ: 1987Ab17 suggest (11/2+) based on comparison of compound-nucleus calculation to γ excit in (n,n'γ); however, this is not consistent with γ excit in Coul. ex.
1683.146 10	7/2+	A HI KLM		Jπ: 7/2,11/2 from γ(θ) in (γ,γ'). 5/2+,7/2+ from γ(θ) and excit in Coul. ex. 1987Ab17 suggest 9/2+ based on comparison of compound-nucleus calculation to γ excit in (n,n'γ).
1711.66 <i>g</i> 20	(13/2+) ^e	P		
1716.12 10	5/2+ [#]	HI KLM		Jπ: 1987Ab17 suggest 9/2+ based on comparison of compound-nucleus calculation to γ excit in (n,n'γ); however, this is not consistent with γ excit in Coul. ex. Also suggested 9/2+ in (n,n').
1740 1		H		
1761.167 10		A I K		Jπ: 7/2 from γ(θ) in (γ,γ'). 3/2 from comparison of compound-nucleus calculation to γ excit in (n,n'γ).
1766.428 24	(5/2)+	A I KLM		Jπ: from L=2 in (³ He,d). 3/2 from γ(θ) in Coul. ex. if 1767γ assigned in Coul. ex. Same as 1765.5γ in β ⁻ decay. ≠3/2+ from γ from 9/2(+) resonance.
1780 15	1/2+ [§]	DE		%IT=100.
1800.4 <i>g</i> 4	(17/2+) ^e	P	315 ns 35	T _{1/2} or Γ: (fragment)γ(t) (2012As06).
1810		L		
1837 4		E HI		
1854 1		H		
1856.62 4	(3/2+,5/2+) [§]	A DE I KL		Jπ: γ from 9/2(-) resonance. 3/2+ from comparison of DWBA to σ(θ) in (⁷ Li, ⁶ He).
1894.0 5		I K		
1920.43 4	(7/2+)	A HI KL		Jπ: 5/2-,7/2,9/2+ from γ's from 9/2- resonance and to 5/2+. (7/2+) from comparison of compound-nucleus calculations to γ excit in (n,n'γ).
1940.83 12	(7/2+)	KL		Jπ: comparison of compound-nucleus calculations to γ excit in (n,n'γ).
1950	(3/2+)	O		

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Adopted Levels, Gammas (continued) ^{139}La Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$ or Γ	Comments
1954 4		I		
1962.8 3	(13/2 ⁺) ^e		P	
1962.84 11	(5/2 ⁺) ⁺	A DE KL		$J\pi$: 3/2 ⁺ , 5/2 ⁺ from L=2 in ($^3\text{He}, d$) or ($d, ^3\text{He}$). $\neq$ 3/2 ⁺ from 7/2 ⁻ resonance. (3/2 ⁺) from comparison of compound-nucleus calculations to γ excit in ($n, n'\gamma$).
1980 1		H		
2032.75 ^f 25	(15/2 ⁺) ^e		P	
2035 [@]		KL		XREF: K(?).
2059.73 10		A HI K		
2123 3		I		
2136 1		H		
2152 1		H L		
2158.1 11		I K		XREF: K(?).
2232 5	(7/2, 11/2)	e I		$J\pi$: (7/2, 11/2) from $\gamma(\theta)$ in (γ, γ'). 3/2 ⁺ and 7/2 ⁺ from L=2+4 doublet in ($^7\text{Li}, ^6\text{He}$). $J\pi$: see comment for 2232 level.
2240 [@] 12	3/2 ⁺ , 5/2 ⁺ [§]	De		
2276 1		H		
2291 5		I		
2310 19	1/2 ⁺ [§]	DE L		E(level): from ($^3\text{He}, d$), (α, t).
2313 1		H		
2357 1		H		
2385 [@] 1		H L		
2390 5		I		
2401	(11/2 ⁻ , 9/2 ⁻)	E L		$J\pi$: L($^7\text{Li}, ^6\text{He}$)=(5).
2440 1		H L		
2448 1		H		
2466		L		
2573 1		H L		
2597		L		
2600 1		H		
2685 1	—	H L		$J\pi$: L(α, α')=3.
2705.0 10		H		
2712? 1		H		
2724 1		H		
2747 1		H		
2774 1		H		
2780	(—)	L		$J\pi$: L(α, α')=(3).
2800 1		H		
2811 1	(+)	H L		$J\pi$: L(α, α')=(2).
2828 1		H		
2862 1		H		
2868 1		H		
2870	+	L		$J\pi$: L(α, α')=2.
2877? 1		H		
2885.9 ^f 5	(19/2 ⁺) ^e		P	
2890	(—)	L		$J\pi$: L(α, α')=(3).
2918.0 5	(17/2 ⁺) ^e		P	
2928? 1		H		
2964 1		H		
2972 1		H		
2990 1		H		
3043 1		H		
3053 1		H		
3061.2 5	(19/2 ⁻) ^e		P	
3077 1		H		
3095? 1		H		
3114 1		H		
3147 4		G		
3150.3 6	(19/2 ⁺) ^e		P	
3175.3 5	(21/2 ⁺) ^e		P	
3184.3 ^f 5	(23/2 ⁺) ^e		P	
3196? 1		H		

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Adopted Levels, Gammas (continued) ^{139}La Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$ or Γ	Comments
3221 1		H		
3247.9 6	(21/2-) e		P	
3252 1		H		
3262 1		H		
3275 1		H		
3303 1		H		
3305.6 6	(23/2-) e		P	
3351 1		H		
3355 2	-&	G		
3361? 1		H		
3364.5 6	(21/2+) e		P	
3370 1		H		
3375 2	(15/2)-	G		$J\pi$: L(d,p)=3 from 5+ target and comparison of experimental σ with theory.
3401 1		H		
3433 2		G		
3445 1		H		
3458 1		H		
3475 1		H		
3483 1		H		
3485 2	-&	G		
3517 2	-&	G		
3523 1		H		
3527 1		H		
3544 1		H		
3555 2	-&	G		
3557 1		H		
3561 1		H		
3573 1		H		
3586 1		H		
3611 2	-&	G		
3631 1		H		
3664 1		H		
3688 2	-&	G		
3732 1		H		
3748 2	-&	G		
3785 2	-&	G		
3790 1		H		
3799 1		H		
3805 2	-&	G		
3832 1		H		
3841 2		G		
3854 1		H		
3868 2		G		
3878 1		H		
3886 1		H		
3905 2	-&	G		
3919 1		H		
3927 2	(17/2)-&	G		
3931 1		H		
3941 1		H		
3952 2	-&	G		
3963 1		H		
3980 2	-&	G		
4014 2	-&	G		
4095 2	-&	G		
4116.2 6	(25/2+) e		P	
4148 2	-&	G		
4230 2	-&	G		
4252.3 ^h 6	(23/2+) e		P	
4336 2	(-)&	G		
4394 2	(-)&	G		
4628.0 7	(27/2-) e		P	

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Adopted Levels, Gammas (continued) ^{139}La Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$ or Γ	Comments
4641.2 ^h 7	(25/2 ⁺) ^e			P
4791.2 8				P
5217.6 ^h 8				P
5380.6 6	(27/2 ⁺) ^e	J		
5389.8 12		J		
5406.8 13		J		
5423.1 7		J		
5545.4 7		J		
5552.7 9		J		
5572.0 11		J		
5582.1 10		J		
5594.8 7		J		
5620.4 8		J		
5658.8 7		J		
5688.1 5		J		
5708.6 7		J		
5716.5 6		J		
5723.0 3		J		
5811.3 8		J		
5830.9 9		J		
5848.9 6		J		
5940.2 8		J		
5984.1 20		J		
6015.9 8	7/2 ^{-a}	IJ	0.051 eV +14-8	Γ from (γ,γ'):E=6.0-8.6 MeV.
6047.1 14		J		
6077.9 11		J		
6097.8 12		J		
6112.0 15	9/2(-)	J		
6114.2 4		I	0.068 eV 34	J π : 9/2 from $\gamma(\theta)$ in (γ,γ'). $\pi=(-)$ since E1 absorption is generally two orders of magnitude larger than M1 for heavier nuclei. Γ from (γ,γ'):E=6.0-8.6 MeV.
6131.1 9		J		
6150.8 10		J		
6178 3		J		
6194.1 9		J		
6214.2 5		J		
6233.3 8		J		
6249.2 20		J		
6260.2 20		J		
6269.5 12		J		
6301.1 6		J		
6326.1 6		J		
6354.8 5		J		
6366.5 10		J		
6383.5 5		J		
6402.6 9		J		
6417.4 23	9/2 ^{-a}	I	0.081 eV +13-7	Γ from (γ,γ'):E=6.0-8.6 MeV.
6435.2 20		J		
6441.9 11		J		
6450.9 4		J		
6465.3 7		J		
6483.8 16		J		
6491.3 8		J		
6501.4 6		J		
6526.7 6		J		
6539.6 5		J		
6549.6 8		J		
6619.4 6		J		
6651.3 7		J		
6674.8 8		J		
6713.0 6		J		
6723.8 15		J		

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Adopted Levels, Gammas (continued) ^{139}La Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$ or Γ	Comments
6755.8 7		J		
6758.8 16	7/2 ^c	I		E(level): this level may be the same as 6755.8 level, although, the decay patterns are different.
6767.6 18		J		
6875.4 8		J		
6889.9 8		J		
6901.1 10		J		
6926.3 8		J		
6969.0 6		J		
6983.4 7		J		
7019.7 10		J		
7036.1 9		J		
7052.4 7		J		
7154.0 11		J		
7158 3		J		
7272.8 15		J		
7278.3 22		I		E(level): this level may be the same as 7272.8 level, although, the decay patterns are different.
7320.0 8		J		
7327.2 8		J		
7370.0 8		J		
7400.0 7		J		
7414.0 7		J		
7444.9 12		J		
7451.1 9		J		
7462.8 7		J		
7472.0 9		J		
7506.7 7		J		
7552.7 8		J		
7562.1 4		J		
7570.2 11		J		
7579.8 6		J		
7591.6 11		J		
7599.1 7		J		
7636.2 5	7/2 ^{-a}	IJ	0.17 eV 4	Γ from (γ, γ') : E=6.0–8.6 MeV.
7661.3 18		J		
7667 3		J		
7678.6 16		J		
7684.7 9		J		
7692.4 12		J		
7699 3		J		
7765.1 13		J		
7789.4 13		J		
7905.2 6		J		
7912.5 7		J		
7922.2 9		J		
7961 3		J		
7972.3 7		J		
8527.2 10		I		
8551.5 6		J		
8582.3 10	(7/2, 9/2) ^d	I		
8595.7 5		J		
8781.0 1		F		
8798.9 1		F		
8844.6 3		F		
8867.5 4		F		
8908.5 7		F		
8996.4 1		F		
9016.3 2		F		
9037.1 2		F		
9082.7 3		F		

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Adopted Levels, Gammas (continued)

¹³⁹La Levels (continued)

E(level) [†]	Jπ [‡]	XREF	T _{1/2} or Γ
9131.4 3		F	
16177.8	(7/2-)	C	65.2 keV ^b 5
16808.2	(3/2-)	C	98 keV ^b 1
17263.9	(1/2-)	C	89 keV ^b 1
17482.3	(9/2-)	C	48 keV ^b 4
17612.3	(5/2-)	C	73 keV ^b 1
17752.3	(13/2+)	C	34 keV ^b 9
17818.8	(9/2-)	C	66 keV ^b 11
17869.4	(7/2-)	C	76 keV ^b 3
17888.3	(5/2-)	C	66 keV ^b 2
17957.8	(3/2-)	C	57 keV ^b 6
18019.3	(9/2-)	C	118 keV ^b
18120.6	(7/2-)	C	95 keV ^b 11
18140.4	(5/2-)	C	57 keV ^b 4
18293.3	(7/2-)	C	64 keV ^b 5
18335.0	(3/2-)	C	94 keV ^b 5
18358.9	(5/2-)	C	68 keV ^b 5
18363.8	(1/2-)	C	84 keV ^b 4
18512.7?	(5/2-)	C	76 keV ^b
18624.9?	(3/2-)	C	2 keV ^b

[†] From least-squares fit to E_γ data, assuming 1 keV uncertainty when not stated. For levels populated in (γ,γ'):E=1.2-4.1 MeV, 1 keV uncertainty is assumed by the evaluators.

[‡] From angular momentum transfer in inelastic scattering for levels between 2.6 and 3.0 MeV; angular momentum transfer in (d,p) for levels between 3.0 and 4.4 MeV, except as noted; and resonance analysis for unbound states above 16 MeV. For levels populated in (γ,γ'), Jπ is limited to 5/2,7/2,9/2 from expected dipole excitation from 7/2+ g.s. of ¹³⁹La.

§ From angular momentum transfer in (³He,d) or (d,³He).

From γ(θ) and comparison of excitation function to theory in Coulomb excitation.

@ From inelastic scattering.

& L(d,p) and/or comparison to theoretical calculations.

a From γ(θ) and polarization of elastically scattered γ in (γ,γ') E=6.0-8.6 MeV.

b Width from (pol p,p'):IAR.

c From γ(θ) in (γ,γ').

d From γ-deexcitation pattern.

e For high-spin levels from (¹²C,Fγ), tentative assignments are from yrast type of population, band structures and consistency of intensities of cascading and cross over transitions.

f (A): γ cascade based on g.s.

g (B): γ cascade based on 5/2+.

h (C): Band based on (23/2+).

γ(¹³⁹La)

E(level)	E _γ [†]	I _γ [†]	Mult. [‡]	δ [‡]	α	Comments
165.8577	165.8575 11	100	M1		0.2516 7	α: based on α(K)(exp)=0.2146 10 (recommended by 1985HaZA from several experimental values, see ¹³⁹ Ce ε decay). α(L)(exp)=0.0289 12 (1976Ha11). Corresponding value from BrIcc code is 0.261 4. B(M1)(W.u.)=0.00257 4. δ: +0.034 34 from ε decay. <0.160 6 from adopted Jπ, T _{1/2} , and α and B(E2)↑ in Coul. ex. B(E2)(W.u.)<2 from δ(E2/M1)=0.034 34.
1209.0	1043.1 3	100				
1216?	1216					
1219.047	1053.162 32	12.8 18	E2			B(E2)(W.u.)=1.76 24. E _γ : unweighted av of data from Coul. ex., β ⁻ decay, and (n,n'γ).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{La})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. ‡	$\delta^{\ddagger}$	α	Comments
1219.047	1219.044 10	100 1	E2+M1	-4.9 4		B(E2)(W.u.)=7.4 11; B(M1)(W.u.)=0.00076 17. E γ : unweighted av of data from Coul. ex., β^- decay, (n,n' γ), (γ,γ'), and ($\mu^-,n\gamma$). δ : -0.28 6 or +3.5 7. I γ : from β^- decay. Others: 72.0 17 in Coulomb. ex. and 76 9 in (n,n' γ). δ : -0.28 6 or -2.3 5. B(E2)(W.u.)(5/2+)=3.7 13 from B(E2) $\uparrow$ in Coul. ex.
1256.797	1090.938 10 1256.772 22	100.0 24 39.9 11	M1+E2 M1+E2			
1381.408	1215.542 12 1381.560 93	100.0 8 5.2 3				
1420.3	1420.0 5		[M2]			
1420.490	1254.631 10 1420.478 10	11.5 1 100	M1+E2			δ : -0.15 2 or +5.3 9. B(E2)(W.u.)=3.5 4 from B(E2) $\uparrow$ in Coul. ex.
1476.489	1310.617 10 1476.488 10	100 3 11.5 18				
1536.388	1370.509 10	100 4	M1+E2	-0.81 25		B(E2)(W.u.)=13 6; B(M1)(W.u.)=0.06 3. I γ : from Coulomb ex. Other: 102 7 in β^- decay is in agreement but somewhat less precise. B(E2)(W.u.)=14.0 14; B(M1)(W.u.)=0.070 16.
1537.69	1536.391 10 1537.69 10	100.0 10 100	M1+E2	-0.89 9		
1558.72	1392.944 75 1558.697 31	47 4 100 5				I γ : other: 74 7 in (n,n' γ).
1578.163	1578.156 14	100	M1+E2			δ : -0.29 3 or -2.2 2 for J(1578)=5/2, -0.17 2 or +1.6 2 for J(1578)=7/2. B(E2)(W.u.)=18.4 16 for J(1578)=5/2, B(E2)(W.u.)=13.8 12 for J(1578)=7/2 from B(E2) $\uparrow$ in Coul. ex.
1683.146	1517.73 18 1683.133 10	1.62 17 100.0 9	M1+E2			δ : -0.34 7 or -2.0 4 for J(1683)=7/2. B(E2)(W.u.)=11.9 16. B(E2)(W.u.) from B(E2) $\uparrow$ in Coul. ex.
1711.66	174.0 3 291.3 3 330.3 3	53 9 19 6 100 15				
1716.12	1716.11 10	100	M1+E2			δ : +0.42 7 or +3.8 6. B(E2)(W.u.)=19.3 22. B(E2)(W.u.) from B(E2) $\uparrow$ in Coul. ex.
1740	1740	100				
1761.167	1595.299 10 1761.18 13	100.0 10 2.8 11				
1766.428	1600.577 26 1766.346 59	100 4 73 3	[E2]			B(E2)(W.u.)=22 4.
1800.4	88.7 5	100	[E2]		3.05 8	
1854	1854	100				
1856.62	1690.750 36	100				
1894.0	1894.0 $\S$ 5	100				
1920.43	1754.604 82 1920.407 42	68 6 100 5				
1940.83	174.6 2 363.1 2 403.8 2	100 69 87				E γ : somewhat poor fit, level-energy difference=404.4.
1962.8	425.2 3	100				
1962.84	1796.97 11	100				
1980	1980	100				
2032.75	70.0 3 232.3 4 495.0 3	6.3 26 100 13 37 7	[M1+E2]		5.1 21	
2059.73	1894.28 $\S$ 13 2059.72 10	35 5 100 7				

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{La})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. ‡	$\delta^{\ddagger}$	α	Comments
2136	2136	100				
2152	2152	100				
2158.1	308.3 § 3	100 14				All three γ rays are from (n,n' γ).
	477.0 § 9					
	581.3 § 5	66 19				
2276	2276	100				
2313	2313	100				
2357	2357	100				
2385	2385	100				
2440	2440	100				
2448	2448	100				
2573	2573	100				
2600	2600	100				
2685	2685	100				
2705.0	2705	100				
2712?	2712	100				
2724	2724	100				
2747	2747	100				
2774	2774	100				
2800	2634	100				
	2800	85 26				
2811	2811	100				
2828	2828	100				
2862	2696	10				
	2862	100 19				
2868	2868	100				
2877?	2712	100				
	2877	109 21				
2885.9	853.2 4	100				
2918.0	1206.3 5	100				
2928?	2928	100				
2964	2964	100				
2972	2972	100				
2990	2990	100				
3043	2877	59				
	3043	100 15				
3053	3053	100				
3061.2	1260.8 5	100				
3077	3077	100				
3095?	2928	100				
	3095	108 15				
3114	2948	25				
	3114	100 18				
3150.3	232.3 4	100				
3175.3	1374.9 4	100				
3184.3	(9.0 8)	0.5 2	[M1]		190 70	
	298.4 3	100 15				
3196?	3196	100				
3221	3221	100				
3247.9	97.6 5	100 14				
	186.7 4	84 13				
3252	3252	100				
3262	3095	56				
	3262	100 20				
3275	3275	100				
3303	3303	100				
3305.6	(57.7 8)	41 6	[M1]		5.29 24	
	130.3 3	100 19				
3351	3351	100				
3361?	3196	100				
	3361	85 11				
3364.5	478.6 4	100				
3370	3370	100				

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{La})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. ‡	$\delta^{\ddagger}$	Comments
3401	3235	100			
	3401	138 38			
3445	3445	100			
3458	3292	100			
	3458	67 13			
3475	3475	100			
3483	3317	23			
	3483	100 19			
3523	3523	100			
3527	3361	100			
	3527	117 30			
3544	3378	100			
	3544	117 22			
3557	3391	6			
	3557	100 32			
3561	3395	100			
	3561	32 6			
3573	3407	6			
	3573	100 20			
3586	3586	100			
3631	3631	100			
3664	3664	100			
3732	3732	100			
3790	3790	100			
3799	3799	100			
3832	3832	100			
3854	3854	100			
3878	3878	100			
3886	3886	100			
3919	3919	100			
3931	3931	100			
3941	3941	100			
3963	3963	100			
4116.2	940.9 4	100			
4252.3	887.8 4	16 3			
	1068.0 4	100 10			
4628.0	512 1	11 3			
	1322.3 5	100 10			
4641.2	388.9 3	100			
4791.2	1485.6 6	100			
5217.6	576.4 4	100			
5380.6	5380.5 6	100			
5389.8	5389.7 12	100			
5406.8	5406.7 13	100			
5423.1	5423.0 7	100			
5545.4	5545.3 7	100			
5552.7	5552.6 9	100			
5572.0	5571.9 11	100			
5582.1	5582.0 10	100			
5594.8	5594.7 7	100			
5620.4	5620.3 8	100			
5658.8	5658.7 7	100			
5688.1	5688.0 5	100			
5708.6	5708.5 7	100			
5716.5	5716.4 6	100			
5723.0	5722.9 3	100			
5811.3	5811.2 8	100			
5830.9	5830.8 9	100			
5848.9	5848.8 6	100			
5940.2	5940.1 8	100			
5984.1	5984 2	100			
6015.9	3895 4	1.1			
	4062 4	1.1			

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{La})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. ‡	$\delta^{\ddagger}$	Comments
6015.9	4334 4	13.6			
	4438 4	27.9	D(+Q)	+0.005 15	
	4481 4	5.8			
	4538 4	4.8			
	4798 6	14.4	D+Q	+0.15 10	
	5852 4	21.5	(E1(+M2))	-0.02 6	Mult.: from $\gamma(0)$ and I_{γ}/E_{γ}^3 in (γ, γ') . B(E1)(W.u.)= 1.59×10^{-5} +25-44.
	6015.4 8	100	(E1(+M2))	-0.01 3	B(E1)(W.u.)= 6.8×10^{-5} +11-19.
6047.1	6047.0 14	100			
6077.9	6077.8 11	100			
6097.8	6097.7 12	100			
6112.0	6111.9 15	100			
6114.2	3956	8 2			
	4055	4 2			
	4221 2	4 1			
	4259	4 1	[M2, E3]		
	4345	21 1			
	4428	19 1			
	4534	7 1			
	4575	5 1			
	4638	11 1			
	4694 §#	22# 1			
	4734	9 1			
	4858 §	<2			
	4896	19 1			
	5949	=1			
	6115 2	100 1			
6131.1	6131.0 9	100			
6150.8	6150.7 10	100			
6178	6178 3	100			
6194.1	6194.0 9	100			
6214.2	6214.1 5	100			
6233.3	6233.1 8	100			
6249.2	6249 2	100			
6260.2	6260 2	100			
6269.5	6269.3 12	100			
6301.1	6300.9 6	100			
6326.1	6325.9 6	100			
6354.8	6354.6 5	100			
6366.5	6366.3 10	100			
6383.5	6383.3 5	100			
6402.6	6402.4 9	100			
6417.4	4186 § 4	3.0	D(+Q)		
	4356 § 4	1.0			
	4459 § 6	1.0			
	4498 § 4	0.6			
	4580 § 4	0.9			
	4661 § 4	<1			
	4704 § 4	2			
	4838 § 4	4 1	D		
	4882 4	6 1	(E1)		Mult.: dipole from $\gamma(0)$ in (γ, γ') . E1 from decay scheme. B(E1)(W.u.)= 1.8×10^{-5} +4-5.
	4999 §# 4	4# 1	D(+Q)	-0.1 +3-2	
	4999 §# 4	4# 1	D(+Q)	-0.03 8	
	5034 4	2 1	D(+Q)		
	6418 4	100 1	(E1(+M2))	-0.001 4	B(E1)(W.u.)=0.000134 +13-22.
6435.2	6435 2	100			
6441.9	6441.7 11	100			
6450.9	6450.7 4	100			
6465.3	6465.1 7	100			
6483.8	6483.6 16	100			
6491.3	6491.1 8	100			
6501.4	6501.2 6	100			

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Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{La})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. ‡	Comments
6526.7	6526.5 6	100		
6539.6	6539.4 5	100		
6549.6	6549.4 8	100		
6619.4	6619.2 6	100		
6651.3	6651.1 7	100		
6674.8	6674.6 8	100		
6713.0	6712.8 6	100		
6723.8	6723.6 15	100		
6755.8	6755.6 7	100		
6758.8	4704 §	48 9		
	5075 4	10 6		
	5180 4	20 6	D	
	5221 4	14 6		
	5375 4	68 6		
	5502 § 4	60		
	5540 6	13 6		
	6594 4	100 7	D	
	6760 4	48 7		
6767.6	6767.4 18	100		
6875.4	6875.2 8	100		
6889.9	6889.7 8	100		
6901.1	6900.9 10	100		
6926.3	6926.1 8	100		
6969.0	6968.8 6	100		
6983.4	6983.2 7	100		
7019.7	7019.5 10	100		
7036.1	7035.9 9	100		
7052.4	7052.2 7	100		
7154.0	7153.8 11	100		
7158	7158 3	100		
7272.8	7272.6 15	100		
7278.3	5150 4	100		
	5360 4	74		
	5459 4	44		
	5699 4	48		
	7279 4	70		
7320.0	7319.8 8	100		
7327.2	7327.0 8	100		
7370.0	7369.8 8	100		
7400.0	7399.8 7	100		
7414.0	7413.8 7	100		
7444.9	7444.7 12	100		
7451.1	7450.9 9	100		
7462.8	7462.6 7	100		
7472.0	7471.8 9	100		
7506.7	7506.5 7	100		
7552.7	7552.5 8	100		
7562.1	7561.9 4	100		
7570.2	7570.0 11	100		
7579.8	7579.6 6	100		
7591.6	7591.4 11	100		
7599.1	7598.9 7	100		
7636.2	5867 §	16 2		
	7636.0 5	100 6	E1	B(E1)(W.u.)=0.00018 5.
7661.3	7661.1 18	100		
7667	7667 3	100		
7678.6	7678.4 16	100		
7684.7	7684.5 9	100		
7692.4	7692.2 12	100		
7699	7699 3	100		
7765.1	7764.9 13	100		
7789.4	7789.2 13	100		
7905.2	7905.0 6	100		

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Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{La})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$
7912.5	7912.3 7	100	8527.2	8527	100 5
7922.2	7922.0 9	100	8551.5	8551.2 6	100
7961	7961 3	100	8582.3	7002 $\S$	9 6
7972.3	7972.1 7	100		7363	23 10
8527.2	6985 5	27 2		8582 3	100 2
	7312 5	15 2	8595.7	8595.4 5	100

$\dagger$ When available, values are from ^{139}Ba β^- decay. In other values are mostly independently known.

$\ddagger$ For low-lying (<2 MeV) levels, values are from $\gamma(\theta)$ data in Coulomb excitation from 7/2+ ground state in ^{139}La . Parity is considered as positive in such excitation. For gamma rays from levels above 6 MeV, values are from $\gamma(\theta)$ data in (γ, γ') : E=6.0–8.6 MeV.

$\S$ Placement of transition in the level scheme is uncertain.

Multiply placed; undivided intensity given.

(A) γ cascade based on g.s.

(B) γ cascade based on 5/2+

(C) Band based on (23/2+)

¹³⁹Ba β⁻ Decay (82.93 min) 2012Da17,2012Da04,2001Za08

Parent ¹³⁹Ba: E=0.0; Jπ=7/2-; T_{1/2}=82.93 min 9; Q(g.s.)=2314.6 23; %β⁻ decay=100.

¹³⁹Ba-J,T_{1/2}: From ¹³⁹Ba Adopted Levels.

¹³⁹Ba-Q(β⁻): From 2012Wa38.

2012Da17: measured Eγ, Iγ, γγ coin, T_{1/2} of ¹³⁹Ba.

2012Da04: measured Eγ, Iγ, T_{1/2} of ¹³⁹Ba.

2001Za08: ¹³⁹Ba from ¹³⁸Ba(n,γ), measured Eγ, Iγ, γγ using combination of HPGe, Ge(Li), BGO-Compton suppressed Ge detector, and NaI(Tl) detector.

1986Fa08: measured Eγ, Iγ. The authors essentially confirmed results of 1969Be15, with a few additional weak γ rays.

1980Ge04: measured Eγ, Iγ and half-life of ¹³⁹Ba decay and βγ-coincidences (4π,NaI).

1978La03: measured Eγ, Iγ between 1.2 and 2.0 MeV and investigated ambiguities in Iγ between 1968Hi13 and 1969Be15.

1975Fl07, 1969Su01: measured βγ-coin.

1969Be15, 1968Hi13: measured Eγ, Iγ, γγ coin.

1969Su01: measured Eγ, Iγ, γ(t) (NaI) and βγ-coincidences and βγ(θ) (scin,NaI).

1524 keV level from 1980Ge04 was established as belonging to ⁴²K in 2012Da17.

¹³⁹La Levels

Decay scheme is essentially that proposed by 1969Be15 and 1968Hi13. Later studies have provided more precise gamma-ray energies and intensities.

A 1042.9 level proposed by 1988Fa06 is omitted here as it is not confirmed in 2012Da04, 2012Da17 and 2001Za08.

Levels at 1524.8 and 1900.3 proposed by 2001Za08 are omitted here as these are not confirmed in recent decay studies by 2012Da04, 2012Da17 and 1988Fa06.

E(level) [†]	Jπ [‡]	T _{1/2} [‡]	Comments
0.0	7/2+	stable	
165.859 7	5/2+	1.50 ns 3	T _{1/2} : measurements in β ⁻ decay: 1.48 ns 3 (1966Be42, βγ(t), scin), 1.50 ns 10 (1956De57, βγ(t), scin), 1.50 ns 10 (1955Ge38, βce(t), scin).
1219.047 10	9/2+	0.57 ps 5	
1256.797 11	(5/2)+		
1381.409 14	(9/2+)		
1420.491 8	5/2+, 7/2+		
1476.489 8	(9/2+)		
1536.388 8	7/2+	0.044 ps 7	
1558.72 3	3/2+, 5/2+		
1578.156 14	5/2+, 7/2+		
1683.145 10	7/2+		
1761.168 13			
1766.432 25	(5/2)+		
1856.62 4	(3/2+, 5/2+)		
1920.43 4	(7/2+)		
1962.84 11	(5/2)+		
2059.89 8			

[†] From least-squares fit to Eγ data.

[‡] From Adopted Levels.

β⁻ radiations

Eβ ⁻	E(level)	Iβ ^{-†}	Log ft	Comments
(254.7 23)	2059.89	0.000151 10	9.08 4	
(351.8 23)	1962.84	0.000068 8	9.88 6	
(394.2 23)	1920.43	0.000284 14	9.43 2	
(458.0 23)	1856.62	0.00010 7	10.1 3	
(548.2 23)	1766.432	0.000587 18	9.59 2	
(553.4 23)	1761.168	0.00254 5	8.97 1	
(631.5 23)	1683.145	0.00310 5	9.08 1	
(736.4 23)	1578.156	0.000639 13	10.00 1	
(755.9 23)	1558.72	0.000433 18	10.21 2	
(778.2 23)	1536.388	0.00501 20	9.19 2	
(838.1 23)	1476.489	0.0166 5	8.78 2	
(894.1 23)	1420.491	0.291 4	7.64 1	
(933.2 23)	1381.409	0.00330 5	9.65 1	
(1057.8 23)	1256.797	0.00135 3	10.24 1	
(1095.6 23)	1219.047	0.00560 13	9.68 1	

Continued on next page (footnotes at end of table)

¹³⁹Ba β⁻ Decay (82.93 min) 2012Da17,2012Da04,2001Za08 (continued)

β⁻ radiations (continued)

Eβ ⁻	E(level)	Iβ ^{-†}	Log <i>ft</i>	Comments
(2148.7 23)	165.859	29.68 31	7.087 5	Iβ ⁻ : from Iγ(165γ)(1+α)-ΣIγ(to 165), where Iγ(165γ)=23.76% 25 (measured by 1980Ge04).
(2314.6 23)	0.0	69.98 31	6.845 3	Iβ ⁻ : 100-(β feeding to excited states).

† Absolute intensity per 100 decays.

γ(¹³⁹La)

A 1042.9 with Iγ=0.01 in 1988Fa06 was not confirmed by 2012Da04, 2012Da17 and 2001Za08. Based on γγ-coin and half-life analysis, 2012Da17 assigned this γ to the decay of ⁸²Br. In 2001Za08, Iγ<0.0005, consistent with non-observation.

Following γ rays with Eγ(Iγ) reported by 2001Za08 only are omitted here: 268.27 7 (2.10 18), 1524.65 18 (0.0770 5), 1900.23 27 (0.0438 7). None of these γ rays have been confirmed in 2012Da04 and 2012Da17.

Iγ normalization: From Iγ(166)=23.76 25 per 100 decays of ¹³⁹Ba, and Iγ(166γ)/Iγ(1420γ)=100.0 10/1.100 13 (1980Ge04) and Iγ(1420)=100.

Eγ [†]	E(level)	Iγ [‡] #	Mult.§	δ§	α	Comments
165.8575 11	165.859	9090 91	M1		0.2516 7	α: from ¹³⁹ Ce ε decay based on experimental values. Corresponding value from BrIcc code is 0.261 4. Eγ: from 1999Al12 in ¹³⁹ Ce ε decay. Others: 165.825 20 (2012Da04), 165.85 1 (2012Da17), 165.96 5 in table 1 but 165.85 in level-scheme figure 5 of 2001Za08, 165.84 (1986Fa08), 165.85 from 1968Hi13 who quote it from thesis by Baer (1967), measurement using curved-crystal spectrometer. Iγ: from Iγ(166γ)/Iγ(1420γ)=100.0 10/1.100 13 (1980Ge04) and Iγ(1420)=100. Others: 9370 100 (2012Da04), 9473 370 (2012Da17), 8335 149 (2001Za08), 7300 (1986Fa08), 9090 150 (1980Ge04), 7300 730 (1969Be15), 6230 900 (1968Hi13). %Iγ=23.76 5 (1980Ge04). Measured I(K x-ray)/I(165.9γ)=0.2414 8 (2008Ni02).
1053.162 32	1219.047	0.275 10	E2			Eγ: others: 1053.14 5 (2012Da17), 1053.83 8 (2001Za08), 1052.9 (1986Fa08), 1053.1 3 (1980Ge04). Iγ=0.273 13 (2012Da04), 0.276 10 (2012Da17), 0.1968 6 (2001Za08), 0.12 (1986Fa08), 0.197 20 (1980Ge04).
1090.938 10	1256.797	3.71 9	M1+E2			Eγ: others: 1090.92 2 (2012Da17), 1090.71 4 (2001Za08), 1090.9 (1986Fa08), 1090.7 2 (1980Ge04). Iγ=3.80 4 (2012Da04), 3.61 2 (2012Da17), 4.361 1 (2001Za08), 3.1 (1986Fa08), 4.36 22 (1980Ge04).
1215.542 12	1381.409	1.20 1				Eγ: others: 1215.49 2 (2012Da17), 1215.31 8 (2001Za08), 1215.5 (1986Fa08), 1215.3 2 (1980Ge04). Iγ=1.19 2 (2012Da04), 1.20 1 (2012Da17), 1.223 2 (2001Za08), 1.2 (1986Fa08), 1.22 6 (1980Ge04).
1219.044 10	1219.047	1.87 4	M1+E2	-4.9 4		Eγ: others: 1219.03 1 (2012Da17), 1218.81 15 (2001Za08), 1219.1 (1986Fa08), 1218.8 2 (1980Ge04). Iγ=1.91 2 (2012Da04), 1.83 2 (2012Da17), 1.7676 3 (2001Za08), 1.5 (1986Fa08), 1.77 9 (1980Ge04).

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^{139}Ba β^- Decay (82.93 min) 2012Da17,2012Da04,2001Za08 (continued) $\gamma(^{139}\text{La})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger\#}$	Mult. §	$\delta^{\S}$	Comments
1254.631 10	1420.491	11.5 1			E γ : others: 1254.6 2 (2012Da17), 1254.36 12 (2001Za08), 1254.8 (1986Fa08), 1254.36 12 (1980Ge04). $I\gamma=11.5$ 1 (2012Da04), 11.4 1 (2012Da17), 11.476 16 (2001Za08), 10 (1986Fa08), 11.48 11 (1980Ge04).
1256.772 22	1256.797	1.48 4	M1+E2		E γ : others: 1256.8 2 (2012Da17), 1256.66 2 (2001Za08), 1256.7 (1986Fa08), 1256.7 2 (1980Ge04). $I\gamma=1.44$ 4 (2012Da04), 1.52 4 (2012Da17), 1.331 2 (2001Za08), 1.03 (1986Fa08), 1.33 7 (1980Ge04).
1310.617 10	1476.489	5.70 16			E γ : others: 1310.56 2 (2012Da17), 1310.37 2 (2001Za08), 1310.6 (1986Fa08), 1310.37 10 (1980Ge04). $I\gamma=5.87$ 6 (2012Da04), 5.54 (2012Da17), 5.598 10 (2001Za08), 5.4 (1986Fa08), 5.6 6 (1980Ge04).
1370.509 10	1536.388	0.97 7	M1+E2	-0.81 25	E γ : others: 1370.6 1 (2012Da17), 1370.25 2 (2001Za08), 1370.6 (1986Fa08), 1370.3 2 (1980Ge04). $I\gamma=1.04$ 1 (2012Da04), 0.90 5 (2012Da17), 1.049 3 (2001Za08), 1.1 (1986Fa08), 1.05 5 (1980Ge04).
1381.560 93	1381.409	0.063 4			E γ : others: 1381.3 3 (2012Da17), 1380.80 2 (2001Za08), 1382 (1986Fa08), 1380.8 3 (1980Ge04). $I\gamma=0.058$ 4 (2012Da04), 0.067 9 (2012Da17), 0.0940 3 (2001Za08), 0.03 (1986Fa08), 0.094 9 (1980Ge04).
1392.944 75	1558.72	0.053 4			E γ : others: 1392.7 1 (2012Da17), 1392.117 6 (2001Za08), 1393 (1986Fa08), 1392.1 3 (1980Ge04). $I\gamma=0.050$ 4 (2012Da04), 0.055 7 (2012Da17), 0.0654 2 (2001Za08), 0.03 (1986Fa08), 0.065 7 (1980Ge04).
1420.478 10	1420.491	100	M1+E2		E γ : others: 1420.44 1 (2012Da17), 1420.19 10 (2001Za08), 1420.5 (1986Fa08), 1420.19 10 (1980Ge04). $I\gamma=100$ 1 in 2012Da04, 100 in 2012Da17 and 2001Za08 % $I\gamma=0.261$ 5 (1980Ge04).
1476.488 10	1476.489	0.656 13			E γ : others: 1476.39 2 (2012Da17), 1476.09 9 (2001Za08), 1254.8 (1986Fa08), 1476.1 3 (1980Ge04). $I\gamma=0.643$ 8 (2012Da04), 0.669 9 (2012Da17), 0.669 3 (2001Za08), 10 (1986Fa08), 0.67 7 (1980Ge04).
1517.73 18	1683.145	0.019 2			E γ : others: 1517.5 3 (2012Da17), 1518 (1986Fa08), 1254.36 12 (1980Ge04). γ not seen by 2001Za08. $I\gamma=0.018$ 2 (2012Da04), 0.020 9 (2012Da17), 0.02 (1986Fa08), 11.48 11 (1980Ge04). $I\gamma<0.0010$ (2001Za08).
1536.391 10	1536.388	0.951 9	M1+E2	-0.89 9	E γ : others: 1536.30 6 (2012Da17), 1536.02 9 (2001Za08), 1536.3 (1986Fa08), 1536.0 3 (1980Ge04). $I\gamma=0.955$ 10 (2012Da04), 0.947 9 (2012Da17), 0.965 6 (2001Za08), 1.0 (1986Fa08), 0.97 10 (1980Ge04).
1558.697 31	1558.72	0.113 5			E γ : others: 1558.53 7 (2012Da17), 1558.31 32 (2001Za08), 1558.5 (1986Fa08), 1558.3 3 (1980Ge04). $I\gamma=0.108$ 4 (2012Da04), 0.119 6 (2012Da17), 0.1293 8 (2001Za08), 0.09 (1986Fa08), 0.120 12 (1980Ge04).
1578.146 14	1578.156	0.245 4	M1+E2		E γ : others: 1578.05 6 (2012Da17), 1577.83 39 (2001Za08), 1578.3 (1986Fa08), 1577.8 4 (1980Ge04). $I\gamma=0.249$ 4 (2012Da04), 0.240 7 (2012Da17), 0.259 2 (2001Za08), 0.2 (1986Fa08), 0.259 26 (1980Ge04).
1595.299 10	1761.168	0.948 9			E γ : others: 1595.33 2 (2012Da17), 1594.95 11 (2001Za08), 1595.7 (1986Fa08), 1594.9 3 (1980Ge04). $I\gamma=0.876$ 9 (2012Da04), 1.02 4 (2012Da17), 0.867 7 (2001Za08), 0.93 (1986Fa08), 0.87 9 (1980Ge04).
1600.577 26	1766.432	0.130 5			E γ : others: 1600.51 7 (2012Da17), 1600.39 21 (2001Za08), 1601.4 (1986Fa08), 1600.4 3 (1980Ge04). $I\gamma=0.124$ 3 (2012Da04), 0.135 6 (2012Da17), 0.137 11 (2001Za08), 0.05 (1986Fa08), 0.137 14 (1980Ge04).
1683.133 10	1683.145	1.17 1	M1+E2		E γ : others: 1683.04 6 (2012Da17), 1682.81 4 (2001Za08), 1683.4 (1986Fa08), 1682.8 2 (1980Ge04). $I\gamma=1.16$ 1 (2012Da04), 1.18 1 (2012Da17), 1.183 12 (2001Za08), 1.2 (1986Fa08), 1.18 6 (1980Ge04).

Continued on next page (footnotes at end of table)

^{139}Ba β^- Decay (82.93 min) 2012Da17,2012Da04,2001Za08 (continued) $\gamma(^{139}\text{La})$ (continued)

$E\gamma^\dagger$	E(level)	$I_\gamma^{\ddagger\#}$	Comments
1690.750 36	1856.62	0.040 25	<p>Eγ: others: 1690.6 3 (2012Da17), 1690.51 6 (2001Za08), 1691.2 (1986Fa08), 1690.5 3 (1980Ge04).</p> <p>I_γ=0.102 4 (2012Da04), 0.040 25 (2012Da17), 0.0879 9 (2001Za08), 0.11 (1986Fa08), 0.088 9 (1980Ge04).</p> <p>I_γ: from 2012Da17. Based on the $\gamma\gamma$-coin data and half-life analysis, 2012Da17 concluded that only a fraction of the 1691γ belongs to the decay of ^{139}Ba, other component was ascribed to the decay of ^{124}Sb.</p>
1754.604 82	1920.43	0.044 4	<p>Eγ: others: 1754.6 1 (2012Da17), 1754.68 16 (2001Za08), 1755 (1986Fa08), 1754.7 3 (1980Ge04).</p> <p>I_γ=0.040 3 (2012Da04), 0.048 5 (2012Da17), 0.0391 5 (2001Za08), 0.02 (1986Fa08), 0.039 4 (1980Ge04).</p>
1761.18 13	1761.168	0.027 11	<p>Eγ: others: 1761.4 6 (2012Da17), 1762.72 8 (2001Za08), 1762 (1986Fa08), 1762.7 5 (1980Ge04).</p> <p>I_γ=0.016 2 (2012Da04), 0.038 7 (2012Da17), 0.0329 4 (2001Za08), 0.03 (1986Fa08), 0.033 3 (1980Ge04).</p>
1766.346 59	1766.432	0.095 4	<p>Eγ: others: 1766.4 3 (2012Da17), 1766.00 7 (2001Za08), 1767.6 (1986Fa08), 1766.0 2 (1980Ge04).</p> <p>I_γ=0.099 5 (2012Da04), 0.090 3 (2012Da17), 0.0898 12 (2001Za08), 0.1 (1986Fa08), 0.090 9 (1980Ge04).</p>
1796.97 11	1962.84	0.026 3	<p>Eγ: others: 1796.1 3 (2012Da17), 1796.35 5 (2001Za08), 1797 (1986Fa08), 1796.4 3 (1980Ge04).</p> <p>I_γ=0.024 2 (2012Da04), 0.029 4 (2012Da17), 0.0408 7 (2001Za08), 0.02 (1986Fa08), 0.041 4 (1980Ge04).</p>
1894.28 13	2059.89	0.015 2	<p>Eγ: others: 1896 (1988Fa06), 1896 1 (1969Be15), 1894.7 7 (1968Hi13).</p> <p>I_γ from 2012Da04. Others: <0.02 (2012Da17), 0.02 (1986Fa08), <0.008 (2001Za08), 0.02 (1969Be15), 0.008 6 (1968Hi13).</p>
1920.407 42	1920.43	0.065 3	<p>Eγ: others: 1920.3 2 (2012Da17), 1920.21 13 (2001Za08), 1922 (1986Fa08), 1920.2 3 (1980Ge04).</p> <p>I_γ=0.062 3 (2012Da04), 0.068 6 (2012Da17), 0.061 12 (2001Za08), 0.04 (1986Fa08).</p>
2059.72 10	2059.89	0.043 3	<p>Eγ: others: 2060.1 3 (2012Da17), 2061.22 35 (2001Za08), 2061 (1986Fa08), 2060.2 4 (1980Ge04).</p> <p>I_γ=0.043 3 (2012Da04), 0.045 5 (2012Da17), 0.0226 5 (2001Za08), 0.05 (1986Fa08), 0.0226 23 (1980Ge04).</p>

† From 2012Da04, except for 165.8 γ which is from 1999Al12. Values from 2012Da17, 2001Za08, 1986Fa08 and 1980Ge04 are given under comments.

‡ Average of values from 2012Da17 and 2012Da04, unless otherwise indicated.

§ From Adopted Gammas.

$^\#$ For absolute intensity per 100 decays, multiply by 0.00261 3.

^{139}Ba β^- Decay (82.93 min) 2012Da17,2012Da04,2001Za08 (continued)

Decay Scheme

¹³⁹Ce ϵ Decay (137.641 d) 2008BeZV

Parent ¹³⁹Ce: E=0.0; J π =3/2⁺; T_{1/2}=137.641 d 20; Q(g.s.)=264.6 20; % ϵ decay=100.

¹³⁹Ce-J,T_{1/2}: From ¹³⁹Ce Adopted Levels.

¹³⁹Ce-Q(ϵ): From 2012Wa38, based on measured 264.6 20 (1996Hi14, internal bremsstrahlung).

2008BeZV: DDEP evaluation of ¹³⁹Ce decay, the α (exp) and α_K (exp) recommended by 1985HaZA were adopted in this evaluation.

1956Ke23 measured (K x ray)-(166 γ) (4 π NaI). P_{LM⁺}/P_K=0.37 2.

1965Ge04 measured ce and ce-X_K(t) (mag spect,scin).

1967Ma07 measured ϵ K(exp) and Auger-ce(t) (mag spect).

1972Sc08 measured E γ and x rays, ce(x ray)-coincidences (Si(Li), Ge(Li)), and (x ray) γ -coincidences (Ge(Li)).

1975Ha43 measured x rays (Si(Li)), E γ (NaI), and electrons (mag spect,scin).

1975Mo12 measured (K x ray) γ -coincidences and (K x ray)-(K x ray) coincidences.

1975Pi06 measured 4 π (x,electron) γ -coincidences (4 π pc,NaI), electrons (4 π pc), and γ 's (4 π NaI). P_K ω_K =0.639 6.

1976Ha11 measured (electron-x-x) coincidences (mag spect,Si(Li)).

1976Ha36 measured (x ray) γ -coin (NaI,Ge(Li)). P_K ω_K =0.726 10.

1987BeYL measured (K x ray)-(166 γ) coincidences (Ge(Li),Si(Li)). P_K ω_K =0.658 22.

1993Ko26 measured K x rays, E γ ; planar and coaxial intrinsic Ge and deduced 3.87 25 $\leq$ K x ray(K capture)/K x ray(K conversion) $\leq$ 5.05 15.

1993Mi20 measured γ (x ray) coin (CsI(Tl)). $\Gamma_{\text{invisible axion}}/\Gamma_{\gamma}<1.21\times10^{-6}$ for 166 γ .

1999Al12: measured precise energy of the 165-keV γ ray using an intrinsic Ge (LEPS-type) detector.

2009GaZY: measured I γ , I(x ray), E(x ray), γ (x ray)-coin., (ce)(x ray)-coin; deduced K-capture probability.

1976Be18 observed no anisotropy in L x ray- γ (θ).

Others: 1954Pr31, 1960St10, 1961Kn02, 1962Gr17, 1962Ta03, 1963Ha07, 1964Ha20, 1970BaYT, 1978SeZS, 1988DaZS, 1988KoZM.

¹³⁹La Levels

E(level)	J π	T _{1/2} [†]	Comments
0.0	7/2 ⁺		
165.8576 11	5/2 ⁺	1.499 ns 19	T _{1/2} : measurements via ϵ decay: 1.60 ns 4 (1970Ko38, ce γ (t), spect), 1.48 ns 3 (1967Ma07), 1.47 ns 6 (1965Ge04), and 1.47 ns 5 (1962Be31, K x ray- γ (t),scin). See also 1967Ma07.

[†] From Adopted Levels.

β^+, ϵ Data

ω_K =0.906 26 (1977Ba48) assumed by 1975Mo12 and 1976Ha36 to extract P_K; ω_K =0.926 (1979Kr22) assumed by 1987BeYL.

Evaluators used the value from 1977Ba48.

E ϵ	E(level)	I $\epsilon^{\dagger}$	Log ft	I($\epsilon+\beta^+$) [†]	Comments
98.7 20	165.8576	100	5.42 3	100	E ϵ : from 1996Hi14 (measured (internal bremsstrahlung)166 γ ; Ge(HP)). ϵ K(exp): unweighted av of 0.735 11 (1956Ke23), 0.68 2 (1967Ma07), 0.78 3 (1972Sc08), 0.705 20 (1972Ca07), 0.726 10 (1975Ha43), 0.705 20 (1975Pi06), 0.801 34 (1976Ha36), 0.695 31 (1987BeYL), and 0.74 3 (1994Ku43). ϵ K(theory)=0.704 6. See 1988Ri08 for possible effects of finite widths of atomic levels on capture rates. Double K-shell ionization probability=2.0 $\times$ 10 ⁻⁶ 16 (1991Hi01. 166 γ -K α x ray-hypersatellite K α x ray; intrinsic Ge). 1991Hi01 note that this result justifies the neglect of P _{KK} (ϵ) in derivation of P _{KK} (ic) by 1987Sc30.
(264.6 $\pm$ 20)	0.0	5. $\times$ 10 ⁻⁷ 5	14.8 5	5. $\times$ 10 ⁻⁷ 5	I ϵ : From $\Gamma_{\text{invisible axion}}/\Gamma_{\text{total}}$ (1993Mi20). Other: <0.0036 from log ft systematics (1973Ra10).

[†] Absolute intensity per 100 decays.

$\ddagger$ Existence of this branch is questionable.

¹³⁹Ce ε Decay (137.641 d) 2008BeZV (continued)

 $\gamma(^{139}\text{La})$

$I\gamma(\text{K}\alpha \text{ x ray})/I\gamma(166\gamma)=0.813 \ 20$ and $I\gamma(\text{K}\beta \text{ x ray})/I\gamma(166\gamma)=0.197 \ 6$ (1972Ca07, 4π CsI(Tl)) and $I\gamma(\text{K}\alpha \text{ x ray})/I\gamma(166\gamma)=0.794 \ 11$ (1994Ku43, (x ray) $\gamma(166\gamma)$) are in excellent agreement with 0.798 8 and 0.1942 14 calculated from the decay scheme; $I\gamma(\text{K}\beta \text{ x ray})/I\gamma(166\gamma)=0.1430 \ 21$ (1994Ku43) disagrees.

$I\gamma$ normalization, $I(\gamma+\text{ce})$ normalization: $I\epsilon(\text{to g.s.})<9.7\times 10^{-7}$ (1993Mi20). Other: 0.99988 +12-24 based on log ft systematics (1999BeZQ, 1999BeZS).

$E\gamma$	E(level)	$I\gamma^\S$	Mult. [†]	$\alpha(\text{exp})^\ddagger$	$I(\gamma+\text{ce})^\S$	Comments
165.8575 11	165.8576	79.90 CA	M1	0.2516 7	100	$\alpha(\text{K})\text{exp}=0.2146 \ 10$ (1985HaZA); $\alpha(\text{L})\text{exp}=0.0289 \ 12$ (1976Ha11). $E\gamma$: from 1999Al12 (Intrinsic Ge (LEPS-type); recommended by 2000He14). $I\gamma$: from $I(\gamma+\text{ce})$ and $\alpha(\text{exp})$. Other: 79.95% 6 (1982RuZV, $4\pi\gamma$ pc). $\delta(\text{E2/M1})=+0.034 \ 34$ from 1963Ha07 ((γ, θ, t) and polarization). Others: -0.06 (1961Kn02), <0.02 (1962Gr17). $\alpha(\text{K})\text{exp}$: recommended value based on 0.2148 12 (1962Ta03), 0.214 5 (1975Mo12. Combination of their $\alpha(\text{K})\text{exp}=0.207 \ 9$ and $\alpha(\text{exp})=0.254 \ 6$ (1971Ar43)), 0.214 2 (1975Pl06), and 0.2152 33 (1976Ha11). Theory: $\alpha(\text{K})(\text{M1})=0.223 \ 4$ (BrIcc, 2008Ki07). Other: see 1985HaZA. K/L+: other: 7.4 2 (1965Ge04). K/M+=28 1. L1:L2:L3::1:0.072 3:0.016 1 (1965Ge04). Double K-shell ionization probability= 6.0×10^{-5} 14 (1987Sc30. K x ray-K x ray coin; Ge, NaI). See also comment on $\epsilon(\text{to } 166)$. $\Gamma_{\text{invisible axion}}/\Gamma_\gamma<1.21\times 10^{-6}$ (1993Mi20).

[†] From $\alpha(\text{exp})$ values.

[‡] Recommended value from 1985HaZA based on 0.2514 11 (1962Ta03), 0.254 6 (1971Ar43), 0.251 2 (1975Pl06), 0.252 5 (1976Ha11), and 0.2159 10 (1977Sc38). 0.2446 12 (1973LeZO, 1973Le29) discarded by 1985HaZA. Theory: $\alpha(\text{M1})=0.261$ (BrIcc, 2008Ki07).

[§] Absolute intensity per 100 decays.

¹³⁸Ba(pol p,p),(pol p,p'): IAR 1989Ny02,1977C102

E=9.4–12.4 MeV.

1977C102 measured $\sigma(\theta)$, $A(\theta)$, and excitation functions; polarization $\leq 70\%$, surface barrier detectors, $\theta=40^\circ$, 60° , 90° , 120° , 140° , 160° . Resonance analysis.

1989Ny02 measured $\sigma(\theta)$, $A(\theta)$, and excitation functions; eight Si surface barrier detectors at $\theta=130^\circ$, 140° , 160° , 170° mounted symmetrically left and right of the beam axis. FWHM=45 keV. Resonance analysis.

Others: 1987Sp01, 1985Do18, 1976Da19, 1970Wi18, 1970Se02, 1968Ve07, 1965Vo03.

All data are from 1989Ny02. There is generally good agreement between 1989Ny02 and 1977C102, except as noted.

¹³⁹La Levels

Average spreading width ($\Gamma^\downarrow$)=47 keV 2.

E(level) [†]	$J\pi^\ddagger$	$\Gamma^\ddagger$	$L^\ddagger$	$\Gamma^\downarrow(\text{keV})^\ddagger$	Comments
16177.8	7/2-	65.2 keV 5	3	46.0 8	$E_{\text{lab}}=9995$ keV.
16808.2	3/2-	98 keV 1	1	52 5	$E_{\text{lab}}=10630$ keV.
17263.9	1/2-	89 keV 1	1	50 2	$E_{\text{lab}}=11089$ keV.
17482.3	9/2-	48 keV 4	5	44 7	Γ : other: 80 keV (1977C102). $E_{\text{lab}}=11039$ keV.
17612.3	5/2-	73 keV 1	3	48 4	$E_{\text{lab}}=11440$ keV.
17752.3	13/2+	34 keV 9	6		$E_{\text{lab}}=11581$ keV. E(level): resonance not reported by 1977C102.
17818.8	9/2-	66 keV 11	5	62 14	Γ : other: 130 keV (1977C102). $E_{\text{lab}}=11648$ keV.
17869.4	7/2-	76 keV 3	3	60 9	$E_{\text{lab}}=11699$ keV. Γ : other: 48 keV (1977C102).
17888.3	5/2-	66 keV 2	3	48 13	Γ : other: 126 keV (1977C102). $E_{\text{lab}}=11718$ keV.
17957.8	3/2-	57 keV 6	1	38 16	$E_{\text{lab}}=11788$ keV.
18019.3?	(9/2-)	118 keV			E(level): resonance reported by 1977C102 only. $E_{\text{lab}}=11850$ keV.
18120.6	7/2-	95 keV 11	3	68 23	$J\pi$: other: 3/2- from 1977C102. $E_{\text{lab}}=11952$ keV.
18140.4	5/2-	57 keV 4	3	53 11	Γ : other: 113 keV (1977C102). $E_{\text{lab}}=11972$ keV.
18293.3	7/2-	64 keV 5	3		Γ : other: 90 keV (1977C102). $E_{\text{lab}}=12126$ keV.
18335.0	3/2-	94 keV 5	1		$E_{\text{lab}}=12168$ keV.
18358.9	5/2-	68 keV 5	3		$E_{\text{lab}}=12192$ keV.
18363.81	1/2-	84 keV 4	1		$E_{\text{lab}}=12197$ keV.
(18512.7 [§])	(5/2-)	76 keV	(3)		$E_{\text{lab}}=12347$ keV.
(18624.9 [§])	(3/2-)	2 keV	(1)		$E_{\text{lab}}=12460$ keV.

[†] S(p)=6255.7 23 (2012Wa38).

[‡] From resonance analysis.

[§] These resonances were not fitted in the analysis but are necessary for a good fit to the data (1989Ny02).

$^{138}\text{Ba}(^3\text{He},\text{d}),(\alpha,\text{t})$ 1971Wi041971Wi04: $E(^3\text{He})=40.3$ MeV. Measured $\sigma(\theta)$; FWHM=35. DWBA.1973Na08: $E(^3\text{He})=22$ MeV; $E\alpha=27$ MeV. Measured $\sigma(\theta)$. Observed g.s., 166, and 1420. ^{139}La Levels

E(level)	$J\pi^\dagger$	L	C ² S
0.0	7/2+	4	0.54
166 2	5/2+	2	0.90
1210 10	1/2+	0	0.10
1420 12	11/2-	5 $\ddagger$	0.71
1560 13	3/2+	2	0.07
1780 15	1/2+, 3/2+	0+2	0.67, 0.83
1850 15	3/2+	2	0.30
1960 16	3/2+	2	0.19
2240 18	3/2+	2	0.10
2310 19	1/2+	0	0.13

 † Assumed for extraction of C²S. $\ddagger$ $\sigma(\text{t},45^\circ)/\sigma(\text{d},30^\circ)$ agrees with L=5 (1973Na08). **$^{138}\text{Ba}(^7\text{Li},^6\text{He})$ 1980Cl08**E=52 MeV. Measured $\sigma(\theta)$; mag spect, pc. FWHM=70 keV. DWBA. ^{139}La Levels

E(level)	$J\pi^\dagger$	L	C ² S	Comments
0.0	7/2+	4	0.72 17	
166	5/2+ $\ddagger$	2	1.03 15	
1210	1/2+	0	0.14 4	
1420	11/2-	5	1.19 22	
1560	5/2+ $\ddagger$	2	0.06 2	
1770	1/2+, 3/2+	0+2	0.28+1.22	C ² S: $\Delta\text{C}^2\text{S}=0.04,0.18$.
1850	3/2+ $\ddagger$	2	0.43 8	
1960	3/2+ $\ddagger$	2	0.28 6	
2240	3/2+, 7/2+	2+4	0.12+0.24	C ² S: $\Delta\text{C}^2\text{S}=0.04,0.08$.
2310	1/2+	0	0.15 5	
2400	11/2-	(5)	0.21 7	

 † Assumed for extraction of C²S, except as noted. $\ddagger$ From comparison of $\sigma(\theta)$ to DWBA calculations. $\sigma(\theta)$ seems to distinguish between $d_{3/2}$ and $d_{5/2}$.

$^{138}\text{La}(\text{n},\gamma),(\text{n},\text{n}): \text{Resonances}$ 2006MuZX $J\pi(^{138}\text{La g.s.})=5+$. g =statistical weight factor. $S(\text{n})(^{139}\text{La})=8778.0\ 26$ (2012Wa38). ^{139}La Levels

E(level)	$J\pi$	L	$2g\Gamma_{\text{n}}$ eV	Comments
8758.1?	(11/2)	0		E(level): fictitious level.
				$\Gamma_{\gamma}=(0.095)$ eV. $E(\text{n})_{\text{Lab}}=-20$ keV.
8781.0 1		[0]	0.00130 5	$\Gamma_{\gamma}=0.095$ eV 6. $E(\text{n})_{\text{Lab}}=2.99$ keV.
8798.9 1		[0]	0.0042 2	$E(\text{n})_{\text{Lab}}=21$ keV.
8844.6 3		[0]	0.016 1	$E(\text{n})_{\text{Lab}}=67.1$ keV.
8867.5 4		[0]	0.019 1	$E(\text{n})_{\text{Lab}}=90.2$ keV.
8908.5 7		[0]	0.053 3	$E(\text{n})_{\text{Lab}}=131.5$ keV.
8996.4 1		[0]	0.140 15	$E(\text{n})_{\text{Lab}}=220$ keV.
9016.3 2		[0]	0.31 3	$E(\text{n})_{\text{Lab}}=240$ keV.
9037.1 2		[0]	0.36 4	$E(\text{n})_{\text{Lab}}=261$ keV.
9082.7 3		[0]	0.63 5	$E(\text{n})_{\text{Lab}}=307$ keV.
9131.4 3		[0]	0.23 4	$E(\text{n})_{\text{Lab}}=356$ keV.

 $^{138}\text{La}(\text{d},\text{p})$ 1971Du02Target $J\pi=5+$. Measured: $\sigma(\theta)$; $\theta=45^\circ$, 65° , 72° , 78° , and 92° , FWHM=11. DWBA. ^{139}La Levels

E(level)	$J\pi$	L	Comments
0.0		2	
1535 4			
3147 4			
3355 2		†	
3375 2		†	
3433 2			
3485 2		3	
3517 2		3	
3555 2		3	
3611 2		3	
3688 [‡] 2		3	
3748 2		3	
3785 2		3	
3805 2		3	
3841 2			
3868 2			
3905 2		3	
3927 2	(17/2)-	3	$J\pi: (17/2)-$ from comparison with theory.
3952 2		3	
3980 [‡] 2		3	
4014 2		3	
4095 2		3	
4148 2		3	
4230 2		3	
4336 2		(1+3)	
4394 2		(1+3)	

† L=3 for doublet.

‡ Possible doublet.

¹³⁹La(γ, γ'): E=1.2-4.1 MeV 2007Sc18

2007Sc18: E(end-point)=4.1 MeV. Bremsstrahlung beam using 4.3 MV Stuttgart DYNAMITRON accelerator. Measured E γ , I γ using three HPGe detectors at angles of 90°, 127° and 150°.

¹³⁹La Levels

E(level)	J $\pi^{\#}$	$g\Gamma_0^{\S}$	I $_{s,0}$ (eV b) ‡	Comments
0.0	7/2+			
165.9	5/2+			
1216? †		0.41 $\times 10^{-3}$ eV 11	1.1 3	B(E1) $\uparrow$ =0.22 $\times 10^{-5}$ 6; B(M1) $\uparrow$ =0.020 6.
1219		0.85 $\times 10^{-3}$ eV 14	2.0 4	B(M1) $\uparrow$ =0.041 7.
1381 †		0.68 $\times 10^{-3}$ eV 18	0.0	B(E1) $\uparrow$ =0.25 $\times 10^{-5}$ 7; B(M1) $\uparrow$ =0.022 6.
1420		1.67 $\times 10^{-3}$ eV 17	2.9 3	B(M1) $\uparrow$ =0.050 5.
1538		0.0075 eV 4	8.2 6	One peak likely consists of both transitions. B(M1) $\uparrow$ =0.179 9.
1578		0.0042 eV 3	6.4 5	B(E1) $\uparrow$ =1.02 $\times 10^{-5}$ 8; B(M1) $\uparrow$ =0.092 7. Two states given in literature, peak is likely a combination of both.
1683		1.33 $\times 10^{-3}$ eV 20	1.8 3	B(M1) $\uparrow$ =0.024 4.
1714		1.01 $\times 10^{-3}$ eV 16	0.85 21	B(M1) $\uparrow$ =0.017 3.
1740		0.52 $\times 10^{-3}$ eV 15	0.66 19	B(E1) $\uparrow$ =0.10 $\times 10^{-5}$ 3; B(M1) $\uparrow$ =0.009 2.
1854		0.84 $\times 10^{-3}$ eV 16	0.94 18	B(E1) $\uparrow$ =0.13 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.011 2.
1921		0.0027 eV 3	0.90 19	B(E1) $\uparrow$ =0.36 $\times 10^{-5}$ 4; B(M1) $\uparrow$ =0.033 3.
1980		0.65 $\times 10^{-3}$ eV 18	0.63 17	B(E1) $\uparrow$ =0.08 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.007 2.
2059		0.0036 eV 3	0.81 15	B(E1) $\uparrow$ =0.39 $\times 10^{-5}$ 3; B(M1) $\uparrow$ =0.035 3.
2136		0.85 $\times 10^{-3}$ eV 21	0.72 18	B(E1) $\uparrow$ =0.08 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.008 2.
2152		0.87 $\times 10^{-3}$ eV 17	0.72 14	B(E1) $\uparrow$ =0.08 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.008 2.
2276		1.19 $\times 10^{-3}$ eV 18	0.88 13	B(E1) $\uparrow$ =0.10 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.009 1.
2313		1.00 $\times 10^{-3}$ eV 18	0.72 13	B(E1) $\uparrow$ =0.08 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.007 1.
2357		0.75 $\times 10^{-3}$ eV 18	0.52 13	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.005 1.
2385		1.38 $\times 10^{-3}$ eV 19	0.93 13	B(E1) $\uparrow$ =0.10 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.009 1.
2440		0.61 $\times 10^{-3}$ eV 17	0.40 11	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
2448		0.88 $\times 10^{-3}$ eV 22	0.56 14	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.005 1.
2573		0.68 $\times 10^{-3}$ eV 18	0.39 11	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
2600		0.79 $\times 10^{-3}$ eV 22	0.45 12	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
2685		0.75 $\times 10^{-3}$ eV 19	0.40 10	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
2705		0.88 $\times 10^{-3}$ eV 21	0.46 11	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
2712? †		0.0012 eV 3	0.63 16	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.005 1.
2724		1.23 $\times 10^{-3}$ eV 21	0.64 11	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.005 1.
2747		1.38 $\times 10^{-3}$ eV 22	0.70 11	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.006 1.
2774		0.0025 eV 3	1.25 14	B(E1) $\uparrow$ =0.11 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.010 1.
2800		0.0021 eV 3	0.48 10	B(E1) $\uparrow$ =0.09 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.008 1.
2811		0.96 $\times 10^{-3}$ eV 21	0.47 10	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
2828		1.33 $\times 10^{-3}$ eV 21	0.64 10	B(E1) $\uparrow$ =0.06 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.005 1.
2862		17.7 $\times 10^{-3}$ eV 12	7.6 6	B(E1) $\uparrow$ =0.72 $\times 10^{-5}$ 5; B(M1) $\uparrow$ =0.065 5.
2868		0.94 $\times 10^{-3}$ eV 23	0.44 11	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
2877? †		1.7 $\times 10^{-3}$ eV 3	0.40 12	B(E1) $\uparrow$ =0.07 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.006 1.
2928? †		1.13 $\times 10^{-3}$ eV 23	0.51 10	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
2964		0.88 $\times 10^{-3}$ eV 21	0.38 9	B(E1) $\uparrow$ =0.03 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
2972		0.0010 eV 3	0.42 12	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
2990		0.0052 eV 4	2.24 19	B(E1) $\uparrow$ =0.19 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.017 1.
3043 †		0.0027 eV 4	0.72 12	$g\Gamma_0$: 0.0017 eV 3 for alternative assignments. B(E1) $\uparrow$ =0.09 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.008 1. or B(E1)=0.06 $\times 10^{-5}$ 1, B(M1)=0.005 1, depending on alternative placement of γ rays.
3053		0.0059 eV 5	2.41 20	B(E1) $\uparrow$ =0.20 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.018 2.
3077		1.17 $\times 10^{-3}$ eV 25	0.48 10	B(E1) $\uparrow$ =0.04 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
3095? †		3.1 $\times 10^{-3}$ eV 4	0.65 11	$g\Gamma_0$: 0.003 eV 4 for alternative assignments. B(E1) $\uparrow$ =0.10 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.009 1.
3114		0.0085 eV 7	2.69 23	B(E1) $\uparrow$ =0.27 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.024 2.
3196? †		0.0016 eV 3	0.61 11	B(E1) $\uparrow$ =0.05 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.004 1.
3221		27.0 $\times 10^{-3}$ eV 20	10.0 7	B(E1) $\uparrow$ =0.77 $\times 10^{-5}$ 6; B(M1) $\uparrow$ =0.070 5.
3252		0.0011 eV 3	0.40 12	B(E1) $\uparrow$ =0.03 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.003 1.
3262 †		0.0060 eV 5	1.38 15	$g\Gamma_0$: 0.0038 eV 4 for alternative assignments. B(E1) $\uparrow$ =0.16 $\times 10^{-5}$ 2; B(M1) $\uparrow$ =0.015 1. or B(E1)=0.11 $\times 10^{-5}$ 1, B(M1)=0.10 1, depending on alternative placements of γ rays.
3275		0.0019 eV 4	0.69 15	B(E1) $\uparrow$ =0.05 $\times 10^{-5}$ 1; B(M1) $\uparrow$ =0.005 1.

Continued on next page (footnotes at end of table)

¹³⁹La(γ, γ'): E=1.2-4.1 MeV 2007Sc18 (continued)

¹³⁹La Levels (continued)

E(level)	$g\Gamma_0^\S$	$I_{s,0}$ (eV b) [‡]	Comments
3303	0.0017 eV 3	0.59 11	B(E1) $\uparrow$ =0.04 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.004 1.
3351	0.0015 eV 4	0.50 12	B(E1) $\uparrow$ =0.04 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.004 1.
3361?†	4.1 $\times$ 10 ⁻³ eV 5	1.38 15	$I_{s,0}$ (eV b): 0.64 12 for alternative assignments. B(E1) $\uparrow$ =0.10 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.009 1.
3370	13.9 $\times$ 10 ⁻³ eV 11	4.7 4	B(E1) $\uparrow$ =0.35 $\times$ 10 ⁻⁵ 3; B(M1) $\uparrow$ =0.032 3.
3401	0.0043 eV 6	0.83 15	B(E1) $\uparrow$ =0.011 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.001 1.
3445	0.0016 eV 5	0.52 15	B(E1) $\uparrow$ =0.04 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.003 1.
3458	0.0062 eV 6	0.80 12	B(E1) $\uparrow$ =0.14 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.013 1.
3475	0.0015 eV 4	0.47 14	B(E1) $\uparrow$ =0.03 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.003 1.
3483	14.9 $\times$ 10 ⁻³ eV 11	3.8 3	B(E1) $\uparrow$ =0.34 $\times$ 10 ⁻⁵ 3; B(M1) $\uparrow$ =0.030 2.
3523	0.0058 eV 7	1.81 22	B(E1) $\uparrow$ =0.13 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.012 1.
3527†	0.0057 eV 7	0.95 17	B(E1) $\uparrow$ =0.12 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.011 2. or B(E1)=0.07 $\times$ 10 ⁻⁵ 1, B(M1)=0.006 1, depending on alternative placements of γ rays.
3544	0.0084 eV 7	1.39 16	$g\Gamma_0$: or 3.1 $\times$ 10 ⁻³ eV 6 for alternative assignments. B(E1) $\uparrow$ =0.18 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.016 1.
3557	0.034 eV 3	9.8 8	B(E1) $\uparrow$ =0.73 $\times$ 10 ⁻⁵ 5; B(M1) $\uparrow$ =0.066 5.
3561	20.3 $\times$ 10 ⁻³ eV 19	1.5 3	B(E1) $\uparrow$ =0.43 $\times$ 10 ⁻⁵ 4; B(M1) $\uparrow$ =0.039 4.
3573	0.050 eV 3	14.1 10	B(E1) $\uparrow$ =1.04 $\times$ 10 ⁻⁵ 7; B(M1) $\uparrow$ =0.094 7.
3586	0.0083 eV 8	2.49 23	B(E1) $\uparrow$ =0.17 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.016 1.
3631	0.040 eV 3	11.7 9	B(E1) $\uparrow$ =0.80 $\times$ 10 ⁻⁵ 6; B(M1) $\uparrow$ =0.073 5.
3664	0.0018 eV 5	0.52 13	B(E1) $\uparrow$ =0.04 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.003 1.
3732	0.0021 eV 7	0.57 19	B(E1) $\uparrow$ =0.04 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.003 1.
3790	0.0050 eV 8	1.35 20	B(E1) $\uparrow$ =0.09 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.008 1.
3799	0.0031 eV 7	0.83 18	B(E1) $\uparrow$ =0.05 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.005 1.
3832	0.0043 eV 8	1.12 20	B(E1) $\uparrow$ =0.07 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.007 1.
3854	7.8 $\times$ 10 ⁻³ eV 10	2.0 3	B(E1) $\uparrow$ =0.13 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.012 2.
3878	0.0032 eV 9	0.81 22	B(E1) $\uparrow$ =0.05 $\times$ 10 ⁻⁵ 1; B(M1) $\uparrow$ =0.005 1.
3886	2.8 $\times$ 10 ⁻³ eV 10	0.7 3	B(E1) $\uparrow$ =0.05 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.004 2.
3919	4.7 $\times$ 10 ⁻³ eV 11	1.2 3	B(E1) $\uparrow$ =0.07 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.007 2.
3931	15.4 $\times$ 10 ⁻³ eV 20	3.8 5	B(E1) $\uparrow$ =0.24 $\times$ 10 ⁻⁵ 3; B(M1) $\uparrow$ =0.022 3.
3941	5.6 $\times$ 10 ⁻³ eV 14	1.4 3	B(E1) $\uparrow$ =0.09 $\times$ 10 ⁻⁵ 2; B(M1) $\uparrow$ =0.008 2.
3963	7.6 $\times$ 10 ⁻³ eV 19	1.9 5	B(E1) $\uparrow$ =0.12 $\times$ 10 ⁻⁵ 3; B(M1) $\uparrow$ =0.011 3.

† Alternative assignments possible for γ transition(s).

‡ Integrated cross section.

§ g=statistical weight factor.

From Adopted Levels.

$\gamma(^{139}\text{La})$

E(level)	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	Comments
1216?	1216@	100	
1219	1053	10	
	1219	90# 15	
1381	1216\$@	95#	
	1381	5# 1	
1420	1254	9	
	1420	91# 9	
1538	1372	33	
	1538	67# 3	I_γ : transition width likely overestimated, should be treated as upper limit. Note that in 2001Bu16 evaluation, Γ_0/Γ =0.50 7, not 0.67 3 as quoted by 2007Sc18.
1578	1578	100	
1683	1517	2	
	1683	98# 15	
1714	294&	36	E_γ : questionable γ taken from (n,n' γ); not included in Adopted Gammas.
	1714	64# 10	
1740	1740	100	
1854	1854	100	
1921	1755	68	
	1921	32# 13	I_γ : note that in 2001Bu16 evaluation, Γ_0/Γ =0.55 9, not 0.32 13 as quoted by 2007Sc18.

Continued on next page (footnotes at end of table)

¹³⁹La(γ, γ'): E=1.2-4.1 MeV 2007Sc18 (continued)

 $\gamma(^{139}\text{La})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Comments
1980	1980	100	
2059	1893	75	
	2059	25 [#] 7	I γ : Note that in 2001Bu16 evaluation, $\Gamma_0/\Gamma=0.71$ 36 not 0.25 7 as quoted by 2007Sc18.
2136	2136	100	
2152	2152	100	
2276	2276	100	
2313	2313	100	
2357	2357	100	
2385	2385	100	
2440	2440	100	
2448	2448	100	
2573	2573	100	
2600	2600	100	
2685	2685	100	
2705	2705	100	
2712?	2712 [@]	100	
2724	2724	100	
2747	2747	100	
2774	2774	100	
2800	2634	54	
	2800	46 14	
2811	2811	100	
2828	2828	100	
2862	2696	9	
	2862	91 17	
2868	2868	100	
2877?	2712 [@]	48	
	2877 ^{§@}	52 10	
2928?	2928 [@]	100	
2964	2964	100	
2972	2972	100	
2990	2990	100	
3043	2877 [@]	37	
	3043 [§]	63 9	I γ : other: 100 if 2877 has alternate placement.
3053	3053	100	
3077	3077	100	
3095?	2928 [@]	48	
	3095 [@]	52 7	
3114	2948	20	
	3114	80 15	
3196?	3196 [@]	100	
3221	3221	100	
3252	3252	100	
3262	3095 [@]	36	
	3262 [§]	64 13	I γ : other: 100 if 3096 has alternate placement.
3275	3275	100	
3303	3303	100	
3351	3351	100	
3361?	3196 [@]	54	
	3361 [@]	46 6	
3370	3370	100	
3401	3235	42	
	3401	58 16	
3445	3445	100	
3458	3292	60	
	3458	40 8	
3475	3475	100	
3483	3317	19	
	3483	81 15	
3523	3523	100	
3527	3361 [@]	46	
	3527 [§]	54 14	I γ : other: 100 if 3361 has alternate placement.
3544	3378	46	

Continued on next page (footnotes at end of table)

¹³⁹La(γ,γ'): E=1.2-4.1 MeV 2007Sc18 (continued)

$\gamma(^{139}\text{La})$ (continued)

E(level)	E $\gamma^\dagger$	I $\gamma^\ddagger$	E(level)	E $\gamma^\dagger$	I $\gamma^\ddagger$	E(level)	E $\gamma^\dagger$	I $\gamma^\ddagger$
3544	3544	54 10	3586	3586	100	3854	3854	100
3557	3391	6	3631	3631	100	3878	3878	100
	3557	94 30	3664	3664	100	3886	3886	100
3561	3395	76	3732	3732	100	3919	3919	100
	3561	24 5	3790	3790	100	3931	3931	100
3573	3407	6	3799	3799	100	3941	3941	100
	3573	94 19	3832	3832	100	3963	3963	100

[†] From level-energy differences.

[‡] Branching ratios. Evaluators assume transitions to only the ground state and the first excited state at 165.9 keV, when branching ratios are deduced from Γ_0/Γ values in 2007Sc18.

[§] Alternative assignments possible.

[#] 2007Sc18 state that Γ_0/Γ is from 2001Bu16 evaluation (Nuclear Data Sheets for A=139), but the evaluators note that in some cases, as noted, values do not match.

[@] Multiply placed.

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

¹³⁹La(γ,γ'): E=5.4-11.5 MeV 2010Ma40

2010Ma40: E(end-point)=11.5 MeV. Bremsstrahlung beam using superconducting electron accelerator ELBE at Rossendorf (FZD). Measured E γ , I γ using four Compton-suppressed HPGe detectors, two at 90°, and the other two at 127° relative to the beam direction.

¹³⁹La Levels

E(level)	J π	$g\Gamma_0^2/\Gamma$ (eV) [‡]	I $_s$ (eVb) [†]	E(level)	$g\Gamma_0^2/\Gamma$ (eV) [‡]	I $_s$ (eVb) [†]
0.0	7/2+			6260.2 20	0.27 eV 8	27 8
5380.6 6		0.15 eV 5	20 6	6269.5 12	0.60 eV 11	58 11
5389.8 12		0.10 eV 6	13 8	6301.1 6	0.42 eV 7	41 6
5406.8 13		0.12 eV 9	16 11	6326.1 6	0.50 eV 7	47 7
5423.1 7		0.19 eV 6	25 8	6354.8 5	0.80 eV 10	76 10
5545.4 7		0.055 eV 25	7 3	6366.5 10	0.37 eV 7	35 7
5552.7 9		0.04 eV 3	5 3	6383.5 5	0.57 eV 14	54 14
5572.0 11		0.15 eV 8	19 10	6402.6 9	0.9 eV 3	81 33
5582.1 10		0.14 eV 6	17 8	6435.2 20	0.20 eV 8	19 8
5594.8 7		0.21 eV 6	25 7	6441.9 11	0.57 eV 12	53 11
5620.4 8		0.11 eV 4	13 5	6450.9 4	0.96 eV 13	89 12
5658.8 7		0.16 eV 4	19 5	6465.3 7	0.35 eV 8	33 7
5688.1 5		0.09 eV 3	10 4	6483.8 16	0.38 eV 21	35 20
5708.6 7		0.21 eV 9	24 11	6491.3 8	0.57 eV 25	52 22
5716.5 6		0.30 eV 13	35 15	6501.4 6	0.54 eV 20	49 18
5723.0 3		0.41 eV 21	48 24	6526.7 6	0.37 eV 6	33 5
5811.3 8		0.13 eV 9	15 10	6539.6 5	0.54 eV 7	49 7
5830.9 9		0.09 eV 4	10 5	6549.6 8	0.32 eV 6	28 5
5848.9 6		0.13 eV 4	15 5	6619.4 6	0.13 eV 5	12 4
5940.2 8		0.26 eV 8	29 9	6651.3 7	0.59 eV 14	52 12
5984.1 20		0.06 eV 4	7 4	6674.8 8	0.30 eV 11	26 9
6015.5 8		0.18 eV 5	19 5	6713.0 6	0.52 eV 9	44 8
6047.1 14		0.10 eV 4	11 4	6723.8 15	0.18 eV 6	15 5
6077.9 11		0.31 eV 9	33 9	6755.8 7	0.77 eV 17	65 15
6097.8 12		0.33 eV 8	34 8	6767.6 18	0.33 eV 10	28 8
6112.0 15		0.26 eV 7	26 7	6875.4 8	0.7 eV 3	59 23
6131.1 9		0.36 eV 8	37 8	6889.9 8	0.73 eV 21	59 17
6150.8 10		0.33 eV 8	34 8	6901.1 10	0.56 eV 16	45 13
6178.3		0.13 eV 5	13 5	6926.3 8	0.9 eV 5	72 40
6194.1 9		0.46 eV 8	46 8	6969.0 6	0.36 eV 10	28 7
6214.2 5		0.83 eV 11	82 10	6983.4 7	0.29 eV 7	23 6
6233.3 8		0.49 eV 8	48 8	7019.7 10	0.19 eV 6	15 4
6249.2 20		0.23 eV 7	23 7	7036.1 9	0.22 eV 6	17 4

Continued on next page (footnotes at end of table)

¹³⁹La(γ,γ'): E=5.4-11.5 MeV 2010Ma40 (continued)

¹³⁹La Levels (continued)

E(level)	$g\Gamma^2_0/\Gamma$ (eV) [‡]	I_s (eVb) [†]	E(level)	$g\Gamma^2_0/\Gamma$ (eV) [‡]	I_s (eVb) [†]
7052.4 7	0.27 eV 6	21 5	7599.1 7	0.26 eV 6	18 4
7154.0 11	0.14 eV 4	10 3	7636.2 5	0.13 eV 4	9 3
7158 3	0.10 eV 4	8 3	7661.3 18	0.13 eV 8	8 5
7272.8 15	0.12 eV 9	8 7	7667 3	0.38 eV 8	25 5
7320.0 8	0.19 eV 7	14 5	7678.6 16	0.24 eV 4	16 2
7327.2 8	0.19 eV 6	14 4	7684.7 9	0.42 eV 5	27 3
7370.0 8	0.25 eV 6	18 4	7692.4 12	0.33 eV 4	21 2
7400.0 7	0.32 eV 6	22 4	7699 3	0.13 eV 3	9 2
7414.0 7	0.34 eV 7	24 5	7765.1 13	0.10 eV 7	6 5
7444.9 12	0.27 eV 9	18 6	7789.4 13	0.10 eV 6	6 4
7451.1 9	0.36 eV 10	25 7	7905.2 6	0.37 eV 9	23 6
7462.8 7	0.34 eV 9	23 6	7912.5 7	0.37 eV 4	23 3
7472.0 9	0.29 eV 10	20 7	7922.2 9	0.28 eV 9	17 5
7506.7 7	0.44 eV 9	30 6	7961 3	0.08 eV 5	5 3
7552.7 8	0.24 eV 9	16 6	7972.3 7	0.35 eV 8	21 5
7562.1 4	0.22 eV 8	15 5	8551.5 6	0.13 eV 5	7 3
7570.2 11	0.17 eV 6	12 4	8595.7 5	0.19 eV 5	10 2
7579.8 6	0.31 eV 7	21 5			
7591.6 11	0.18 eV 5	12 4			

[†] Energy-integrated cross section deduced from intensities at 127°.

[‡] Partial width of g.s. transition, $g=(2J+1)/(2J(\text{target})+1)$, where $J(\text{target})=7/2$.

$\gamma(^{139}\text{La})$

$E\gamma^\dagger$	E(level)	$E\gamma^\dagger$	E(level)	$E\gamma^\dagger$	E(level)
5380.5 6	5380.6	6300.9 6	6301.1	7272.6 15	7272.8
5389.7 12	5389.8	6325.9 6	6326.1	7319.8 8	7320.0
5406.7 13	5406.8	6354.6 5	6354.8	7327.0 8	7327.2
5423.0 7	5423.1	6366.3 10	6366.5	7369.8 8	7370.0
5545.3 7	5545.4	6383.3 5	6383.5	7399.8 7	7400.0
5552.6 9	5552.7	6402.4 9	6402.6	7413.8 7	7414.0
5571.9 11	5572.0	6435 2	6435.2	7444.7 12	7444.9
5582.0 10	5582.1	6441.7 11	6441.9	7450.9 9	7451.1
5594.7 7	5594.8	6450.7 4	6450.9	7462.6 7	7462.8
5620.3 8	5620.4	6465.1 7	6465.3	7471.8 9	7472.0
5658.7 7	5658.8	6483.6 16	6483.8	7506.5 7	7506.7
5688.0 5	5688.1	6491.1 8	6491.3	7552.5 8	7552.7
5708.5 7	5708.6	6501.2 6	6501.4	7561.9 4	7562.1
5716.4 6	5716.5	6526.5 6	6526.7	7570.0 11	7570.2
5722.9 3	5723.0	6539.4 5	6539.6	7579.6 6	7579.8
5811.2 8	5811.3	6549.4 8	6549.6	7591.4 11	7591.6
5830.8 9	5830.9	6619.2 6	6619.4	7598.9 7	7599.1
5848.8 6	5848.9	6651.1 7	6651.3	7636.0 5	7636.2
5940.1 8	5940.2	6674.6 8	6674.8	7661.1 18	7661.3
5984 2	5984.1	6712.8 6	6713.0	7667 3	7667
6015.4 8	6015.5	6723.6 15	6723.8	7678.4 16	7678.6
6047.0 14	6047.1	6755.6 7	6755.8	7684.5 9	7684.7
6077.8 11	6077.9	6767.4 18	6767.6	7692.2 12	7692.4
6097.7 12	6097.8	6875.2 8	6875.4	7699 3	7699
6111.9 15	6112.0	6889.7 8	6889.9	7764.9 13	7765.1
6131.0 9	6131.1	6900.9 10	6901.1	7789.2 13	7789.4
6150.7 10	6150.8	6926.1 8	6926.3	7905.0 6	7905.2
6178 3	6178	6968.8 6	6969.0	7912.3 7	7912.5
6194.0 9	6194.1	6983.2 7	6983.4	7922.0 9	7922.2
6214.1 5	6214.2	7019.5 10	7019.7	7961 3	7961
6233.1 8	6233.3	7035.9 9	7036.1	7972.1 7	7972.3
6249 2	6249.2	7052.2 7	7052.4	8551.2 6	8551.5
6260 2	6260.2	7153.8 11	7154.0	8595.4 5	8595.7
6269.3 12	6269.5	7158 3	7158		

[†] Deduced by evaluators from level energies with recoil correction removed.

¹³⁹La(γ,γ'): E=6.0-8.6 MeV 1972Wo21,1970Sz01,1970Mo30

E=6.0-8.6 MeV.

1970Mo30: E=6.0-7.7 MeV from (n, γ) on Ti and Fe. Measured γ 's, $\gamma(\theta)$ and effective elastic cross section (NaI,Ge(Li)) and resonance γ polarization (Compton polarimeter).

1970Sz01: E=6.1-8.6 MeV from (n, γ) on Cl, Ti, Ni, Cu. Measured γ 's, $\gamma(\theta)$, and intensity ratios at T=77° K and room temperature. See also (γ,γ').

1972Wo21: E=6.0-7.7 MeV from (n, γ) on Ti and Fe. Measured resonance γ 's and $\gamma(\theta)$, γ polarization (Compton polarimeter), temperature variation of σ , and nuclear self-absorption.

1993BeZW: Cl(n, γ) source. Measured resonance γ 's.

¹³⁹La Levels

E(level) ^b	J π [†]	Γ [‡]	Comments
0.0	7/2+§		
166.6 13	5/2+§		
1184 4	(5/2)+§		
1218.0 9	9/2(+)		J π : from $\gamma(\theta)$ (1970Sz01).
1257?	(5/2)+§		
1385.4 13	(7/2)		J π : 7/2,11/2 from 5034 $\gamma(\theta)$ and 7/2,9/2 from γ 's from 7/2 and 9/2 resonances (1970Mo30). Evaluators note that 5034 $\gamma(\theta)$ may also be consistent with 9/2.
1423.9 12	7/2,11/2		
1477.6 13	(9/2+)§		
1541.4 10	7/2§		
1581.0 13	9/2		J π : 5/2,9/2 from 4838,4438 $\gamma(\theta)$ and 7/2,9/2 from γ 's from 7/2 and 9/2 resonances (1970Mo30).
1687.3 13	7/2,11/2		J π : from $\gamma(\theta)$ (1970Sz01).
1714 4	5/2+§		
1759 5	7/2#		
1774.0 ^a 14	3/2+,5/2+§		
1837 4			
1860.1 ^a 14	3/2+,5/2+§		
1898.1 ^a 14			
1919 ^a			
1956 ^a			
2064.2 14			
2123			
2163.2 14			
2232 ^a 5	(7/2,11/2)		
2291 5			
2390 5	(7/2+)§		
6018.0 17	7/2-@	0.051 eV +14-6	
6119.2 ^{&a} 9	9/2(-)	0.068 eV 34	J π : 9/2 from $\gamma(\theta)$ (1970Sz01). $\pi=(-)$ since E1 absorption is generally two orders of magnitude larger than M1 for heavier nuclei. Γ : from $\Gamma_0=0.025$ eV 10 and $\Gamma_0/\Gamma=0.37$ 11 (1993BeZW). Other: ≤ 0.022 eV 17 (1970Sz01) from $\Gamma_0^2/\Gamma=0.015$ eV and $\Gamma_0/\Gamma \geq 0.43$ 1.
6420.4 24	9/2-@	0.081 eV +13-7	
6764.4 17	7/2		$\Gamma_\gamma \geq 0.060$ eV (1970Sz01). Γ_γ : From source line-resonant level spacing < 8 eV and elastic scattering effective $\sigma=7$ mb.
7279 3			
7637 4	7/2-@	0.17 eV 4	Γ : from $\Gamma_0/\Gamma=0.28$ 4 and $\Gamma_0=0.047$ 6, both in 1972Wo21.
8528.0 ^a 8			
8581.4 ^{&a} 13	7/2,9/2		J π : from γ 's to 7/2+ and 9/2 (1970Sz01).

[†] From $\gamma(\theta)$ of 1970Mo30, except as noted.

[‡] From J, branching ratios, and effective elastic cross sections.

§ From the Adopted Levels.

From $\gamma(\theta)$ (1970Sz01).

@ From $\gamma(\theta)$ and polarization of elastically scattered γ (1970Mo30).

& From 1993BeZW.

^a From 1970Sz01.

^b From 1970Mo30, unless otherwise mentioned.

¹³⁹La(γ, γ'): E=6.0-8.6 MeV 1972Wo21,1970Sz01,1970Mo30 (continued)

 $\gamma(^{139}\text{La})$
 Γ_γ values are from 1972Wo21.

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult. [‡]	$\delta^\ddagger$	Comments
	^x 3646 4				
	^x 3678 4				
	^x 3689 4				
	^x 3810 4				
	^x 3888 4				
	^x 3954 4				
	^x 3980 4				
	^x 4012 4				
	^x 4037 4				
	^x 4233 4				
	^x 4239 4				
	^x 4391 4				
	^x 4448 4				
	^x 4480 4				
	^x 4580 4				
	^x 4615 4				
1218.0	1219 [§] 2	100 [§]			
1423.9	1419 [§] 2	100 [§]			
1541.4	1536 [§] 6	100 [§]			
1581.0	1572 [§] 9	100 [§]			
1687.3	1680 [§] 9	100 [§]			
1759	1760 [§] 10	100 [§]			
1774.0	1600 [§] 9	100 [§]			
6018.0	3895 4	1.1			
	4062 4	1.1			
	4334 4	13.6			
	4438 4	27.9	D(+Q)	+0.005 15	
	4481 4	5.8			
	4538 4	4.8			
	4798 4	14.4	D+Q	+0.15 10	
	5852 4	21.5	(E1(+M2))	-0.02 6	Mult.: from $\gamma(\theta)$ and $I\gamma/E\gamma^3$ (1970Mo30).
	6018 4	100	E1(+M2) [#]	-0.01 3	Γ_γ : $\Gamma_0/\Gamma=0.50$ 6 (1972Wo21) compared to 0.52 from decay scheme of 1970Mo30.
6119.2	3956 [§]	8 [§] 2			
	4055 [§]	4 [§] 2			
	4221 [§]	4 [§] 1			
	4259 [§]	4 [§] 1	[M2, E3]		
	4345 [§]	21 [§] 1	[M2, E3]		
	4428 [§]	19 [§] 1			
	4534 [§]	7 [§] 1			
	4575 [§]	5 [§] 1			
	4638 [§]	11 [§] 1			
	4694 ^{§c}	22 ^{§c} 1			
	4734 [§]	9 [§] 1			
	4858 ^{§d}	<2 [§]			
	4896 [§]	19 [§] 1			
	5949 [§]	=1 [§]			
	6115 ^{§b} 2	100 [§] 1			
6420.4	4186 ^{@d} 4	3.0	D(+Q)		δ : $\delta(9/2 \rightarrow 7/2)=+0.07$ 18; $\delta(9/2 \rightarrow 11/2)=+0.01$ 23.
	4356 ^{@d} 4	1.0			
	4459 ^{@d} 4	1.0			
	4498 ^{@d} 4	0.6			
	4580 ^{@d} 4	0.9			
	4661 4	<1 [§]			
	4704 ^{&de} 4	2			
	4838 ^{ad}	4 [§] 1	D(+Q)	-0.1 +3-2	
	4882 4	6 [§] 1	D(+Q)	-0.03 8	
	4999 ^{ad} 4	4 [§] 1	D(+Q)		δ : $\delta(9/2 \rightarrow 7/2)=+0.06$ 12; $\delta(9/2 \rightarrow 11/2)=+0.02$ 4.
	5034 4	2 [§] 1	D(+Q)		δ : $\delta(9/2 \rightarrow 7/2)=+0.10$ 18.
					A_2 : $A_2(\text{theory})=+0.092$ (9/2 $\rightarrow$ 7/2), -0.133 (9/2 $\rightarrow$ 9/2), (9/2 $\rightarrow$ 11/2)=+0.05, assuming pure dipole. Evaluators note that 9/2 $\rightarrow$ 9/2 is not ruled out.

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$^{139}\text{La}(\gamma, \gamma')$: E=6.0–8.6 MeV 1972Wo21,1970Sz01,1970Mo30 (continued) $\gamma(^{139}\text{La})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [‡]	$\delta^{\ddagger}$	Comments
6420.4	6418 4	100 § 1	E1 (+M2) #	-0.001 4	Γ_{γ} : $\Gamma_0/\Gamma=0.78$ 8 (1972Wo21).
6764.4	4704&de	48 § 9			$E\gamma$: from 1970Sz01.
	5075 4	10 § 6			
	5180 4	20 § 6	D (+Q)	+0.03 18	
	5221 4	14 § 6			
	5375 4	68 § 6			
	5502@d 4	60			$E\gamma$: from 1970Sz01.
	5540 4	13 § 6			
	6594 4	100 § 7	D (+Q)	-0.01 6	
	6760 § 4	48 § 7			
7279	5150 4	100			
	5360 4	74			
	5459 4	44			
	5699 4	48			
	7279 4	70			
7637	5867 §	16 § 2			$E\gamma$: 1970Sz01 in level-scheme Fig. 3 show a 5687 γ feeding a 1770 level, but the level-energy difference gives $E\gamma=5867$ keV. It is possible that $E\gamma=5687$ in authors' Fig. 3 is a typo and that it should be 5867 keV, which the evaluators list here.
	7637 4	100 § 6	E1 #		$E\gamma$: from 1970Sz01. Γ_{γ} : $\Gamma_0/\Gamma=0.28$ 4 (1972Wo21) compared to 0.86 2 from decay scheme of 1970Mo30.
8528.0	6985 §	27 § 2			
	7312 §	15 § 2			
	8527 §	100 § 5			
8581.4	7002 §d	9 § 6			
	7363 §	23 § 10			
	8582 §b 3	100 § 2			

[†] $E\gamma$ and relative photon branching from each level are from 1970Mo30, except as noted.

[‡] From $\gamma(\theta)$ of 1970Mo30, except as noted.

§ From 1970Sz01. At $\theta=90^\circ$.

From $\gamma(\theta)$ and polarization (1970Mo30).

@ Not assigned by 1970Sz01.

& Assigned to 6760 resonance by 1970Sz01 and to 6418 resonance by 1970Mo30.

a Ambiguity in placement from 6418 or 6760 resonances. Placed with 6418 based on energy considerations and on $\gamma(\theta)$.

b From 1993BeZW.

c Multiply placed; undivided intensity given.

d Placement of transition in the level scheme is uncertain.

e Multiply placed.

x γ ray not placed in level scheme.

¹³⁹La(n,n'γ),(n,n') 1987Ab17

1987Ab17: E=1.3–2.7 MeV. Measured γ's and γ-excitation functions at 90°; tof, 0.1 MeV steps. Compared compound–nucleus calculations to γ-ray excitation functions. Only gammas which have been placed were listed by 1987Ab17.

Others:

1968Da14: E=2.9 MeV. Measured γ's and γγ-coincidences (Ge(Li),NaI).

1969Ma05: E=2320–2580, ΔE=3. Measured σ(θ=30°–135°); tof, scin. Hauser–Feshbach.

1969Va03: E=0.5–2.3 MeV. Measured γ's; tof. No attempt was made to observe crossover transitions between levels above 1 MeV and a threshold of 200 keV.

1978AhZX: fast reactor spectrum. Measured γ's at 90° for 0.12 MeV≤Eγ≤3.4 MeV.

Decay scheme is based on that proposed by 1987Ab17, except as noted. Other: 1989Sc07.

¹³⁹La Levels

1310 level proposed by 1968Da14 not confirmed.

E(level)	Jπ [†]	Comments
0.0	7/2+ [‡]	
165.86 8	5/2+ [‡]	
1209.0 4	1/2+ [‡] §	
1219.12 10	9/2+ [‡] §	
1256.82 13	5/2+	
1381.30 11	9/2+	
1420.57 [#] 10	5/2+, 7/2+ [‡] @	Jπ: 11/2+ proposed by 1987Ab17 based on excitation functions is inconsistent.
1476.45 16	9/2+	
1536.72& 18	7/2+ [‡] &	
1537.70& 10	11/2+&	
1558.39 15	3/2+	
1578.03 10	(11/2+) [@]	
1683.11 20	9/2+ [@]	
1716.12 10	9/2+ [@]	
1761.2 13	3/2+	
1766.30 25	(5/2)+ [‡]	Jπ: 3/2+ proposed from excitation function in (n,n'γ).
1856.4 4	(9/2+)	
1894.0 5		
1920.74 18	(7/2+)	
1940.85 18	7/2+	
1963.0 4	(3/2+) [‡] §	
2035? ^a 7		
2060.9 5		
2161.19 25		

[†] From comparison of compound–nucleus calculations to γ-ray excitation functions, except as noted.

[‡] From the Adopted Levels.

§ Compound–nucleus calculations consistent with adopted Jπ.

[#] No indication of a doublet with Jπ=(11/2)– for a second component found by 1987Ab17. 1439 10 level observed by 1969Ma05 may correspond to this level.

@ Compound–nucleus calculations not consistent with adopted Jπ.

& 1987Ab17 propose a doublet based on their comparison of compound–nucleus calculations to the 1537γ excitation function. The experimental excitation function is more than a factor of 10 larger than that calculated for 7/2+ by itself. See also footnote on 1537γ doublet.

^a From 1969Ma05.

γ(¹³⁹La)

The γγ-coincidence data are from 1968Da14.

1968Da14 reported a 270.6 10 γ which has not been observed by the other experimental groups.

1969Va03 reported 1820.0 15 and 1835.0 15 gammas which have not been observed by the other experimental groups.

E(level)	Eγ [†]	Iγ [†]	E(level)	Eγ [†]	Iγ [†]
	^x 232.5 6			^x 1853.64§ 10	
	^x 330.70 [‡] 10			^x 1951.4 3	
	^x 425.2§ 2			^x 2071.4 6	
	^x 846.8 3			^x 2210.5 8	
	^x 1462.6			^x 2244.6 10	
	^x 1613.6 8			^x 2276.2 12	
	^x 1626.7 8			^x 2298.0 10	

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¹³⁹La(n,n'γ),(n,n') 1987Ab17 (continued)

γ(¹³⁹La) (continued)

E(level)	Eγ [†]	Iγ [†]	E(level)	Eγ [†]	Iγ [†]
	^x 2314.2 12		1683.11	1520.0 ^b h 20	4 ^b
	^x 2356.1 15			1683.1 2	100 12
	^x 2386.8 10		1716.12	1716.11 10	100 ^b
	^x 2407.0 12		1761.2	1595.3 ^{&} 13	100 ^{&}
165.86	165.85 10	100	1766.30	291.3 ^{eh} 2	56 ^{be}
1209.0	1043.1 3	100		1600.9 6	100 20
1219.12	1054.2 8	10 [#] 4		1766.0 ^{ah} 4	100 12
	1219.10 [#] 10	100 [#] 13	1856.4	1690.5 3	100
1256.82	1090.97 10	100 9	1894.0	1894.0 ^{ahi} 5	100 ⁱ
	1256.0 ^{@g} 10	76 9	1920.74	1755.0 ^f 4	83 10
1381.30	1215.49 [#] 10	100 [#] 11		1920.7 2	100 12
	1381.1 2	4.8 [#] 5	1940.85	174.6 ^e 2	100 ^{&}
1420.57	1256.0 ^{@gh} 10	9 ^b		363.1 ^e 2	69 ^{&e}
	1420.56 10	100 ^b		403.8 ^e 2	87 ^{&e}
1476.45	1310.64 ^c 15	100 10	1963.0	1797.1 4	100
	1476.1 4	13.6 15	2060.9	1894.0 ^{ahi} 5	71 ⁱ 9
1536.72	1370.5 ^d 2	100 ^d 4		2060.9 5	100 12
	1537.3 ^d g 10	100 ^d 4	2161.19	308.3 ^{eh} 3	100 14
1537.70	1537.69g 10	100		477.0 ^{&h} 9	
1558.39	1392.4 2	74 7		581.3 ^{eh} 5	66 19
	1558.5 2	100 10			
1578.03	1578.09 10	100 ^b			

[†] Relative photon branching ratios from each level (from 1978AhZX, except as noted).

[‡] 1987Ab17 assigned a 329.6γ [Iγ(329.6γ)/Iγ(1537)=24/52] to 1537, 7/2+; however, this would imply an M3 transition which is not consistent with RUL.

[§] Assignment of 424.8 7 γ to 1683 and 1852.7 13 γ to 1856 by 1987Ab17 not consistent with β⁻ decay; Iγ(424.8γ)/Iγ(1683γ)=0.25 (1987Ab17) and Iγ(425γ)/Iγ(1683γ)=0.57 11 (1978AhZX) and Iγ(1852.7γ)/Iγ(1690.1γ)=2.5 and Iγ(1853.64γ)/Iγ(1690.5)=2.1 4 (1987Ab17). Also, Eγ's differ from results of least-squares analysis by more than 5σ.

[#] 1987Ab17 observed a 1218.8 15 doublet and used the branching Iγ(1053γ)/Iγ(1219γ)=10/90 and Iγ(1219γ)/Iγ(1381γ)=95/5 from other work to resolve the doublet..

[@] 1987Ab17 see no evidence for the multiple placement of the 1256γ and place it as completely deexciting the 1256 level.

[&] From 1987Ab17. Iγ renormalized by evaluators from percent branching ratios to branching ratios normalized by evaluators to 100 for strongest transition.

^a Not placed by 1987Ab17.

^b From 1968Da14.

^c Alternate placement as deexciting 1310 level suggested by 1978AhZX and 1968Da14 not confirmed by 1987Ab17.

^d Eγ=1537.69 10 (1978AhZX) differs significantly from 1536.11 22 based on least-squares analysis. This suggests that in work of 1978AhZX the 1538, 11/2+, level is preferentially populated while in the work of 1987Ab17 there is more of an equal population (Eγ=1537.3 10). Iγ from Coul. ex.; 1987Ab17 obtained Iγ(329.6γ):Iγ(1370γ):Iγ(1537γ)=24:24:52; however, the decomposition of the intensity of the 1537 doublet depended on the assumption that the 329.6γ deexcites the 1537, 7/2+ level.

^e Unplaced by 1978AhZX. Iγ(291γ)/Iγ(1716γ)=0.45 7, Iγ(291γ)/Iγ(1601γ)=1.6 4, Iγ(363γ)/Iγ(175γ)=0.45 12, Iγ(404γ)/Iγ(175γ)=0.49 14 (1978AhZX). Placement of 291.3γ at 1716 is from 1968Da14. The energy of 291.3 2 is discrepant with results from least-squares analysis by more than 5 σ.

^f Alternative placement from 1756 level (1969Va03) not confirmed.

^g Multiply placed.

^h Placement of transition in the level scheme is uncertain.

ⁱ Multiply placed; undivided intensity given.

^x γ ray not placed in level scheme.

$^{139}\text{La}(\text{d},\text{d}'),(\alpha,\alpha')$ 1972Ba02,1971Gr461971Gr46: $E\alpha=12$ MeV. Measured $\sigma(\theta=100^\circ,120^\circ,160^\circ)$, FWHM=35 keV. See also Coulomb excitation.1972Ba02: $E\alpha=45$ MeV; measured $\sigma(\theta)$, FWHM=45; DWBA. $E(\text{d})=22.7$ MeV; measured $E(\text{d})$, FWHM=12. ^{139}La Levels

E(level) [†]	J π	L [‡]	Comments
0.0	7/2+		J π : from Adopted Levels.
166 [§]			
1219			
1254 6		2	
1424 6		2	
1539 6		2	
1579 6		2	
1684		#	
1718		#	
1772		@	
1810		@	
1856		@	
1924		&	
1943		&	
1961		&	
2035		a	
2064		a	
2310 ^b			
2383		c	
2401		c	
2438		c	
2466		c	
2573		d	
2597		d	
2685		3	
2780 ^b		(3)	
2810 ^b		(2)	
2870 ^b		2	
2890 ^b		(3)	

[†] From 1971Gr46 for E(level)<1600 ($\Delta E=6$ relative to 1219) and from (d,d') (1972Ba02) for E(level)>1600, except as noted.[‡] From DWBA comparison in (α,α') (1972Ba02).[§] From 1972Ba02. Not observed in (α,α').

L=2 for doublet.

@ L=2+4 for triplet.

& L=2+4 for triplet.

a L=2+4 doublet.

b Unresolved multiplet in (α,α').

c L=3 for multiplet.

d L=3 for doublet.

Coulomb Excitation 1979Ku18,1971Gr46

1979Ku18: E(p)=5.25 MeV; measured thick-target yields (E(p)=4.00–5.25 MeV), γ 's, and $\gamma(\theta)$.

1971Gr46: E α =12 MeV; measured γ rays up to 2 MeV. See also (α,α').

1965Al21: E(¹⁴N)=52 MeV; measured E γ , $\gamma\gamma$.

The 230, 400, 500, 570, 630, 680, 800, 850, 910, 1070 γ rays from 1965Al21 were not confirmed by 1971Gr46. The 472.3 and 558.4 γ rays tentatively placed by 1971Gr46 were not confirmed by 1979Ku18. Levels proposed earlier at 570, 850, 1020 and 1070 were not confirmed by 1979Ku18, and are omitted here. On the other hand 1979Ku18 proposed a new level at 830 keV with J π =3/2+ and B(E2) $\uparrow$ =0.0067 5 decaying by an 830 γ with A₂=+0.0236 40. This level seems erroneous as it is not confirmed in any other spectroscopic investigations, thus omitted here.

All data are from 1979Ku18, except as noted.

1979Ku18 propose a level at 830 (with B(E2)=0.0067 5) deexciting by an E2 γ to the g.s. This level and associated γ have not been confirmed in any other study.

¹³⁹La Levels

E(level)	J π [†]	T _{1/2} [‡]	Comments
0.0	7/2+ [§]		
167.6? 9	5/2+ [§]		B(E2) $\uparrow$ ≤0.008 (1971Gr46).
1218.7 9	9/2+	0.58 ps 9	B(E2) $\uparrow$ =0.040 6.
1257.5 9	5/2+, 7/2+		B(E2) $\uparrow$: Unweighted av of 0.046 3 (1979Ku18) and 0.034 3 (1971Gr46).
1421.4 10	5/2+, 7/2+		B(E2) $\uparrow$ =0.012 4.
1538.4 9	7/2+	0.044 ps 7	B(E2) $\uparrow$: Unweighted av of 0.016 2 (1979Ku18) and 0.0086 21 (1971Gr46).
1578.9 10	5/2+, 7/2+		B(E2) $\uparrow$ =0.0150 15.
1683.8 10	5/2+, 7/2+		Other B(E2)=0.015 3 (1971Gr46).
1715.0 10	5/2+		B(E2) $\uparrow$ =0.060 6.
1767.2 10	3/2+		Other B(E2)=0.063 9 (1971Gr46).
			B(E2) $\uparrow$ =0.059 5.
			Other B(E2)=0.050 9 (1971Gr46).
			B(E2) $\uparrow$ =0.051 7.
			B(E2) $\uparrow$ =0.062 7.
			B(E2) $\uparrow$ =0.047 7.

[†] From comparison of excitation functions to theory and $\gamma(\theta)$, except as noted.

[‡] From B(E2) using adopted J π and γ properties.

[§] From the Adopted Levels.

$\gamma(^{139}\text{La})$

E(level)	E γ [†]	I γ [‡]	Mult. [§]	δ [#]	Comments
167.6?	165.1@a 10				
1218.7	1051.1 10	10 1	E2		A ₂ =+0.0098 14.
	1218.7 10	90 1	E2+M1	-4.9 4	A ₂ =-0.0071 3.
					δ : alternate of -0.033 3 excluded since it would imply B(M1)(W.u.)=17 4.
1257.5	1090.3 10	58 1	E2+M1		A ₂ =-0.0394 39.
	1257.2 10	42 1	E2+M1		δ : $\delta(5/2+)$ =-0.28 6 or +3.5 7, $\delta(7/2+)$ =+0.26 5 or -23 5.
					A ₂ =-0.068 7.
					δ : $\delta(5/2+)$ =-0.28 6 or -2.3 5, $\delta(7/2+)$ =-0.19 4 or -1.5 3.
1421.4	1421.4 10	100	E2+M1		A ₂ =-0.078 6.
					δ : $\delta(5/2+)$ =-0.31 5 or -2.2 3, $\delta(7/2+)$ =-0.15 2 or +5.3 9.
1538.4	1370.5&	50 2	E2+M1	-0.81 25	A ₂ =+0.272 41.
	1538.7 10	50 2	E2+M1	-0.89 9	A ₂ =+0.0604 30.
1578.9	1578.9 10	100	M1+E2		A ₂ =-0.0726 36.
					δ : $\delta(5/2+)$ =-0.29 3 or -2.2 2, $\delta(7/2+)$ =-0.17 2 or +1.6 2.
1683.8	1683.8 10	100	M1+E2		A ₂ =-0.088 9.
					δ : $\delta(5/2+)$ =-0.10 2 or -1.4 3, $\delta(7/2+)$ =-0.34 7 or -2.0 4.
1715.0	1715.0&	100	M1+E2		A ₂ =+0.213 17.
					δ : +0.42 7 or δ =+3.8 6.
1767.2	1767.2&	100	E2		A ₂ =+0.0222 47.

[†] From 1971Gr46 for energies with uncertainties. Others from 1979Ku18.

[‡] Relative photon branching ratios from each level.

[§] From comparison of excitation functions to theory and $\gamma(\theta)$.

[#] From $\gamma(\theta)$.

@ Not observed by 1979Ku18.

Footnotes continued on next page

Coulomb Excitation 1979Ku18,1971Gr46 (continued)

 $\gamma(^{139}\text{La})$ (continued)

& Not observed by 1971Gr46.

^a Placement of transition in the level scheme is uncertain.

¹⁴⁰Ce(μ^- , $n\gamma$) 1973Lu01

1973Lu01: muons at 100 MeV/c, Measured $E\gamma$, $I\gamma$.

¹³⁹La Levels

<u>E(level)</u>	<u>$J\pi^\dagger$</u>
0.0	7/2+
165.3 7	5/2+
1219.6 7	9/2+
1256.8 6	(5/2)+
1381.7 9	(9/2+)
1421.4 6	5/2+, 7/2+

[†] From the Adopted Levels.

 $\gamma(^{139}\text{La})$

<u>$E\gamma$</u>	<u>E(level)</u>	<u>$I\gamma^{\dagger\ddagger}$</u>
165.4 9	165.3	49 10
1091.6 7	1256.8	2.3 5
1216.4 6	1381.7	1.1 2
1219.6 7	1219.6	2.7 10
1256.7 6	1256.8	1.8 4
1421.4 6	1421.4	1.2 2

[†] Photons per 100 stopped muons.

[‡] Absolute intensity per 100 incident particles.

¹⁴⁰Ce(d,³He) 1971Jo16

1971Jo16: E=28.9 MeV. Measured $\sigma(\theta)$; FWHM=30-50. DWBA. Other: 1971Wi04.

¹³⁹La Levels

<u>E(level)</u>	<u>$J\pi^\dagger$</u>	<u>L</u>	<u>$C^2S^\ddagger$</u>
0.0	7/2+	4	5.65
166	5/2+	2	1.53
1220	1/2+	0	0.018
1420	11/2-	5	0.75
1560	3/2+	2	0.043
1950	3/2+	2	0.017

[†] Assumed for extraction of C^2S .

[‡] Normalized to $\Sigma C^2S=8$, the number of protons beyond the closed Z=50 shell.

²³⁸U(¹²C,Fγ) ²⁰¹²As06

Two reactions: ²³⁸U(¹²C,Fγ) and ²⁰⁸Pb(¹⁸O,Fγ).

¹²C beam at E=90 MeV provided by the Legnaro XTU Tandem accelerator. The ¹⁸O beam at E=95 MeV provided by the Vivitron accelerator of IReS (Strasbourg). Targets=100 mg/cm² ²⁰⁸Pb, 47 mg/cm² ²³⁸U. Gamma rays were detected by the Euroball array consisting of 15 cluster Ge, 26 clover Ge detectors, and 30 tapered single-crystal Ge detectors. Measured E_γ, I_γ, γγ-coin, isomer T_{1/2}. Deduced levels, J, π, configurations, B(E2).

¹³⁹La Levels

E(level) [†]	Jπ [‡]	T _{1/2}	Comments
0.0 [#]	7/2+ [§]		
165.6 [@] 3	5/2+ [§]		
1380.8 [@] 4	(9/2+)		
1419.9 4	11/2-		
1537.1 [#] 3	(11/2+)		
1711.1 [@] 3	(13/2+)		
1799.9 [@] 5	(17/2+)	315 ns 35	T _{1/2} : measured by 2012As06 from (fragment)γ(t) distribution.
1962.2 4	(13/2+)		
2032.2 [#] 4	(15/2+)		
2885.4 [#] 6	(19/2+)		
2917.5 6	(17/2+)		
3060.7 6	(19/2-)		
3149.8 6	(19/2+)		
3174.8 6	(21/2+)		
3183.8 [#] 6	(23/2+)		
3247.4 6	(21/2-)		
3305.1 6	(23/2-)		
3364.0 6	(21/2+)		
4115.6 7	(25/2+)		
4251.8 ^{&} 7	(23/2+)		
4627.4 8	(27/2-)		
4640.7 ^{&} 7	(25/2+)		
4790.7 9			
5217.1 ^{&} 8	(27/2+)		

[†] From least-squares fit to E_γ data.

[‡] From the branching ratios and existence of cross-over transitions. The assignments for the lowest two levels are known.

[§] From Adopted Levels.

[#] (A): γ cascade based on g.s.

[@] (B): γ cascade based on 5/2+.

[&] (C): Band based on (23/2+).

γ(¹³⁹La)

E(level)	E _γ	I _γ [†]	Mult.	α	I(γ+ce) [‡]	Comments
165.6	165.6 3					
1380.8	1215.2 5	95 9	[E2]		95 9	
	1380.9 6	5 2	[M1+E2]		5 2	
1419.9	1420.0 5		[M2]			
1537.1	1537.0 4					
1711.1	174.0 3	28 5	[M1+E2]	0.26 3	35 6	
	291.3 3	10 3	[E1]	0.01286	10 3	
	330.3 3	53 8	[E2]	0.0347	55 8	
1799.9	88.7 5		[E2]	3.05 8		
1962.2	425.2 3					
2032.2	70.0 3	3.4 14	[M1+E2]	5.1 21	20 4	
	232.3 4	54 7	[M1+E2]	0.1060 24	60 8	
	495.0 3	20 4	[E2]	0.01060	20 4	
2885.4	853.2 4					
2917.5	1206.3 5					
3060.7	1260.8 5					
3149.8	232.3 4					
3174.8	1374.9 4					
3183.8	(9.0 8)	0.24 11	[M1]	190 70	45 7	I(γ+ce): inferred from γγ coin data, γ not observed.
	298.4 3	52 8	[E2]	0.0477	55 8	

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$^{238}\text{U}(^{12}\text{C},\text{F}\gamma)$ 2012As06 (continued) $\gamma(^{139}\text{La})$ (continued)

E(level)	$E\gamma$	$I\gamma^\dagger$	Mult.	α	$I(\gamma+\text{ce})^\ddagger$	Comments
3247.4	97.6 5	44 6	[E1]	0.251 5	55 8	
	186.7 4	37 6	[M1+E2]	0.207 19	45 7	
3305.1	(57.7 8)	11.1 16	[M1]	5.29 24	70 9	I($\gamma+\text{ce}$): inferred from $\gamma\gamma$ coin data, γ not observed.
	130.3 3	27 5	[E1]	0.1131 18	30 5	
3364.0	478.6 4					
4115.6	940.9 4					
4251.8	887.8 4	14 3	[M1+E2]		14 3	
	1068.0 4	86 9	[M1+E2]		86 9	
4627.4	512 1	10 3	[E1]		10 3	
	1322.3 5	90 9	[E2]		90 9	
4640.7	388.9 3					
4790.7	1485.6 6					
5217.1	576.4 4					

† Deduced by the evaluators from I($\gamma+\text{ce}$) in 2012As06 and α (theory) for multipolarities assumed from $\Delta(J\pi)$.

‡ From 2012As06.

Adopted Levels, Gammas

Q(β⁻)=-2129.1 30; S(n)=7453 12; S(p)=7717 7; Q(α)=-1524 7 2012Wa38.
S(2n)=17174 7, S(2p)=13807 7 (2012Wa38).

¹³⁹Ce Levels

Cross Reference (XREF) Flags

A ¹³⁹Ce IT Decay (57.58 s)
B ¹³⁹Pr ε Decay (4.41 h)
C ¹³⁰Te(¹²C,3nγ): E=65 MeV
D ¹³⁰Te(¹²C,3nγ): E=50.5 MeV
E ¹³⁰Te(¹⁴C,5nγ)
F ¹³⁷Ba(α,2nγ),¹³⁸Ba(α,3nγ)
G ¹³⁸Ce(n,γ) E=thermal
H ¹³⁹La(p,nγ)
I ¹⁴⁰Ce(d,t),(³He,α),(p,d)...

E(level) [†]	Jπ [‡]	XREF	T _{1/2} [§]	Comments
0.0	3/2+	ABCDEF GHI	137.63 d 3	%ε=100. μ=1.06 4 (1991Mu06,2014StZZ). Jπ: spin from ABMR (1973In04), and γ(θ) in oriented nuclei (1963Ha07, 1962Gr17,1961Kn02); π from L=2 and analyzing powers in (p,d). T _{1/2} : weighted average (internal) of 137.5 d 3 (1965An07), 137.2 d 4 (1972Em01), 137.66 d 4 (1976Va30), 137.59 d 4 (1978La21; ΔT _{1/2} =0.12 at 3σ level), 137.65 d 3 (1982RuZY), 137.8 d 2 (1982RyZX), and 137.73 d 20 (2014Un01). The value of 137.73 d 90 from 1992Un01 is superseded by 137.73 d 20 from 2014Un01. 1982RuZV replaced earlier measurements by 1973MeYE, 1976MeZK, and 1980RuZY and 1982HoZJ. Others: 1987ChZD, 1988DaZS. See also 1982HoZF and 1999BeZS evaluations. μ: NMR on oriented nuclei (1991Mu06). Others: 1.0 2 (nuclear orientation with γ detection, 1963Ha07); 0.85 15 (1962Gr17, same method as in 1963Ha07).
255.075 16	1/2+	B HI	110 ps 20	T _{1/2} : from ε decay.
754.24@ 8	11/2-	ABCDEF HI	57.58 s 32	Jπ: L=0 and analyzing powers in pickup reactions. %IT=100. Jπ: L=5 and analyzing powers in pickup reactions. T _{1/2} : from time variation of 754-keV γ from ¹³⁹ Ce IT decay (2012To09). Others: 54.8 s 10 (1967Ge09), 56.44 s 48 (1967Yu01), 56.54 s 13 (quoted in 2012Au07 from S. Itoh et al (1994), Conf. Proc.).
1320.248 20	5/2+	B HI	<1.0 ps	Jπ: L=2 in pickup reactions and A(θ) in (pol p,d). 1988Ch23 note that slope of excit in (p,nγ) not consistent with 5/2+.
1347.338 10	7/2+	B HI		Jπ: L=4 in pickup reactions. E2 γ to 3/2+.
1578.24 22	7/2-	B H		Jπ: E2 γ to 11/2-; log f ^{Iu} t=8.3 from 5/2+.
1579.11 19	(7/2-)	H		Jπ: γs to 5/2+ and 11/2-.
1596.592 20	(3/2)+	B HI	<0.9 ps	Jπ: 3/2+,5/2+ from L=2 in pickup reactions. Jπ=3/2 from excit in (p,nγ).
1630.674 18	3/2+	B HI	<3.8 ps	Jπ: from L=2 in pickup reactions; M1(+E2) γ to 1/2+. 5/2 from excit in (p,nγ) discrepant.
1790	(1/2+)	I		Jπ: from energy systematics of second 1/2+ level in N=81 nuclei (1971Jo05).
1818.434 22	5/2+	B HI	0.45 ps +11-8	Jπ: L=2 in pickup reactions; E2 γ to 1/2+.
1842.94? 13	(7/2-)	B		Jπ: γ to 11/2- and log f ^{Iu} t=7.7 from 5/2+ parent.
1889	1/2+	I		
1907.657 23	(3/2)+	B HI	1.2 ps 6	Jπ: L=2 and analyzing powers in pickup reactions; excit in (p,nγ).
1965.36 24	(3/2,5/2+)	B g		Jπ: γ to 1/2+ and log f ^{Iu} t=6.8 from 5/2+.
1984.83 7	(3/2,5/2+)	B gH		Jπ: γ to 1/2+ and log f ^{Iu} t=5.5 from 5/2+.
2016.26 4	(3/2+)	B Hi	≤4.3 ps	Jπ: 3/2,5/2,7/2+ from γ to 3/2+ and log f ^{Iu} t=5.3 from 5/2+. 3/2+ from excit in (p,nγ). "Non-standard" angular distribution in pickup reactions.
2017.6 5		Hi		
2028.6 5	(11/2-,13/2)	F		Jπ: γ to 11/2- and possible γ from (15/2-).
2063.84 20	11/2(-)	CDE		Jπ: ΔJ=0, dipole γ to 11/2-.
2069.7 4		H		

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Adopted Levels, Gammas (continued) ^{139}Ce Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF	T _{1/2} [§]	Comments
2088.6 3	3/2+, 5/2+	HI	>0.8 ps	J π : L=2 in pickup reactions.
2096.0 4		H		
2105.1 3		H		
2138.7 4	3/2+, 5/2+	HI		J π : L=2 in pickup reactions.
2164.1 5	(13/2-)	E		
2183.4 3		H		
2195.7 4		H		
2208.7 4		H		
2219.5 5		H		
2220.8 3		H		
2228.0 4		H		
2245.9 3	(7/2)+	HI		J π : L=4 in pickup reaction; γ to (3/2)+.
2279.8 3	(5/2+)	H		J π : gammas to 1/2+, 7/2- and 7/2+.
2286	11/2-	I		J π : L=5 and analyzing power in pickup reaction.
2287.7 3	(3/2+, 5/2, 7/2+)	H		J π : γ rays to (3/2)+ and 7/2+.
2354.5 4		H		
2361.23 [@] 20	(15/2-)	CDEF		J π : stretched Q γ to 11/2-; stretched (E2) to 11/2(-).
2363 [#]	(7/2+, 9/2+) [#]	I		J π : L=4 in pickup reactions.
2364.0 3	(3/2+, 5/2+)	H		J π : gammas to 3/2+ and 7/2+; possible γ to 1/2+.
2392.0 5		H		
2400.4 3		H		
2421.0 4	3/2+, 5/2+	HI	0.43 ps +37-15	J π : L=2 in pickup reactions.
2441.5 3		H		
2455	7/2+, 9/2+	I		J π : L=4 in pickup reactions.
2484.9 6		H		
2489.5 5		HI		
2499.83 23		H		
2541.2 5		H		
2551.4 5		H		
2553.5 3	(3/2+, 5/2, 7/2+)	H	0.50 ps +37-15	J π : γ s to (3/2)+ and 7/2+.
2556 [#]	(9/2+) [#]	I		J π : L=4 in pickup reactions; 9/2+ preferred from A(0) in (pol p,d).
2568.84 21		H		
2598.2 5		H		
2606.4 5		HI		XREF: I(?).
2631.9 [@] 3	(19/2-)	CDEF	70 ns 5	μ =+3.99 6 (1980Ba68,2014StZZ). J π : J(2632)>J(2362) from excit; T _{1/2} ≤ ≈100 ns suggests mult(269 γ)=Q (1977Lu04). π =- from comparison of g(exp)=+0.405 8 to g(theory)=+0.40 3 assuming Configuration= $\nu 1h_{11/2}^{-1} \otimes (4+ \text{ in } ^{140}\text{Ce})$ (1984Vo12). T _{1/2} : from $\gamma(t)$ in ($\alpha, 3n\gamma$). μ : TDPAD method in ($\alpha, 3n\gamma$) (1980Ba68). Other: +3.85 8 (TDPAD,1984Vo12).
2634.3 3		H		
2700.8 3		HI		
2752.69 23		H		
2776.8 4		H		
2797.4 4	7/2+	HI		J π : L=4 and analyzing powers in pickup reactions.
2819.3 4	11/2-	HI		J π : L=5 and analyzing powers in pickup reactions.
2819.6 [@] 3	(21/2-)	CDEF	≤3.0 ns	J π : from $\gamma(0)$ in ($\alpha, 3n\gamma$) and γ -deexcitation pattern. T _{1/2} : from $\gamma(t)$ in ($\alpha, 3n\gamma$). J π : L=5 in pickup reactions.
2822.5	9/2-, 11/2-	I		
2831.9 3		H		
2849.2 3		H	0.63 ps +21-13	
2900.4 4		H		
2908.6 4	(9/2)+, 3/2+, 5/2+	HI		E(level), J π : L=2+4 in pickup reactions for a possible doublet; 9/2+ preferred for L=4 from A(0) in (pol p,d).
2951.6 4		H		
2964	3/2+, 5/2+	I		J π : L=2 in pickup reactions.
3052.1 4		H		
3082 [#]	(7/2+, 9/2+) [#]	I		J π : L=(4) in pickup reactions.
3114.0 5		H	0.79 ps +42-21	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{139}Ce Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	Comments
3144	1/2+	I	
3172	3/2+, 5/2+	I	$J\pi$: L=2 in pickup reactions.
3187.1 3	(23/2-)	CDEF	$J\pi$: from $\gamma(0)$ in ($\alpha, 3n\gamma$) and γ -deexcitation pattern.
3189.2 4	(7/2+, 9/2+)	HI	$J\pi$: L=(4) in pickup reactions.
3212.5 6		H	
3268.8 5		H	
3282	7/2+, 9/2+	I	$J\pi$: L=4 in pickup reactions.
3302	1/2+	I	
3327	5/2+, 7/2+	I	$J\pi$: L=2+(4) in pickup reactions.
3352	5/2+, 7/2+	I	$J\pi$: L=2+4 in pickup reactions.
3405	(1/2+)	I	
3459.4 6		H	
3483.7 6	(25/2)	F	$J\pi$: from γ -deexcitation pattern.
3523.5 4		H	
3535 [#]	3/2+, 5/2+ [#]	I	$J\pi$: L=2 in pickup reactions.
3592	3/2+, 5/2+	I	$J\pi$: L=2 in pickup reactions.
3655	3/2+, 5/2+	I	$J\pi$: L=2 in pickup reactions.
3703.9 6	(27/2)	F	$J\pi$: from γ -deexcitation pattern.
3852	3/2+, 5/2+	I	$J\pi$: L=2 in pickup reactions.
3877.0 ^a 4	(23/2-)	CDE	
4013.7 ^{&} 4	(23/2+)	CDE	$J\pi$: 23/2- in ($^{12}\text{C}, 3n\gamma$).
4083.8 ^{&} 4	(25/2+)	CDE	$J\pi$: 25/2- in ($^{12}\text{C}, 3n\gamma$).
4098.9 ^a 4	(25/2-)	CDE	
4262.5	(3/2+, 5/2+)	I	$J\pi$: L=(2) in pickup reactions.
4276.8 ^{&} 4	(27/2+)	CDE	$J\pi$: 27/2- in ($^{12}\text{C}, 3n\gamma$).
4404.6 ^a 4	(27/2-)	CDE	
4431.5 11		E	
4570.8 6	(29/2-)	C	
4756.6 ^{&} 4	(29/2+)	CDE	
4808.4 ^a 4	(31/2-)	CDE	$J\pi$: 29/2- in ($^{12}\text{C}, 3n\gamma$):E=65 MeV.
5211.8 8	(31/2-)	C	
5297.9 5	(29/2+)	C E	$J\pi$: 29/2- in ($^{12}\text{C}, 3n\gamma$).
5532.6 ^{&} 4	(31/2+)	CDE	$J\pi$: 31/2- in ($^{12}\text{C}, 3n\gamma$).
5697.6 ^b 6	(31/2-)	E	
5737.1 6	(31/2+)	E	
5822.7 5	(33/2-)	E	
5884.4 ^a 5	(35/2-)	CDE	$J\pi$: 31/2- in ($^{12}\text{C}, 3n\gamma$).
5916.1 ^b 4	(33/2-)	CDE	$J\pi, E(\text{level})$: two levels, one with 31/2- and the other with 33/2- are proposed in ($^{12}\text{C}, 3n\gamma$):E=65 MeV.
6030.8 7	(33/2+)	E	
6077.2 5	(35/2-)	E	
6142.1 ^b 5	(35/2-)	E	
6155.1 ^c 4	(35/2-)	C E	
6331.8 ^c 5	(37/2-)	E	
6487.9 ^b 5	(37/2-)	E	
6797.6 ^c 6	(39/2-)	E	
6844.5 ^b 7	(39/2-)	E	
6967.1 7		E	
7165.3 7		E	
7308.5 ^c 8	(41/2-)	E	
7332.8 ^b 8	(41/2-)	E	
7449.8 11		E	
7571.8 11		E	
7856.0 ^c 9	(43/2-)	E	
7987.1 ^b 9	(43/2-)	E	
8001.2 9		E	

[†] From least-squares fit to $E\gamma$ data, assuming 0.5 keV uncertainty for $E\gamma$, when not stated.[‡] From angular momentum transfer in pickup reactions. For high-spins ($J>13/2$ or so), assignments are based on multiplicities from DCO and angular asymmetry ratios, γ cascades and yrast type of population. No separate arguments are given for these states.[§] From DSA method in (p, γ) (2006Bu04), except as noted.[#] Possible doublet in (d,t). Small L=0 component for second member of doublet.[@] (A): γ cascade based on 11/2-.

Adopted Levels, Gammas (continued)
¹³⁹Ce Levels (continued)

& (B): γ cascade based on (23/2+). Parity reversed in (¹²C,3n γ) data (2009Ch26,2006Bu04). Evaluators adopt positive parity for this band as discussed in detail by 2015Ka06 in their (¹⁴C,5n γ) study, based on comparison with shell-model calculations, and expected configuration= $\nu h_{11/2}^{-1}$ coupled to negative-parity states from $\pi h_{11/2}^{1\otimes} \pi(d_{5/2}/g_{7/2})^1$ in the ¹⁴⁰Ce core.

^a (C): γ cascade based on (23/2-), 3876.7.

^b (D): Magnetic-dipole rotational band based on (31/2-).

^c (E): Band based on (35/2-).

 $\gamma(^{139}\text{Ce})$

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. [‡]	$\delta^{\ddagger}$	α	Comments
255.075	255.11 2	100	M1+E2	1.5 5	0.0840 18	B(M1)(W.u.)=0.0034 17; B(E2)(W.u.)=71 20.
754.24	754.24 8	100	M4		0.0800	B(M4)(W.u.)=2.231 13.
1320.248	1065.32 20	6.1 10				
	1320.24 2	100.0 14	M1, E2			
1347.338	1347.33 1	100	E2			
1578.24	824.0 [@] 2	100	E2			
1579.11	231.4	4.4 26				
	258.4	16.6 9				
	824.9	100 5				
1596.592	249.3	<0.29				
	276.1	14.5 5				
	1341.50 9	14 7				
	1596.58 2	100 8				
1630.674	283.7	1.5 5				
	310.7	<2.7				
	1375.56 3	43.9 [§] 17	(M1+E2)	<1.2		B(M1)(W.u.)>0.00027.
	1630.67 2	100.0 [§] 25	E2			B(E2)(W.u.)>0.21.
1818.434	1563.38 2	100 6	E2			B(E2)(W.u.)=1.8 +4-3.
	1818.30 4	74 5				E γ : slightly poor fit, level-energy difference=1818.42.
1842.94?	1088.70 [@] 10	100				
1907.657	587.37 [@] 15	18 [§] 6				E γ : γ from ε decay only, not seen in (p,n γ), treated as uncertain by evaluators.
	1652.58 2	100 [§] 6				
	1907.61 5	55.2 22				
1965.36	1710.27 24	100 25				
	1965.66 [@] 44	≤ 42				
1984.83	354.00 10	100 20				
	664.60 [@] 15	≤ 24				
	1729.89 9	76 12				
	1985.04 [@] 29	≤ 6				
2016.26	696.01 [@] 10	≤ 24 [§]				
	2016.25 4	100 [§] 12				
2017.6	670.3	100				
2028.6	1274.4	100				
2063.84	1309.7 2	100	D			Mult.: $\Delta J=0$ transition from DCO data in (¹² C,3n γ):E=50.5 MeV.
2069.7	722.4	100				
	1814.5					
2088.6	768.8					
	1833.2	9 6				
	2088.4	100 10				
2096.0	775.7					
	1840.9					
2105.1	758.0					
	785.3	21 5				
	2104.9	100 8				
2138.7	508.0					
	1883.6					
2164.1	1409.4 10	100	(D+Q)			
2183.4	835.5	<10				
	863.5	100 11				
	1928.6	<10				
2195.7	600.2	100 13				

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{Ce})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	α	Comments
2195.7	847.3				
2208.7	612.3	100 6			
	861.1	16 3			
2219.5	899.2				
2220.8	589.9	100 8			
	624.2	7 4			
	873.6	<1			
2228.0	907.5				
	1973.2	100 19			
2245.9	650.0	29 5			
	898.1				
	925.4	100 17			
2279.8	699.2	100 8			
	932.1	28 4			
	960.8	<1			
	2025.3	6 3			
2287.7	379.9	50 18			
	690.3	35 22			
	941.2	100 10			
	967.4	<220			
2354.5	757.8				
	1034.3	100 40			
2361.23	197.0 5	4 7 9			
	297.8 4	6 4 3	(E2)		E γ : unweighted average.
	1606.9 2	100 4	Q [#]		
2364.0	1016.7	41 6			
	1043.7	37 5			
	2109.0				
	2363.8	100 13			
2392.0	2136.9				
2400.4	769.8				
	804.0	43 4			
	1052.9	52 12			
	1080.2	100 12			
2421.0	824.2				
	1073.8	100 15			
2441.5	336.9	42 13			
	1093.5	59 12			
	1121.4	100 11			
2484.9	888.1@	53 4			
	905.8	100 4			
2489.5	1142.2	100			
2499.83	483.5	3 7 4			
	902.5				
	1152.7	7 3			
	1180.0	<0.5			
	2244.9	100 7			
2541.2	1193.9	100			
2551.4	2296.3	100			
2553.5	956.8	40 10	[E2]		B(E2)(W.u.)=7 3.
	1206.3	100 13			
	1233.2	50 10			
2568.84	553.4	14 1			
	938.3	48 6			
	971.0	<91			
	990.1	100 10			
	1221.4	48 5			
	1248.6	9 3			
2598.2	1250.9	100			
2606.4	1259.1				
2631.9	270.7 2	100	E2	0.0688	B(E2)(W.u.)=0.122 9.
2634.3	727.7	6 1			
	1037.2	69 4			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Ce})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	α	Comments
2634.3	1313.6	100 14			
2700.8	793.7	29 3			
	1104.1	100 6			
	1353.3	46 11			
	1380.4	55 9			
2752.69	768.4				
	845.7				
	1155.5				
	1173.5	100 17			
	1431.9				
2776.8	1429.7	100 14			
	1456.3	71 19			
2797.4	781.2	<9			
	1449.9	100 27			
2819.3	1240.1	100 6			
	1472.5@		[M2]		
	2065.1	14 3			
2819.6	187.7 1	100	(M1+E2)	0.215 13	
2831.9	1236.0				
	1484.1	<11			
	1511.5	100 44			
2849.2	1270.6	16.4 21			
	1502.2				
	1528.0	100 5			
2908.6	1561.8				
	1587.8				
2951.6	1604.2				
	1631.4				
3052.1	1704.5				
	1732.0				
3114.0	1793.7	100			
3187.1	367.4 1	100	D+Q		
3189.2	1610.0	100 12			
	1841.9				
3212.5	1633.4	100			
3268.8	1948.5	100			
3459.4	1880.3	100			
3483.7	296.5	100 10			
	659.0@				
3523.5	2175.5	100 12			
	2203.9	44 7			
3703.9	220.1	86 10			
	517.0	100 34			
3877.0	1057.3 2	100	D+Q		
4013.7	1194.1 2	100	D+Q		
4083.8	70.1 2	13.2 17	[M1]	3.29 9	
	206.7 2	13.0 13			
	896.7 1	100 5	D		
4098.9	221.8 2	26 3	D		
	911.8 2	54 10	D+Q		I_{γ} : unweighted average.
	1279.4 2	100 10	Q		
4276.8	193.0 1	100 3	D+Q		
	263.0@ 5	1.3 3			E_{γ} : from ($^{12}\text{C}, 3n\gamma$) only.
4404.6	305.7 1	100 5	D+Q		
	527.6@ 5	11 1			E_{γ} : from ($^{12}\text{C}, 3n\gamma$):E=65 MeV only.
	1217.5 2	54 5	Q		
4431.5	1244.4 10	100			
4570.8	294.0@ 5	100 9	D+Q		
4756.6	479.8 1	100 10	D+Q		
	672.7@ 5	14.7 12			E_{γ} : from ($^{12}\text{C}, 3n\gamma$):E=65 MeV only.
4808.4	403.9 1	100 11	Q		
	709.3@ 5	8.1 8	[M3]		E_{γ} : from ($^{12}\text{C}, 3n\gamma$):E=65 MeV only, and unlikely as it requires mult=M3.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Ce})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	Comments
5211.8	641.0@ 5	100		
5297.9	1021.3 5	100 11	D+Q	
	1213.9 5	59 9		
5532.6	234.7 5	57 5	D+Q	
	776.0 1	109 13	D+Q	I γ : 41 9 from ($^{12}\text{C},3n\gamma$):E=50.5 MeV seems discrepant.
	1255.6 2	100 11	Q	
5697.6	166.0@ 5	176 53		
	1293.3 10	100 10		
5737.1	439.1 5	100 9	D+Q	
	1460.6 10	100 14	Q	
5822.7	1013.6 5	100		
5884.4	61.0 5	8 4		
	1076.3 3	100 10	Q	
5916.1	218.6 5	31 2	D+Q	
	383.4 2	93 19	D	I γ : unweighted average.
	1108.1 5	100 10	D+Q	
	1160.8@ 5	19 3		
6030.8	293.7 2	100	D+Q	
6077.2	192.8 2	100		
6142.1	226.0 2	100	D+Q	
6155.1	239.0 2	100	D+Q	
6331.8	176.4 5	49 5	D+Q	
	253.0@ 10	15 4		
	447.4 2	100 7	(D+Q)	
6487.9	345.8 2	100	D+Q	
6797.6	465.5 5	40 7	D+Q	
	642.7 5	100 13		
6844.5	356.6 5	100	(D+Q)	
6967.1	889.8 5	100		
7165.3	1088.0 5	100		
7308.5	510.9 5	100		
7332.8	488.3 2	100	D+Q	
7449.8	1118.0 10	100		
7571.8	1240.0 10	100		
7856.0	547.5 5	100		
7987.1	654.3 5	100	(D+Q)	
8001.2	835.9 5	100		

[†] From ε decay for γ rays from levels below 2.02 MeV and from high-spin reactions from levels above 2.02 MeV, except as noted. The values, when considered from different reactions, are either weighted averages when not discrepant or unweighted averages when discrepant.

[‡] From $\alpha(\text{K})\text{exp}$ and conversion electron ratios in ε decay for γ rays below 2.02 MeV, from $\gamma(\theta)$ in ($\alpha,3n\gamma$) for γ rays from levels above 2.02 MeV and from DCO ratios in ($^{12}\text{C},3n\gamma$) and ($^{14}\text{C},5n\gamma$) for transitions deexciting levels above 3.8 MeV or so, except as noted.

[§] Branching ratios from ε decay and ($p,n\gamma$) are discrepant.

[#] Stretched.

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

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(E) Band based on (35/2-)

¹³⁹Ce IT Decay (57.58 s) 1967Ge09,1967Yu01,2012To09

Parent ¹³⁹Ce: E=754.24 8; Jπ=11/2-; T_{1/2}=57.58 s 32; %IT decay=100.
¹³⁹Ce-J,T_{1/2}: From ¹³⁹Ce Adopted Levels.
1967Yu01 measured γ(t); NaI.
1967Ge09 measured γ(t) (Ge(Li)) and ce's (mag spect,Si(Li)).
2012To09: measured half-life of isomer.
Others: 1960Ko02, 1960Ja06, 1969Ja02.
All data are from Adopted Levels unless stated otherwise.

¹³⁹Ce Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	3/2+		%ε+%β ⁺ =100.
754.24 8	11/2-	57.58 s 32	%IT=100.

[†] From Adopted Levels.

γ(¹³⁹Ce)

Eγ	E(level)	Iγ [†]	Mult.	α	I(γ+ce) [†]	Comments
754.24 8	754.24	92.6 CA	M4	0.0800	100	Iγ: from I(γ+ce) and α.

[†] Absolute intensity per 100 decays.

Decay Scheme

Intensity: I(γ+ce) per
100 parent decays
%IT=100

¹³⁹Pr ε Decay (4.41 h) 1981ArZW,1976Za03,1975Vy02

Parent ¹³⁹Pr: E=0.0; Jπ=5/2+; T_{1/2}=4.41 h 4; Q(g.s.)=2129.1 30; %ε+%β⁺ decay=100.

¹³⁹Pr-J,T_{1/2}: From ¹³⁹Pr Adopted Levels.

¹³⁹Pr-Q(ε): From 2012Wa38.

1975Vy02 measured γ's, x rays, and γγ-coincidences, β's and ce's, and ceγ(t) (mag spect, Ge(Li)).

1976Za03 measured γ's.

1981ArZW measured γ's and x rays and β's.

Others: 1976KaYX, 1968De02, 1969Be65, 1963Bi20.

Level scheme is basically from 1976Za03; level at 1578 suggested by 1975Vy02 confirmed by 1981ArZW.

¹³⁹Ce Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	3/2+		%ε+%β ⁺ =100.
255.078 16	1/2+	110 ps 20	T _{1/2} : from 1975Vy02.
754.24 8	11/2-	57.58 s 32	%IT=100.
			T _{1/2} : from the Adopted Levels.
			Isomer production ratio=0.008 2 (2000BeZV) discrepant with I(γ+ce)(725γ)=0.015 3 (Evaluators).
1320.249 20	5/2+		
1347.337 10	7/2+		
1578.24 22	7/2-		
1596.590 20	(3/2)+		
1630.674 18	3/2+		
1818.436 22	3/2+, 5/2+		
1842.9 10	(7/2-)		
1907.661 23	(3/2)+		
1965.36 24	(3/2, 5/2+)		
1984.84 7	(3/2, 5/2+)		
2016.27 4	(3/2+)		
2090.0 10	(3/2+, 5/2+)		

[†] From Adopted Levels.

β⁺,ε Data

Iγ(K x ray)=2.17×10⁵ 22 (1981ArZW) compared to 1.71×10⁵ 6 from the decay scheme relative to Iγ(1347γ)=1000.

ε/β⁺=10.2 11 (1981ArZW) compared to 11.08 2 from decay scheme.

β/ce(K)(255γ)=1830 60 (1975Vy02) compared to 460 28 from decay scheme. It is not clear from the text of 1975Vy02 whether the Iβ⁺ includes contributions from ¹³⁹Nd decay.

Eε	E(level)	Iβ ⁺ †	Iε†	Log ft	I(ε+β ⁺)†	Comments
(39 [‡] 4)	2090.0		<0.00047	>6.5		
(113 3)	2016.27		0.0132 16	6.62 7		
(144 3)	1984.84		0.023 3	6.66 7		
(164 3)	1965.36		0.0021 6	7.8 1		
(221 3)	1907.661		0.063 5	6.69 4		
(286 [‡] 4)	1842.9		0.0031 11	8.3 2		
(311 3)	1818.436		0.072 4	6.97 3		
(498 3)	1630.674		0.485 17	6.59 1		
(533 3)	1596.590		0.039 4	7.75 5		
(551 [‡] 3)	1578.24		0.0132 24	8.3 1		
(782 3)	1347.337		0.473 11	7.02 1		
(809 3)	1320.249		0.062 4	7.93 3		
2129 3	0.0	8.28 10	90.47 11	5.631 5	98.75 4	Eε: from Eβ=1107 3 (1981ArZW). Other: Eβ=1090 10 (1975Vy02).
						I(ε+β ⁺): 100-summed ε+β ⁺ feeding to excited states.
						See also normalization comment for gamma-ray intensities.

[†] Absolute intensity per 100 decays.

[‡] Existence of this branch is questionable.

^{139}Pr ε Decay (4.41 h) 1981ArZW,1976Za03,1975Vy02 (continued) $\gamma(^{139}\text{Ce})$

Except as noted all, $E\gamma$ and $I\gamma$ are from 1976Za03 and ce and coincidence data are from 1975Vy02. $\alpha(\text{K})\text{exp}$, normalized by 1975Vy02 to $\alpha(\text{K})(255\gamma, \text{M1})=0.0767$, renormalized by evaluators to $\alpha(\text{K})(255\gamma, \text{M1}+(68\% \text{ 14})\text{E2})=0.0685 \text{ 23}$.
 $I\gamma$ normalization: from $\Sigma I\gamma(1+\alpha)$ (to g.s.), $I(\gamma^\pm)=3.50\times 10^3 \text{ 8}$ (1976Za03. Other: $3.24\times 10^4 \text{ 16}$ (1981ArZW)) relative to $I\gamma(1347\gamma)=100$, and theoretical ε/β^+ for the feeding to the ground state.

$E\gamma$	E(level)	$I\gamma^{\textcircled{a}}$	Mult. [†]	$\delta^\dagger$	α	Comments
255.11 2	255.078	49.8 14	M1+E2	1.5 5	0.0840 18	K:L:M+=1000:191 20:50 6. K:L1:L2:L3=6.8 20:1.00:≤0.15:≤0.15 (1976KaYX).
354.00 $\frac{1}{2}$ 10	1984.84	2.5 5				$E\gamma$: this γ ray is not confirmed in (p,n γ), treated as uncertain by the evaluators.
587.37 $\frac{1}{2}$ 15	1907.661	1.5 5				$I\gamma$: 8 2 (1976Za03).
664.60 $\frac{1}{2}$ 15	1984.84	≤0.6 §				$E\gamma$: this γ ray is not confirmed in (p,n γ).
696.01 $\frac{1}{2}$ 10	2016.27	≤0.6 §				$I\gamma$: 9 5 (1976Za03).
754.24 8	754.24	3.0 5	M4		0.0800	$\alpha(\text{K})\text{exp}=0.056 \text{ 12}$.
824.0 $\frac{1}{2}$ 2	1578.24	2.8 § 5	E2			$\alpha(\text{K})\text{exp}=0.0020 \text{ 8}$.
1065.32 $\frac{1}{2}$ 20	1320.249	0.52 § 26				$I\gamma$: 7 4 (1976Za03).
1088.70 $\frac{1}{2}$ 10	1842.9	0.66 § 23				$I\gamma=22 \text{ 5}$ (1976Za03) would lead to a possible intensity imbalance at the 754 level (−24 10) suggesting that either $I\gamma$ from 1976Za03 is incorrect or 1089 γ is misassigned.
$\times$ 1091.4 $\frac{1}{2}$ 7		≤0.3 §				
1320.24 2	1320.249	14.7 2	M1, E2			$\alpha(\text{K})\text{exp}=0.0014 \text{ 5}$.
1341.50 9	1596.590	1.0 5				
1347.33 1	1347.337	100.0	E2			$\alpha(\text{K})\text{exp}=0.00076 \text{ 10}$.
1375.56 3	1630.674	32.5 15	M1 (+E2)	<1.2		$\alpha(\text{K})\text{exp}=0.00121 \text{ 17}$.
$\times$ 1517.2 $\frac{1}{2}$ 4		≤0.4 §				
1563.38 2	1818.436	8.8 5	E2			$\alpha(\text{K})\text{exp}=0.00045 \text{ 19}$.
1596.58 2	1596.590	7.2 6	M1, E2			$\alpha(\text{K})\text{exp}=0.0076 \text{ 26}$.
1630.67 2	1630.674	72.5 20	E2			$\alpha(\text{K})\text{exp}=0.00055 \text{ 11}$.
1652.58 2	1907.661	8.2 5				
$\times$ 1678.5 $\frac{1}{2}$ 3		≤0.3 §				
1710.27 24	1965.36	0.36 9				
1729.89 9	1984.84	1.9 3				
1818.30 4	1818.436	6.5 4				$E\gamma$: slightly poor fit, level–energy difference=1818.42.
1907.61 5	1907.661	3.6 4				
1965.66 $\frac{1}{2}$ 44	1965.36	≤0.15 §				$I\gamma$: 1.2 5 (1976Za03).
1985.04 $\frac{1}{2}$ 29	1984.84	≤0.15 §				$I\gamma$: 1.6 5 (1976Za03).
2016.25 4	2016.27	2.5 3				
2090 §	2090.0	<0.10 §				

[†] From $\alpha(\text{K})\text{exp}$ and conversion electron ratios, except as noted. δ 's deduced by evaluators.

$\frac{1}{2}$ Not observed by 1975Vy02.

§ From 1981ArZW. The 2090 γ expected from a level near this energy in (d,t) was looked for but not observed by 1981ArZW.

Not observed by 1976Za03. However, it is not clear from the discussion in 1976Za03 whether they have included all unplaced γ 's in their table.

@ For absolute intensity per 100 decays, multiply by 0.00473 11.

& Placement of transition in the level scheme is uncertain.

$\times$ γ ray not placed in level scheme.

^{139}Pr ϵ Decay (4.41 h) 1981ArZW,1976Za03,1975Vy02 (continued)

Decay Scheme

Intensities: I(γ + ϵ) per 100 parent decays

$^{139}_{59}\text{Pr}_{80}$ 5/2+ 0.0 4.41 h
 $\% \epsilon + \% \beta^+ = 100$
 $Q^+ = 2129.1^{30}$

$^{130}\text{Te}(^{12}\text{C},3n\gamma)$: E=50.5 MeV 2006Bu042006Bu04: E=50.5 MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ using three HPGe detectors at Bucharest Tandem accelerator laboratory. ^{139}Ce Levels

E(level) [†]	$J\pi^{\ddagger}$	Comments
0.0	3/2+	E(level): level not populated in this reaction.
255.1	1/2+	
754.24 [§] 8	11/2-	
2063.91 17	11/2-	
2360.90 [§] 17	15/2-	
2631.8 [§] 3	19/2-	
2819.5 [§] 3	21/2-	
3186.9 [§] 3	23/2-	
3876.9 4	(23/2-)	
4013.6 [#] 4	(23/2-)	
4083.7 [#] 3	(25/2-)	
4098.8 3	(25/2-)	
4276.6 [#] 4	(27/2-)	
4404.5 [§] 4	27/2-	
4756.3 [#] 4	(29/2-)	
4808.4 [§] 4	31/2-	
5532.3 [#] 4	(31/2-)	
5884.7? [§] 5		
5916.2? 8		

[†] From least-squares fit to $E\gamma$ data.[‡] As given by 2006Bu04 based on their DCO data and previous assignments for low-lying levels.[§] (A): γ cascade based on $\pi h_{11/2}$ orbital.[#] (B): Band based on (23/2-). $\gamma(^{139}\text{Ce})$ DCO(D) correspond to gates on $\Delta J=1$, dipole transitions, and DCO(Q) to gate on $\Delta J=2$, quadrupole transition.

$E\gamma$	E(level)	$I\gamma$	Mult. [†]	Comments
(70.1)	4083.7			
187.7 1	2819.5	56.3 17	D+Q	DCO(D)=0.68 7.
192.9 1	4276.6	15.3 11	D	DCO(D)=0.85 12.
206.7 2	4083.7	2.5 4		
221.8 2	4098.8	3.3 10	D	DCO(D)=1.13 21.
270.9 2	2631.8	100 5	Q	DCO(D)=1.96 22.
297.0 1	2360.90	5.9 3	Q	DCO(Q)=0.87 18.
305.7 1	4404.5	11.9 5	D	DCO(D)=0.88 11.
367.4 1	3186.9	36.4 9	D	DCO(D)=1.23 11.
403.9 1	4808.4	12.8 12	Q	DCO(D)=1.9 3.
479.8 1	4756.3	7.2 15	D+Q	DCO(D)=0.67 23.
754.24 8	754.24		M4	$E\gamma$, Mult.: from Adopted Levels.
776.0 1	5532.3	3.1 7	(D)	DCO(D)=0.96 30.
896.8 1	4083.7	13.8 7	D	DCO(D)=1.14 25.
912.0 2	4098.8	3.7 5	D	DCO(D)=0.81 23.
1057.3 2	3876.9	12.5 8		
1076.3 [‡] 3	5884.7?	5.2 6		
1107.8 [‡] 7	5916.2?	4.4 4		
1194.1 2	4013.6	3.4 12	D+Q	DCO(D)=1.74 34.
1217.5 2	4404.5	7.7 10	Q	DCO(D)=1.50 40.
1255.6 2	5532.3	7.5 21		
1279.3 2	4098.8	7.5 14	Q	DCO(D)=1.52 28.
1309.7 2	2063.91	5.4 3	D	DCO(Q)=1.48 6.
				Mult.: $\Delta J=0$ transition.
1606.6 2	2360.90	94.3 42	Q	DCO(D)=1.78 25.

[†] Assigned by the evaluators based on DCO data in 2006Bu04.[‡] Placement of transition in the level scheme is uncertain.

¹³⁰Te(¹²C,3n γ): E=65 MeV 2009Ch26

2009Ch26: 2.2 mg/cm² ¹³⁰Te target ¹²C beam provided at E=65 MeV by the 15UD Pelletron Accelerator of the Inter University Accelerator Centre in Delhi. The γ rays were measured using five Clover Ge detectors and identified using gates on strong known transitions. Measured E γ , I γ , $\gamma\gamma$, $\gamma\gamma(\theta)$ (DCO), $\gamma\gamma(\text{lin pol})$. Deduced levels, J, π , multiplicities from measured DCO ratios, shell model configurations. Comparison with large basis shell model and cranked Nilsson-Strutinsky calculations.

¹³⁹Ce Levels

Detailed multi-quasiparticle shell-model configurations for 19/2- to 35/2- levels are given in Table III of 2009Ch26.

E(level) [†]	J π [‡]	T _{1/2} [§]	Comments
0.0	3/2+		
754.0# 5	11/2-	57.58 s 32	%IT=100.
2063.0 7	13/2-		
2361.0# 7	15/2-		
2631.7# 9	19/2-	70 ns 5	
2819.4 10	21/2-		
3186.8 11	23/2-		
3876.7& 11	23/2-		
4013.5@ 11	23/2-		
4083.6@ 11	25/2-		
4098.8& 11	25/2-		
4276.5@ 11	27/2-		
4404.3& 11	27/2-		
4570.5 12	(29/2-)		
4756.3@ 12	29/2-		
4808.1& 12	29/2-		
5211.5 13	(31/2-)		
5297.5 12	29/2-		
5532.3@ 12	31/2-		
5884.5& 13	31/2-		
5916.3 13	31/2-		
5917.3@ 13	33/2-		
6156.3@ 14	35/2-		

[†] From least-squares fit to E γ data.

[‡] From multiplicities deduced from measurement of DCO ratios and linear polarization of γ rays.

[§] From Adopted levels.

(A): γ cascade based on 11/2-.

@ (B): γ cascade based on 23/2-, 4013.5.

& (C): γ cascade based on 23/2-, 3876.7.

 $\gamma(^{139}\text{Ce})$

DCO gate on $\Delta J=1$, dipole transitions, unless otherwise stated. Expected DCO ≈ 1.6 for $\Delta J=2$, quadrupole and ≈ 1.0 for $\Delta J=1$, dipole for gate on $\Delta J=1$, dipole. For $\Delta J=2$, quadrupole gate, expected DCO ≈ 1.0 for $\Delta J=2$ quadrupole and ≈ 0.6 for $\Delta J=1$, dipole.

Measured PDCO (polarization) ratios, but values are not listed in table 1 of 2009Ch26.

E γ	E(level)	I γ	Mult. [†]	α	Comments
70.1 5	4083.6	3.2 3	[M1]	3.29 9	
187.7 5	2819.4	93 9	D		DCO=0.97 6.
192.9 5	4276.5	30 3	D		DCO=0.96 7.
206.9 5	4083.6	3.0 3	[M1]	0.1556 24	
222.1 5	4098.8	4.3 4	D		DCO=1.10 22.
234.8 5	5532.3	4.8 5	D+Q		DCO=1.4 3.
239.0 5	6156.3	8.4 8	D+Q		DCO=1.4 3.
263.0 5	4276.5	0.4 1			
270.7 5	2631.7	100 10	E2	0.0676 11	DCO=1.07 2. POL=+0.08 4. DCO gate on $\Delta J=2$, quadrupole transition. DCO=1.11 4.
294.0 [‡] 5	4570.5	9.3 9	D+Q		
298.0 5	2361.0	2.1 2			
305.5 5	4404.3	23.9 24	D		DCO=1.03 12.
367.4 5	3186.8	59 6	D+Q		DCO=1.09 6.
385.0 5	5917.3	5.9 6	D+Q		DCO=1.14 20.

Continued on next page (footnotes at end of table)

¹³⁰Te(¹²C,3n γ): E=65 MeV 2009Ch26 (continued)

 $\gamma(^{139}\text{Ce})$ (continued)

E γ	E(level)	I γ	Mult. [†]	α	Comments
403.8 5	4808.1	27 3	D+Q		DCO=2.24 18.
479.8 5	4756.3	15.6 16	D+Q		DCO=0.92 9.
527.6 $\frac{5}{2}$	4404.3	2.6 3			
641.0 $\frac{5}{2}$	5211.5	5.6 6			
672.7 $\frac{5}{2}$	4756.3	2.3 2			
709.3 $\frac{5}{2}$	4808.1	2.2 2			
754.0 5	754.0	10.2 10	M4	0.0801	Mult.: from Adopted Gammas.
776.0 5	5532.3	7.9 8	D		DCO=1.1 5.
896.8 5	4083.6	24.8 25	D		DCO=0.95 4.
912.0 5	4098.8	9.8 10	D+Q		DCO=0.71 9.
1021.0 5	5297.5	3.6 4	D+Q		DCO=0.45 14.
1057.3 5	3876.7	6.3 6	D+Q		DCO=0.55 10.
1076.4 5	5884.5	10.9 11	D+Q		DCO=1.4 3.
1108.2 5	5916.3	5.3 5	D+Q		DCO=0.86 19.
1161.0 $\frac{5}{2}$	5917.3	1.1 1			Initial level J π labeled as 31/2- in table I of 2009Ch26 is a misprint.
1194.1 5	4013.5	10.6 11	D		DCO=0.90 13.
1213.9 $\frac{5}{2}$	5297.5	1.9 2			
1217.5 5	4404.3	12.3 12	Q		DCO=1.66 9.
1255.8 5	5532.3	6.5 7	Q		DCO=1.53 25.
1279.4 5	4098.8	13.3 13	Q		DCO=1.61 19.
1309.0 5	2063.0	6.1 6			
1607.0 5	2361.0	97 10			

[†] 2009Ch26 assign E1, M1 or M1+E2 for $\Delta J=1$, dipole or D+Q transitions, and E2 for $\Delta J=2$, quadrupole transitions. In the absence of parity-sensitive measurements, but in consideration of timing resolution of ≈ 50 ns in $\gamma\gamma$ -coin measurement and RUL for E2 and M2 transitions, evaluators assign (M1), (M1+E2) and (E2) for $E\gamma < 500$ keV, and D, D+Q or Q for higher energy transitions.

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

¹³⁰Te(¹⁴C,5n γ) 2015Ka06

2015Ka06: E(¹⁴C)=82 MeV beam provided by the tandem accelerator of IPN, Orsay. Target=2 mg/cm² ¹³⁰Te deposited on 120 mg/cm² thick Bi backing and 136 mg/cm² copper for thermal dissipation. Measured E γ , I γ , $\gamma\gamma$, $\gamma\gamma(\theta)$ (DCO), $\gamma\gamma$ (anisotropy ratios). Deduced levels, J, π , multipolarities, bands, magnetic-dipole rotational band, configuration. Comparison with realistic shell-model calculations.

¹³⁹Ce Levels

E(level) [†]	J π [§]	T _{1/2} [‡]	Comments
0.0	3/2+		Level not populated in this study, listed here for completeness.
754.24# 8	11/2-	57.58 s 32	%IT=100. Decay mode from Adopted Levels.
2063.2 3	(11/2-, 13/2-)		
2164.3 5	(13/2-)		
2361.47# 21	15/2-		
2632.1# 3	19/2-	70 ns 5	
2819.9# 4	21/2-		
3187.3 4	23/2-		
3877.5& 5	23/2-		
4013.8@ 5	23/2+		
4083.9@ 5	25/2+		
4099.1& 5	25/2-		
4277.1@ 5	27/2+		
4404.7& 5	27/2-		
4431.7 11			
4756.9@ 5	29/2+		
4808.6& 5	31/2-		
5298.5 6	29/2+		
5533.0@ 5	31/2+		

Continued on next page (footnotes at end of table)

¹³⁰Te(¹⁴C,5n γ) 2015Ka06 (continued)

¹³⁹Ce Levels (continued)

E(level) [†]	J π [§]	E(level) [†]	J π [§]	E(level) [†]	J π [§]
5697.9 ^a 7	31/2-	6155.4 ^b 6	35/2-	7333.1 ^a 8	41/2-
5737.6 7	31/2+	6331.8 ^b 6	37/2-	7449.8 12	
5822.8 6	(33/2-)	6488.2 ^a 6	37/2-	7571.8 12	
5884.3 ^{&} 6	35/2-	6797.7 ^b 7	39/2-	7856.1 ^b 10	(43/2-)
5916.4 ^a 5	33/2-	6844.8 ^a 8	39/2-	7987.4 ^a 10	43/2-
6031.3 7	33/2+	6966.9 8		8001.1 10	
6077.1 6	(35/2-)	7165.2 8			
6142.4 ^a 6	35/2-	7308.6 ^b 8	(41/2-)		

[†] From least-squares fit to E γ data.

[‡] From Adopted levels.

[§] As proposed in 2015Ka06 based on $\gamma\gamma(\theta)$ data and band structures.

[#] (A): γ cascade based on 11/2-.

[@] (B): γ cascade based on 23/2+. Parity reversed in the present work.

[&] (C): γ cascade based on 23/2-, 3876.7.

^a (D): Magnetic-dipole rotational band based on 31/2-.

^b (E): Band based on 35/2-.

 $\gamma(^{139}\text{Ce})$

DCO(1) for gate on $\Delta J=1$, dipole transitions; DCO(2) for gate on $\Delta J=2$, quadrupole transition. Expected DCO(1) values are 2.0 and 1.0; and DCO(2) values are 1.0 and 0.6 for stretched quadrupole and stretched dipole transitions, respectively.

E γ	E(level)	I γ	Mult. [†]	Comments
61.0 5	5884.3	1.0 5		
70.1 2	4083.9	6.4 19		
166.0 [‡] 5	5697.9	3.7 11		
176.4 5	6331.8	2.7 3	D+Q	DCO(1)=1.24 20; DCO(2)=0.86 30. R(0)(1)=1.19 19.
187.8 2	2819.9	82.9 33	D+Q	DCO(1)=1.15 14; DCO(2)=0.76 12. R(0)(1)=1.33 32.
192.8 2	6077.1	5.6 5		
193.2 2	4277.1	27.0 8	D+Q	DCO(1)=1.53 1; DCO(2)=0.74 4. R(0)(1)=1.38 12.
197.0 5	2361.47	4.5 9		
206.4 5	4083.9	3.7 5		
218.6 5	5916.4	3.3 2	D+Q	DCO(1)=1.30 70; DCO(2)=0.42 20. R(0)(2)=0.63 30.
221.7 5	4099.1	3.5 3		
226.0 2	6142.4	6.0 4	D+Q	DCO(1)=1.46 8; DCO(2)=0.53 16. R(0)(1)=1.11 18.
234.7 5	5533.0	3.0 3	D+Q	DCO(1)=1.10 16; DCO(2)=0.62 5. R(0)(1)=1.09 30, R(0)(2)=1.08 30.
239.0 2	6155.4	6.1 5	D+Q	DCO(1)=1.23 30; DCO(2)=0.61 7. R(0)(1)=1.07 17.
253.0 [‡] 10	6331.8	0.8 2		
270.6 2	2632.1	100.0 30	E2	DCO(1)=1.68 4; DCO(2)=0.86 20. R(0)(1)=1.39 30.
293.7 2	6031.3	5.8 5	D+Q	DCO(1)=1.01 20; DCO(2)=0.54 20. R(0)(1)=1.02 10, R(0)(2)=0.84 14.
298.3 2	2361.47	6.7 7	D+Q	DCO(1)=1.52 18.
305.5 2	4404.7	25.3 13	D+Q	DCO(1)=1.10 30; DCO(2)=0.51 11. R(0)(1)=0.90 16, R(0)(2)=0.81 19.
345.8 2	6488.2	5.2 4	D+Q	DCO(1)=0.89 10; DCO(2)=0.44 5. R(0)(2)=0.75 12.
356.6 5	6844.8	4.5 2	(D+Q)	R(0)(1)=0.68 30.
367.2 2	3187.3	57.8 23	D+Q	DCO(2)=0.47 17. R(0)(2)=0.74 30.
383.4 2	5916.4	7.8 5	D	DCO(1)=1.05 40; DCO(2)=0.40 3. R(0)(1)=0.74 12.

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$^{130}\text{Te}(^{14}\text{C},5n\gamma)$ 2015Ka06 (continued) $\gamma(^{139}\text{Ce})$ (continued)

E_γ	E(level)	I_γ	Mult. [†]	Comments
403.9 2	4808.6	29.9 15	Q	DCO(1)=2.02 30. R(θ)(1)=1.21 40.
439.1 5	5737.6	3.5 3	D+Q	DCO(1)=1.01 16.
447.4 2	6331.8	5.5 4	(D+Q)	R(θ)(1)=0.71 30.
465.5 5	6797.7	1.2 2	D+Q	R(θ)(1)=0.44 13.
479.8 2	4756.9	15.5 8	D+Q	DCO(1)=0.94 19; DCO(2)=0.41 14. R(θ)(1)=0.72 9.
488.3 2	7333.1	5.8 6	D+Q	R(θ)(1)=0.28 17.
510.9 5	7308.6	3.0 3		
547.5 5	7856.1	2.2 2		
642.7 5	6797.7	3.0 4		
654.3 5	7987.4	4.3 5	(D+Q)	DCO(1)=0.95 30. R(θ)(1)=0.52 15.
754.24 8	754.24		M4	E_γ , Mult.: from Adopted dataset.
776.1 2	5533.0	5.3 5	D+Q	DCO(2)=0.52 11. R(θ)(1)=0.58 12.
835.9 5	8001.1	3.6 6		
889.8 5	6966.9	3.1 5		
896.5 2	4083.9	28.1 25	D	DCO(1)=0.49 17; DCO(2)=0.91 14.
911.6 2	4099.1	6.0 9	D+Q	DCO(2)=0.54 14.
1013.6 5	5822.8	3.7 5		
1021.6 5	5298.5	4.2 5	D+Q	R(θ)(1)=0.35 11, R(θ)(2)=0.25 11.
1057.7 5	3877.5	8.0 22	D+Q	R(θ)(2)=0.35 17.
1076.0 5	5884.3	12.7 13	Q	DCO(1)=1.60 40. R(θ)(2)=1.07 17.
1088.0 5	7165.2	3.6 6		
1108.1 5	5916.4	10.6 11	D+Q	DCO(2)=0.35 8. R(θ)(1)=0.66 7, R(θ)(2)=0.60 20.
1118.0 10	7449.8	0.20 2		
1160.1 [‡] 10	5916.4	1.5 3		
1194.3 5	4013.8	10.1 13	D	R(θ)(1)=0.56 16, R(θ)(2)=0.72 41.
1214.4 10	5298.5	3.1 4		
1217.5 5	4404.7	11.6 31	Q	DCO(1)=1.84 30; DCO(2)=1.02 7.
1240.0 10	7571.8	0.30 3		
1244.4 10	4431.7	7.1 14		
1256.5 10	5533.0	5.5 6	Q	DCO(2)=0.99 40.
1280.3 5	4099.1	15.1 17	Q	DCO(2)=0.94 30. R(θ)(2)=0.95 50.
1293.3 10	5697.9	2.1 2		
1310.2 10	2063.2	6.8 8		
1409.4 10	2164.3	5.5 7	(D+Q)	DCO(1)=1.59 60.
1460.6 10	5737.6	3.5 5	Q	DCO(1)=1.62 19. R(θ)(1)=1.27 40, R(θ)(2)=1.44 12.
1607.2 2	2361.47	95.8 38	Q	DCO(1)=1.87 50. R(θ)(1)=1.33 30.

[†] 2015Ka06 assign E1 or M1+E2 for $\Delta J=1$, dipole or dipole+quadrupole transitions, and E2 for $\Delta J=2$, quadrupole transitions. In the absence of parity-sensitive measurements, but in consideration of timing resolution of ≈ 50 ns in $\gamma\gamma$ -coin measurement and RUL for E2 and M2 transitions, evaluators assign (M1+E2) and (E2) for $E_\gamma < 500$ keV, and D, D+Q or Q for higher energy transitions.

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

$^{137}\text{Ba}(\alpha,2n\gamma), ^{138}\text{Ba}(\alpha,3n\gamma)$ 1984Vo12,1977Lu04,1976Lu071976Lu07: $^{138}\text{Ba}(\alpha,3n\gamma)$ E=51 MeV. Measured $\gamma(t)$.1977Lu04: $^{138}\text{Ba}(\alpha,3n\gamma)$ E=45–59 MeV. Measured excitation functions, γ 's, $\gamma(\theta=60^\circ-125^\circ, 5 \text{ angles})$, $\gamma(t)$, and $\gamma\gamma$ -coincidences.1984Vo12: $^{137}\text{Ba}(\alpha,2n\gamma)$ E=27 MeV. Measured $269,1607\gamma(\theta,H,t)$; NaI, T=300°, 650° K.Except as noted, all data are from 1977Lu04. The decay scheme is based on the $\gamma\gamma$ -coincidence data, intensity considerations, and observation that no γ 's deexciting low-spin states known from decay studies were observed. ^{139}Ce Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\ddagger$	Comments
0.0	3/2+		
754.8 10	11/2-	57.58 s 32	%IT=100. $T_{1/2}$ and decay mode from the Adopted Levels.
2029.2 15	(11/2-, 13/2)		E(level): suggested on the basis of the energy-sum relation and excit. J π : (11/2-, 13/2) from γ 's to 11/2- and possible γ from (15/2-).
2362.3 15	(15/2-)		J π : (15/2) from $\gamma(\theta)$ and excit. $\pi=-$ from (E2) γ from (19/2-).
2631.5 18	(19/2-)	70 ns 5	g=+0.405 8 (1984Vo12). Configuration=vh $_{11/2} @ ^{140}\text{Ce}$, first 4+). g: from $1607\gamma(\theta,\beta,t)$. Other: g=0.199 21 from $269\gamma(\theta,\beta,t)$ (269 peak may be contaminated, probably from $^{138}\text{Ba}(\alpha,2n)$ γ 's). J π : J(2632)>J(2362) from excit; $T_{1/2} \leq 100$ ns suggests mult(269) γ =Q (1977Lu04). $\pi=-$ from comparison of g(exp)=+0.405 8 to g(theory)=+0.40 3 for the proposed configuration.
2819.3 20	(21/2-)	≤ 3.0 ns	J π : from $\gamma(\theta)$ and γ -deexcitation pattern.
3185.1 23	(23/2-)		J π : from $\gamma(\theta)$ and excit.
3481.7 24	(25/2)		
3702.0 24	(27/2)		E(level): suggested on the basis of the energy-sum relation and $\gamma\gamma$ -coin.

 † From the Adopted Levels. Contributing arguments are given as comments. ‡ From $\gamma(t)$ of 1976Lu07, except as noted. $T_{1/2}(2632)$ from $269\gamma(t)$; 68 ns 5 from $1608\gamma(t)$. 1984Vo12 give 64 ns 4 from $1607\gamma(t)$ and 56 ns 6 from $269\gamma(t)$ for 2632 but do not discuss these values except to note that the 269 peak may be contaminated, probably from $^{138}\text{Ba}(\alpha,2n)$ γ 's. $\gamma(^{139}\text{Ce})$ Except for the delayed γ from the 11/2- to 3/2+ transition, no delayed transitions were observed in delayed γ -spectra with delays of 10, 20, 40, 60, 100, 200, and 300 μ s with respect to the beam pulses.

E γ	E(level)	$I\gamma^\dagger$	Mult. ‡	α	Comments
187.8	2819.3	57 6	(M1+E2)		I γ : 56 7.
220.1	3702.0	10.3 11			I γ : 9.8 9.
269.2	2631.5	65 4	(E2)	0.0688	I γ : 74 4. Mult.: D,E2 from comparison to RUL. $\neq$ D from comparison of $T_{1/2}(2632)$ with $T_{1/2}(2632)=96$ ns calculated from assumption that 2632 is [^{140}Ce 4+](vh $_{11/2}^{-1}$)19/2- with $T_{1/2}(^{140}\text{Ce}$ 4+)=5 ns (1976Lu07).
296.5	3481.7	18.0 § 17			
333.2&	2362.3				I γ : ≤ 7 .
365.8	3185.1	36 4	D $^\#$		I γ : 33.9 21.
517.0@	3702.0	12 § 4			
554.0@&	3185.1	≤ 9 §			
659.0@&	3481.7				I γ : ≤ 5 .
754.8	754.8	18.0 15	M4		Mult.: from Adopted Gammas.
1274.4	2029.2				I γ : 220 11.
1607.5	2362.3	100 10	Q $^\#$		I γ : 18.7 35. I γ : 100 8.

 † At E=52 MeV and $\theta=125^\circ$ and in coincidence with the cyclotron burst. Data at 45 MeV without coincidence are given under comments. ‡ From $\gamma(\theta)$, except as noted.

§ Not observed at 45 MeV with no coincidence.

Stretched.

@ Placed on the basis of $\gamma\gamma$ -coincidence data and energy sums.

& Placement of transition in the level scheme is uncertain.

 $^{138}\text{Ce}(\text{n},\gamma)$ E=thermal 1969Gr31

Measured γ 's. 12.5% ^{138}Ce . Decay scheme considered doubtful by evaluators due to the large uncertainty on S(n), lack of uncertainties on E_γ , and poor correspondence with known bound states.

 ^{139}Ce Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	Comments
0.0	3/2+	
1916?	(3/2)+	
1980?	(3/2, 5/2+)	
2518?		
(7453 12)	1/2+	E(level): from 2012Wa38. J π : thermal capture on an even-even target.

† From S(n)- E_γ , except for g.s. and capture state. 1969Gr31 give 1941, 2005, and 2543.

‡ From the Adopted Levels.

 $\gamma(^{139}\text{Ce})$

E_γ	$E(\text{level})$	$I_\gamma^\dagger$
4938 ‡	(7453)	13
5476 ‡	(7453)	25
5540 ‡	(7453)	3.5

† Absolute intensity per 100 neutron captures.

‡ Placement of transition in the level scheme is uncertain.

$^{139}\text{La}(\text{p},\text{n}\gamma)$ 2006Bu04,1988Ch23

2006Bu04: 20 mg/cm² enriched ^{139}La target, E=5.0 and 6.0 MeV. Measured $E\gamma$, $\gamma\gamma$, $I\gamma$, γn coin, lifetimes using Doppler shift method. Gamma rays were detected using two HPGe detectors and neutrons using a one-liter NE213 liquid scintillator.

1988Ch23: measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coin.

 ^{139}Ce Levels

Levels at 2364.0 and 2484.0 were reported in 1988Ch23 only.

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}^{\S}$	Comments
0.0	3/2+		
254.9 4	1/2+		
754.24 8	11/2-	57.58 s 32	%IT=100. $T_{1/2}$ and decay mode from Adopted Levels.
1320.3 4	5/2+	<1.0 ps	
1347.4 4	7/2+		
1579.1 5	(7/2-)		
1596.7 4	(3/2)+	<0.9 ps	
1630.8 5	3/2+	<3.8 ps	
1818.4 8	5/2+	0.45 ps +11-8	
1907.3 6	(3/2)+	1.2 ps 6	
1984.4 9	(3/2+, 5/2+)		
2016.3 10	(3/2+)	<4.3 ps	
2016.6 7			
2069.6 8			
2088.5 7	3/2+, 5/2+	>0.8 ps	
2095.8 11			
2105.1 6			
2138.7 8	3/2, 5/2+		
2183.4 7			
2195.8 8			
2208.7 8			
2219.5 11			
2220.9 7			
2228.0 8			
2245.6 8	(7/2+)		
2279.3 7			
2287.6 6	(3/2+, 5/2, 7/2+)		
2354.5 8			
2364.0 7	(3/2+, 5/2+)		
2391.8 11			
2400.5 6			
2421.2 11	3/2+, 5/2+	0.43 ps +37-15	
2441.5 7			
2484.9 11			
2489.6 11			
2499.9 6			
2541.3 11			
2551.2 11			
2553.6 7	(3/2+, 5/2, 7/2+)	0.50 ps +37-15	
2569.1 6			
2598.3 11			
2606.5 11			
2634.2 7			
2700.8 6			
2752.7 7			
2776.8 8			
2797.3 11	7/2+		
2819.5 7	11/2-		
2832.0 7			
2849.2 7		0.63 ps +21-13	
2900.4 6			
2908.6 8	(9/2)+, 3/2+, 5/2+		
2951.6 8			
3051.9 11			
3114.0 11		0.79 ps +42-21	
3189.2 8	(7/2+, 9/2+)		

Continued on next page (footnotes at end of table)

¹³⁹La(p,n γ) 2006Bu04,1988Ch23 (continued)

¹³⁹Ce Levels (continued)

E(level)[†]

3212.5 11
3268.8 11
3459.4 11
3523.6 8

[†] From least-squares fitting to E γ data, assuming $\Delta E\gamma=0.5$ keV for each γ ray.

[‡] From Adopted Levels.

[§] From DSA method (2006Bu04) for levels above 800 keV.

 $\gamma(^{139}\text{Ce})$

E γ =586, 695, 1605.8 and 1729.4 were reported in 1988Ch23 but not seen in 2006Bu04.

E γ	E(level)	I γ	Mult.	Comments
231.4	1579.1	2.0 12		
249.3	1596.7	<0.10		
255.1	254.9	60 4		
258.4	1579.1	7.6 4		
276.1	1596.7	5.05 19		
283.7	1630.8	0.33 12		
310.7	1630.8	0.2 4		
336.9	2441.5	1.0 3		
379.9	2287.6	0.52 19		
483.5	2499.9	0.44 5		
508.0	2138.7			
553.4	2569.1	0.99 8		
589.9	2220.9	10.0 8		
600.2	2195.8	3.9 5		
612.3	2208.7	10.5 6		
624.2	2220.9	0.7 4		
650.0 [†]	2245.6	0.69 13		
670.3	2016.6	1.9 4		
690.3	2287.6	0.37 23		
699.2	2279.3	9.7 8		
722.4	2069.6	<0.10		
727.7	2634.2	1.10 21		
754.24 8	754.24		M4	E γ ,Mult.: From Adopted Gammas.
757.8	2354.5			
758.0	2105.1			
768.4	2752.7			
768.8	2088.5			
769.8	2400.5			
775.7 [†]	2095.8	<0.10		
781.2 [†]	2797.3	<0.10		
785.3	2105.1	0.7 4		
793.7	2700.8	1.62 18		
804.0	2400.5	1.42 13		
824.2 [†]	2421.2			
824.9	1579.1	45.8 23		
835.5	2183.4	<0.10		
845.7	2752.7			
847.3	2195.8			
861.1	2208.7	1.7 3		
863.5	2183.4	0.96 11		
873.6	2220.9	<0.10		
888.1 [†]	2484.9	4.8 4		
898.1	2245.6			
899.2	2219.5			
902.5	2499.9			
905.8	2484.9	9.1 4		
907.5	2228.0			
925.4	2245.6	2.4 4		

Continued on next page (footnotes at end of table)

$^{139}\text{La}(\text{p},\text{n}\gamma)$ 2006Bu04,1988Ch23 (continued) $\gamma(^{139}\text{Ce})$ (continued)

$E\gamma$	E(level)	$I\gamma$	Comments
932.1	2279.3	2.7 4	
938.3	2569.1	3.5 4	
941.2	2287.6	1.05 11	
956.8	2553.6	1.6 4	
960.8 [†]	2279.3	<0.10	
967.4	2287.6	0.6 17	
971.8	2569.1	1.5 51	
990.1	2569.1	7.3 7	
1016.7	2364.0	3.5 5	
1034.3	2354.5	2.0 8	
1037.2	2634.2	13.6 7	
1043.7	2364.0	3.2 4	
1052.9	2400.5	1.7 4	
1065.2	1320.3	4.7 5	
1073.8	2421.2	2.7 4	
1080.2	2400.5	3.3 4	
1093.5	2441.5	1.4 4	
1104.1	2700.8	5.6 8	
1121.4	2441.5	2.39 25	
1142.2	2489.6	10.7 12	
1152.7	2499.9	0.8 3	
1155.5	2752.7		
1173.5	2752.7	3.4 4	
1180.0	2499.9	<0.10	
1193.9	2541.3	17.0 8	
1206.3	2553.6	4.0 5	
1221.4	2569.1	3.5 4	
1233.2	2553.6	2.0 4	
1236.0	2832.0		
1240.1	2819.5	18.8 11	
1248.6	2569.1	0.69 23	
1250.9	2598.3	1.5 3	
1259.1	2606.5	2.1 3	
1270.6	2849.2	2.3 3	
1313.6	2634.2	19.7 11	
1320.3	1320.3	72.1 25	In 255.3 γ gate: $A_2=+0.031$ 9, $A_4=-0.015$ 10 (1988Ch23).
1321.3 [†]	2900.4		
1341.6	1596.7	4.5 5	
1347.4	1347.4	100	In 255.3 γ gate: $A_2=+0.16$ 1, $A_4=-0.01$ 1 (1988Ch23).
1353.3	2700.8	2.6 6	
1375.7	1630.8	9.1 7	In 255.3 γ gate: $A_2=+0.64$ 8, $A_4=+0.05$ 8 (1988Ch23).
1380.4	2700.8	3.1 5	
1429.7	2776.8	2.1 3	
1431.9 [†]	2752.7		
1449.9	2797.3	1.1 3	
1456.3	2776.8	1.5 4	
1472.5	2819.5		
1484.1	2832.0	<0.10	
1502.2	2849.2		
1511.5	2832.0	0.9 4	
1528.0	2849.2	14.0 7	
1561.8	2908.6		
1563.4	1818.4	5.6 6	
1587.8	2908.6	<0.10	
1596.6	1596.7	34.8 17	In 255.3 γ gate: $A_2=+0.01$ 9, $A_4=-0.004$ 14 (1988Ch23).
1604.2	2951.6		
1610.0	3189.2	7.5 9	
1630.7	1630.8	21.8 13	In 255.3 γ gate: $A_2=-0.03$ 3, $A_4=-0.03$ 3 (1988Ch23).
1631.4	2951.6		
1633.4	3212.5		
1652.6	1907.3	19.4 12	In 255.3 γ gate: $A_2=-0.06$ 3, $A_4=+0.10$ 4 (1988Ch23).
1704.5	3051.9		
1729.7	1984.4	17.1 10	

Continued on next page (footnotes at end of table)

¹³⁹La(p,n γ) 2006Bu04,1988Ch23 (continued)

 $\gamma(^{139}\text{Ce})$ (continued)

E γ	E(level)	I γ	Comments
1732.0 [†]	3051.9		
1793.7	3114.0	8.8 7	
1814.5	2069.6		
1818.4	1818.4	4 3	
1833.2	2088.5	0.6 4	
1840.9	2095.8		
1841.9	3189.2		
1880.3	3459.4	2.6 4	
1883.6	2138.7	4.0 5	
1907.7	1907.3	11.0 7	
1928.6	2183.4	<0.10	
1948.5	3268.8	3.4 7	
1973.2	2228.0	4.7 9	
2016.3	2016.3	19.4 9	In 255.3 γ gate: A ₂ =-0.01 4, A ₄ =+0.07 5 (1988Ch23).
2025.3	2279.3	0.6 3	
2065.1	2819.5	2.7 6	
2088.4	2088.5	7.0 7	
2104.9	2105.1	8.6 7	
2109.0 [†]	2364.0		
2136.9	2391.8	3.7 6	
2175.5	3523.6	4.1 5	
2203.9	3523.6	1.8 3	
2244.9	2499.9	11.8 9	
2296.3	2551.2	2.1 4	
2363.8	2364.0	8.6 11	

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

¹⁴⁰Ce(d,t),(³He, α),(p,d),(pol p,d) 1985Di12,1976Be10,1971Jo05

All groups measured $\sigma(\theta)$ and performed DWBA calculations.

1968Ya07: E(p)=55 MeV. Level energies determined to 20 keV absolute uncertainty.

1971Ch07: E(p)=24.55 MeV. Semi telescope. FWHM=45 keV.

1971Jo05: E(p)=35 MeV. Mag spect (FWHM=10-15 keV), semi telescope (FWHM=35 keV).

1976Be10: E(d)=26.2 MeV (FWHM=14 keV); E(³He)=25 MeV (FWHM=23 keV).

1985Di12: E(p)=122 MeV, (pol p,d). Also measured A(θ). QDDM spect, position-sensitive pc. FWHM=200 keV. $\theta=6^\circ-40^\circ$, 2° steps.

Energy dependence of C²S (exact-finite-range calculations) for (p,d) from 1985Di12

E (keV)	J π	L	35 MeV 1971Jo05	55 MeV 1968Ya07	122 MeV 1985Di12
0	3/2+	2	3.4	1.8	1.6
255	1/2+	0	1.8	1.1	1.0
754	11/2-	5	7.3	2.5	1.8
1320	5/2+	2	2.0	1.1	2.1
1907	5/2+, 3/2+	2	1.05, 1.20	0.28, 0.24	0.60, 0.44
2556	7/2+, 9/2+	4	1.8	0.44	0.80, 1.0
2840	7/2+, 9/2+	4	2.7	0.90	0.63, 0.85

¹³⁹Ce Levels

E(level) [†]	J π [‡]	L [§]	C ² S [§]	Comments
0.0	3/2+ [#]	2	4, 4	C ² S: 1.6 (1985Di12), 4.6 (1971Jo05), and 4.0 (1968Ya07).
254	1/2+ [#]	0	1.5, 2.1	
755	11/2- [#]	5	6.9, 5.2	
1321	5/2+ [#]	2	2.5, 2	
1347 [@]	7/2+	4	1.4, 0.7	
1598 ^{&}	(3/2) ^{+a}	2 ^{&}	^{&}	C ² S: C ² S(5/2+)=0.43, 0.44.
1632 ^{&b}	3/2+ ^a	2 ^{&}	^{&}	C ² S: C ² S(5/2+)=0.08.

Continued on next page (footnotes at end of table)

$^{140}\text{Ce}(\text{d,t}),(^3\text{He},\alpha),(\text{p,d}),(\text{pol p,d})$ 1985Di12,1976Be10,1971Jo05 (continued) **^{139}Ce Levels (continued)**

E(level) [†]	$J\pi^{\ddagger}$	$L^{\S}$	$C^2S^{\S}$	Comments
1790		(0)	0.08	Observed only by 1971Jo05 in (p,d). L: from energy systematics of second 1/2+ level in N=81 nuclei. (1971Jo05).
1823@b	5/2+	2	0.1	
1889@b		0	0.23	
1911	(3/2)+ ^a	2	0.74, 0.99	
2018@		c		
2090 ^d	5/2+	2 ^d	0.59 ^d	
2143 ^d	5/2+	2 ^d	0.23 ^d	
2251@b	7/2+	4	0.36	
2286	11/2- [#]	5	1.8, 1.3	C ² S: 0.5 (1985Di12).
2363 ^e	7/2+ [#]	4 ^e	0.65, 0.7	L: from 1985Di12. Other: (4) (1976Be10). C ² S: 1.2 (1985Di12).
2426@b	5/2+	2	0.11	
2455	7/2+	4	0.4, 0.56	
2488		c		
2556 ^e	(9/2)+ ^f	4 ^e		C ² S: C ² S(7/2+)=0.65, 0.74.
2610?@				From (³ He,α) spectrum. Not observed in (d,t) or given in the tables of 1976Be10.
2701@b				
2800	7/2+	4 ^g	0.41 ^g	C ² S: 2.0 (1971Jo05).
2822.5@	11/2-	5 ^g	1 ^g	
2910	3/2+, 5/2+, (9/2)+ ^f	2+4		C ² S: C ² S(5/2+&7/2+)=0.1+0.4, 0.2+0.2. Other: C ² S(5/2+)=0.5, C ² S(7/2+)=3.2 (1971Jo05); C ² S(7/2+)=0.63, C ² S(9/2+)=0.85 (1985Di12).
2964 ^b	5/2+	2	0.06	C ² S: 0.5 (1971Jo05).
3082@e	7/2+	(4) ^e	0.2	
3144@b		0	0.03	
3172?@b	5/2+	2	0.07	
3196	7/2+	(4)	0.82, 1	C ² S: 3.0 (1971Jo05).
3282@	7/2+	4	0.69, 0.65	
3302@b		0	0.02	
3327@b		2+(4)		C ² S: 0.07+±0.25.
3352		2+4		C ² S: 0.19+±0.3, 4.0+0.34. Other: C ² S(7/2+)=1.33 (1968Ya07).
3405?b		(0)	0.016	
3535 ^e	5/2+	2 ^e g	0.08 ^g	
3592 ^b	5/2+	2	0.09	
3655	5/2+	2 ^g	0.12 ^g	
3852 ^b	5/2+	2	0.12	
4262.5 ^b		(2)	0.08	

[†] From (d,t) (1976Be10), except as noted. Levels above 2.9 MeV not reported by 1985Di12; levels above 3.4 MeV not reported in other (p,d) work.

[‡] Assumed for the extraction of C²S, except as noted.

[§] From 1976Be10, except as noted. First value of C²S is from (d,t) and second value is from (³He,α), except as noted. See table above for energy dependence of C²S in (p,d).

[#] Comparison of σ(θ) and A(θ) to DWBA by 1985Di12 consistent with adopted values.

@ Not observed in (p,d).

& 1971Jo05 observe a 1600, L=2, C²S(5/2+)=0.7, level which may correspond to the 1598 level, 1632 level or both of these levels.

^a From the Adopted Levels.

^b Not observed in (³He,α).

^c Non-standard angular distributions (1976Be10).

^d Probable unresolved doublet with E_x=2.11 MeV, L=2, and C²S=1.1 observed by 1971Jo05 in (p,d). C²S(2090+2140)=0.96 in (³He,α).

^e Possible doublet in (d,t). Small L=0 component for second member of doublet.

^f Strong preference for 9/2+ from A(θ) (1985Di12).

^g No values extracted in (³He,α).

Adopted Levels, Gammas

Q(β⁻)=-2806 28; S(n)=9761 16; S(p)=4541 12; Q(α)=-603 12 2012Wa38.
S(2n)=17762 11, S(2p)=12258 8 (2012Wa38).

¹³⁹Pr Levels

Band assignments are from (¹⁹F,4nγ) (2012Ye06).

Cross Reference (XREF) Flags

A ¹³⁹Nd ε Decay (29.7 min)
B ¹³⁹Nd ε Decay (5.50 h)
C ¹²⁴Sn(¹⁹F,4nγ)
D ¹³⁰Te(¹⁴N,5nγ)

E ¹³⁹La(³He,3nγ)
F ¹³⁹La(α,4nγ): Prompt
G ¹³⁹La(α,4nγ): Delayed
H ¹⁴⁰Ce(p,2nγ): Prompt

I ¹⁴⁰Ce(p,2nγ): Delayed
J ¹⁴¹Pr(p,t)
K ¹⁴²Nd(p,α),(pol p,α)

E(level)	Jπ [†]	XREF	T _{1/2}	Comments
0.0	5/2+	ABCDEFGHIJK	4.41 h 4	%ε+%β ⁺ =100. Jπ: spin from ABMR (1972Ek04); π from L(p,t)=0 from 5/2+ target; also σ(θ) and A _y (θ) in (pol p,α). T _{1/2} : from 1968Li08 (γ decay; Ge(Li)). Others: 4.42 h 8 (1975Vy02), 4.92 h 8 (1963Bi20), 4.5 (1954Ha68), 4.5 h 2 (1951St03). μ=1.19 21 (1983AkZY). μ: perturbed angular correlation method in 29.7-min decay (1983AkZY). T _{1/2} : from 5.5-h ε decay. Other: 2.5 ns 2 (1964So03). Jπ: σ(θ) and A _y (θ) in (pol p,α); M1 γ to 5/2+. Jπ: M1 γs to 3/2+ and 7/2+.
113.92 5	7/2+ [§]	ABCDEFGHI K	2.60 ns 8	μ=1.19 21 (1983AkZY). μ: perturbed angular correlation method in 29.7-min decay (1983AkZY). T _{1/2} : from 5.5-h ε decay. Other: 2.5 ns 2 (1964So03). Jπ: σ(θ) and A _y (θ) in (pol p,α); M1 γ to 5/2+.
405.11 7	3/2+	A EF H JK		Jπ: M1 γs to 3/2+ and 7/2+.
589.41 7	5/2+	A E HIJK		
624		K		
821.98 ^d 7	11/2-	BCDEFGHI K	43.4 ns 16	μ=+6.6 5 (1979Ke07,2014StZZ). Jπ: from γγ(θ) in 5.5-h ε decay and mult's of deexciting γ's. T _{1/2} : weighted av of 45.5 ns 9 and 44 ns 4 from (p,2nγ), 43 ns 2 from (³ He,3nγ), and 36.8 ns 20 and 40 ns 2 from ε decay (5.5 h). Others: 35.5 ns 7 (1972Mo23), =36 ns (2012BhZZ, 2011Mu20). μ: TDPAD method in (p,2nγ) (1979Ke07). Other: +7.2 6 (TDPAD, 1982Ri09). Jπ: σ(θ) and A _y (θ) in (pol p,α); ΔJ=2, E2 γ to 5/2+. Jπ: stretched E2 to 7/2+; σ(θ) and A _y (θ) in (pol p,α). Jπ: L(p,t)=2 from 5/2+ target; β feeding from 3/2+ parent.
827.92 9	9/2+	B EF H JK		Jπ: 5/2+, 9/2+ from γ(θ) in (p,2nγ) and E2 γ to 7/2+. ≠5/2+ from E1 γ from 9/2-,11/2-.
851.87 9	11/2+	BCDEF HI K		
916.92 23	(1/2, 3/2, 5/2)+	A H JK		
1009		K		
1023.92 19	9/2+	B EF HIJ		
1074.21 21	(1/2+, 3/2, 5/2) [‡]	A		
1124.02 11		F		
1154		K		
1311.8 4	1/2-	A jK		Jπ: σ(θ) and A _y (θ) in (pol p,α).
1328.43 21	(3/2+, 5/2) [‡]	A jK		
1369.68 12	(9/2-, 13/2-)	B EF HI		Jπ: γ(θ) in (p,2nγ) and M1 γ to 11/2-.
1405.5 5	(1/2+, 3/2, 5/2) [‡]	A		
1449.0 10	3/2-	A K		Jπ: σ(θ) and A _y (θ) in (pol p,α).
1478		K		
1492		A K		
1501.3 4	(1/2+, 3/2, 5/2) [‡]	A jk		
1523.11 ^d 9	13/2-	ABCDEFGHI j		Jπ: M1+E2 γ to 11/2- and M1 γ from 15/2-.
1532.0 10	(1/2+, 3/2, 5/2) [‡]	A jK		
1584.28 22		B H		
1624.32 10	9/2-	B HIJK		Jπ: 9/2-, 11/2- from E1 γ to 9/2+; log ft=6.4 via 11/2- parent. γ to 7/2+; L(p,t)=1,3 from 5/2+ gives negative parity. May be a doublet. See comment on branching ratios. Jπ: σ(θ) and A _y (θ) in (pol p,α). Jπ: from γ(θ) in (p,2nγ) and E2 γ to 11/2-.
1650	1/2+	K		
1722.18 ^d 10	15/2-	BCDEFGHI		
1762		K		
1790.23 22	13/2+	EF H K		XREF: K(1783). Jπ: σ(θ) and A _y (θ) in (pol p,α); stretched E2 cascade to 9/2+.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
¹³⁹Pr Levels (continued)

E(level)	Jπ [†]	XREF	T _{1/2}	Comments
1834.00 9	(9/2-, 11/2-) [@]	B EF H K		β ₂ =1.35 4 (1982PrZV). β ₂ : from γ(0,H,t) in 5.5-h decay.
1857		K		
1867.6 4	(15/2)+	CDEF HI		Jπ: stretched E2 cascade to 11/2+.
1908	7/2+	K		Jπ: σ(θ) and A _y (θ) in (pol p,α).
1926.91 10	(11/2, 13/2)- [@]	B H K		
1941.51 ^d 11	17/2-	CDE HI		Jπ: Stretched M1 γ to 15/2-. No feeding to levels with J≥13/2.
1942.0 7		EFGH		
1952	5/2+	K		Jπ: σ(θ) and A _y (θ) in (pol p,α).
1975		K		
2029.52 14		H jK		
2048.58 11	9/2-, 11/2- [#]	B jK		Jπ: also L(p,t)=1,3 for a level at 2050 keV 30.
2050.1 7		E j		
2097		K		
2127		jK		
2149		jK		
2174.50 12	9/2- ^{\$}	B E jK		Jπ: also L(p,t)=(3) for a level at 2160 keV 50.
2187.49 ^d 12	(19/2)-	CDEFGHI	≈9 ns	Jπ: from γ(θ) in (α,4nγ) and M1+E2 γ to (17/2)-. T _{1/2} : from γγ(t) in ¹³⁰ Te(¹⁴ N,5nγ) (2012BhZZ).
2196.46 11	9/2-, 11/2, 13/2-	B j		Jπ: log ft=6.1 via 11/2- parent; γs to 9/2- and 13/2-. Also L(p,t)=(3) for a level at ≈2240 from 5/2+ target suggests negative parity.
2205.8 5		E jK		
2277.97 13	(19/2)-	CDEFGHI		Jπ: from γ(θ) in (α,4nγ) and M1 γ to (17/2)-.
2291.9 4	9/2, 11/2, 13/2+	B		Jπ: γ to 9/2+ and log ft=6.8 via 11/2- parent.
2367.14 ^d 13	(21/2)-	CDEFGH		Jπ: from γ(θ) in (α,4nγ) and M1 γ to (19/2)-.
2456.30 14		H		
2481.39 16		F		
≈2660		J		
2700.65 25		H		
2726.1 5	19/2-	C		
2741.42 19		F J		XREF: J(2740).
2761.11 13	(19/2-)	CDEFG		
≈2800		J		
2821.0 3	(21/2)+	CDEFG		
2985.64 16	(21/2-)	C F		
3021.45 14	(23/2+)	CDEFG		Jπ: from γ(θ) in (α,4nγ) and ΔJ=1 γ to (21/2)+.
3139.5 6	(25/2)-	C		
3203.96 14		F		
3255.6 6	(25/2)-	C		
3265.88 15	(23/2)+ [@]	CDEFG		
3483.93 16		F		
3564.9 4	(23/2)-	C		
3579.63 17	(25/2+)	C F		
3627.34 17	(25/2+)	CDEFG		
3697.90 ^{&} 15	(25/2-)	CD FG	≈12 ns	T _{1/2} : from γγ(t) in ¹³⁰ Te(¹⁴ N,5nγ) (2012BhZZ).
3972.33 20	(27/2+)	CD F		
4052.4 4	(25/2-)	CD F		
4100.8 ^c 4	(27/2-)	CD FG		
4276.3 6	(27/2)+	C		
4316.6 ^{&} 6	(29/2-)	C		
4377.37 18		F		
4412.4 4	(27/2)+	C		
4444.0 ^a 4	(27/2)+	C		
4536.8 ^c 4	(29/2-)	CD FG		
4626.3 ^a 5	(29/2)+	C		
4834.1 6	(29/2+)	C		
4862.8 ^c 4	(31/2-)	CD FG		
4906.3 ^a 7	(31/2)+	C		
4947.4 ^{&} 8	(33/2-)	C		
5056.2 5	(31/2+)	C		
5171.3 7	(33/2-)	C		

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Adopted Levels, Gammas (continued)

¹³⁹Pr Levels (continued)

E(level)	Jπ [†]	XREF	E(level)	Jπ [†]	XREF
5222.4 5	(31/2)−	C	6282.4 ^a 11	(37/2+)	C
5283.4 ^a 9	(33/2+)	C	6317.3 8	(37/2−)	CD
5363.8 5	(33/2)−	C	6371.4 ^{&} 11	(41/2)−	C
5406.2 ^c 7	(33/2−)	CD	6387.2 10	(39/2−)	CD
5558.5 7	(35/2−)	C	6399.8 ^b 9	(39/2)−	C
5585.9 8	(35/2−)	C	6525.4 ^c 10	(37/2−)	C
5633.2 ^{&} 9	(37/2)−	C	6719.8 9	(39/2−)	C
5670.8 7	(33/2−)	C	6736.3 ^b 10	(41/2)−	C
5740.6 ^a 10	(35/2+)	C	6772.6 10	(37/2−)	C
5824.4 ^c 8	(35/2−)	CD	6854.1 10	(39/2−)	CD
5861.9 ^b 5	(35/2)−	C	6916.4 ^a 12	(39/2+)	C
6039.0 7	(35/2)−	CD	6938.2 11	(41/2−)	C
6118.0 ^b 8	(37/2)−	C	7219.3 ^{&} 12	(45/2−)	C
6182.9 8	(37/2−)	C	7219.5 11	(41/2−)	D

[†] From (HI,xnγ) based on DCO measurements, γ placement or band assignments, unless otherwise stated. Some parentheses have been added by the evaluators.

[‡] From log ft from 3/2+ parent and γ deexcitation pattern.

[§] Jπ(114)=3/2+,5/2+,7/2+ from M1+E2 γ to 5/2+; J(2174)=9/2,11/2,13/2 from log ft=6.0 via 11/2− parent. E1 γ connecting the two levels implies Jπ(114)=7/2+ and Jπ(2174)=9/2−.

[#] Jπ(828)=1/2+,9/2+ from stretched E2 to 5/2+; J(2048)=9/2,11/2,13/2 from log ft=6.5 via 11/2− parent. E1 γ connecting the two levels implies Jπ(828)=9/2+ and Jπ(2048)=9/2−,11/2−.

[@] From multipolarities of deexciting γ's.

[&] (A): πh_{11/2}⊗v(h_{11/2},1/2[541]).

^a (B): ΔJ=1 band based on 27/2+. Configuration=πg_{7/2}⊗vh_{11/2}² or πd_{5/2}⊗vh_{11/2}².

^b (C): π(g_{7/2}d_{5/2}h_{11/2})⊗vh_{11/2}².

^c (D): π11/2[505]⊗vh_{11/2}².

^d (E): γ sequence based on 11/2−.

γ(¹³⁹Pr)

See 29.7-min and 5.5-h ε decay, (α,4nγ), and (p,2nγ) for unplaced gammas.

E(level)	Eγ [†]	Iγ [†]	Mult. [‡]	δ	α	Comments
113.92	113.94 [§] 5	100 [§]	M1+E2	0.16 10	0.904 21	B(E2)(W.u.)=3.0 +40−26; B(M1)(W.u.)=0.00293 14. Mult.,δ: from α(exp) and conversion electron ratios in 5.5-h ε decay.
405.11	405.12 [§] 8	100 [§]	M1 [#]		0.0288	
589.41	184.3 [§] 1	53 [@] 3	M1 ^{&}		0.233	
	475.5 [§] 1	100 [@] 7	M1 [#]		0.0191	
	589.4 [§] 1	47 [@] 3	[M1, E2]			
821.98	708.06 ^a 6	100 ^a	M2+E3	+0.07 4	0.0199	B(E3)(W.u.)=1.2 +17−11; B(M2)(W.u.)=0.137 6. Mult.: from α(K)exp, conversion electron ratios, and γγ(θ) in 5.5-h ε decay. δ: from γγ(θ) in 5.5-h ε decay. B(E3)(W.u.)=5.8 11.
	821.9 ^a 2	6.5 ^a 12	E3 [#]			
827.92	827.86 ^b 10	100 ^b	E2 ^{#c}			
851.87	737.96 ^b 8	100 7	E2+M3	+0.20 4		Mult.: from α(K)exp, conversion electron ratios, and γγ(θ) in 5.5-h ε decay. Stretched E2 from γ(θ) and α(K)exp in (³ He,3nγ) discrepant. δ: from γγ(θ) in 5.5-h ε decay. Eγ: highly unlikely transition.
	852.0 ^{@i} 3	≤0.5	[M3]		0.0263	
916.92	916.9 ^e 3	100 ^e				
1023.92	910.1 3	100	E2(+M1) [#]	>1.1		
1074.21	485.0 ^e 4	18 ^e 3				
	669.0 ^e 3	60 ^e 8				
	1074.2 ^e 4	100 ^e 11				
1124.02	1010.1 ^d 1					
1311.8	1311.8 ^e 4	100 ^e	[M2]			
1328.43	411.5 ^e 2	11 ^e 3				
	923.4 ^e 3	100 ^e 10				

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Pr})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	δ	α	Comments
1328.43	1213.4 ^e 8	24 ^e 8				
	1328.8 ^e 6	21 ^e 6				
1369.68	547.7 [@] 1	100 [@]	M1&c		0.01343	
1405.5	1405.5 ^e 5	100 ^e				
1449.0	1449.0 ^e 10	100 ^e				
1501.3	1096.5 ^e 4	100 ^e 20				
	1500.5 ^e 6	65 ^e 20				
1523.11	701.12 ^b 10	100 ^b	M1, E2 [#]			
1532.0	1532.0 ^e 10	100 ^e				
1584.28	732.4 [@] 2	100 [@]				
1624.32	101.2 1	2.5 8	E2		2.03	Mult.: E2(+M1) from $\alpha(\text{K})\text{exp}$ in 5.5-h ε decay. ≠M1 from decay scheme.
	254.6 1	17.2 ^h 20	M1, E2		0.091 6	
	601.2 4	8.1 13				
	772.5 ⁱ 6	5.8 10				
	796.5 3	60 ^h 6	E1			
	802.0 3	100 ^h 10	E2 (+M1)	>2.4		Mult.: from $\alpha(\text{K})\text{exp}$, conversion electron ratios in 5.5-h ε decay.
	1510.5 5	2.0 8				
1722.18	199.1 ^d 1	4.2 ^{ah} 7	M1 [#]		0.189	
	900.16 ^d 8	100 ^{ah} 7	E2 [#]			
1790.23	962.3 ^a 2	100 ^a	E2 ^{#c}			
1834.00	209.65 7	6.8 7	(M1, E2)		0.1629 25	
	809.6 3	24.1 ^h 24	E1			
	982.2 2	100 ^h 3	E1			
	1006.2 4	12.2 10	E1			
	1012.3 3	10.4 8	E2, M1			
1867.6	1015.7 ^a 3	100 ^a	E2 ^{#c}			E_{γ} : 1014.7 1 in (p,2n γ) and (α ,4n γ).
1926.91	92.91 7	29 6	M1, E2		2.2 6	
	302.7 4	16.2 25	[M1, E2]		0.055 7	
	403.75 8	69 6	(M1)		0.0290	
	1075.2 3	100 ^h 7	E1			
	1105.3 3	78 ^h 6	E2 (+M1)	>1.5		δ : from $\alpha(\text{K})\text{exp}$ in 5.5-h ε decay.
1941.51	219.32 ^a 5	100 ^{ah} 7	M1 (+E2) [#]	<0.1 [#]	0.1449	
	418.8 ^a 4	3.3 ^{ah} 12				
1942.0	1090.1 ^{ai} 4	100 ^a				Alternatively placed with 1941.5 by 1988Ar07 in (p,2n γ).
2029.52	405.2 [@] 1	100 [@]	D+Q			
2048.58	214.6 1	30 5	E2, M1		0.152 3	
	424.3 1	46 6	M1, E2		0.022 4	
	1024.9 4	91 7	E1			
	1219.6 4	100 11	E1			
	1226.7 4	81 9	M1, E2			
2050.1	259.9 ⁱ 3	100				
2174.50	340.5 1	12.6 19	M1, E2		0.040 6	
	1151.2 ⁱ 4	2.6 5				
	1322.3 3	39 4	E1			
	2060.9 3	100 11	E1			
2187.49	245.95 ^d 5	100 ^d	M1 [#]		0.1064	Mult.: stretched dipole from $\gamma(0)$ in (α ,4n γ) discrepant.
2196.46	147.9 1	27 4	(E2, M1)		0.48 6	
	362.42 8	100 8	(E2)		0.0283	
	572.3 2	33 6	(M1)		0.01204	
	673.3 3	27 3	(M1, E2)			
	1344.8 5	20 6				
	1374.7 5	18 6				
2205.8	338.2 ^a 3	100 ^a				
2277.97	336.51 ^d 10	100 ^d	M1 [#]		0.0464	
2291.9	1269.5 ⁱ 8	7.9 18				
	1463.6 5	55 18				
	1470.2 5	100 25				

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Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{Pr})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. ‡	α	Comments
2367.14	179.64 ^b 5	100 ^b	M1	0.250	Mult.: stretched dipole from $\gamma(\theta)$ in ($\alpha,4n\gamma$); M1(+E2), $\delta=0.0$ 1 from $\alpha(\text{K})\text{exp}$ and $\gamma(\theta)$ in ($^3\text{He},3n\gamma$).
2456.30	622.3 [@] 1	100 [@]	D		
2481.39	293.9 ^d 1	100 ^d	D ^f		
2700.65	670.9 ^{@i} 2	100 [@]			
2726.1	1003.9 5	100	Q		
2741.42	260.0 ^{dij} 1				
2761.11	819.7 ^d 1	100 ^d	D ^{#c}		
2821.0	60.2 ^d 1	6.0 ^d 4	(E1)	1.009	
	454.1 ^d 1	23.7 ^d 4	(M2)	0.0730	Mult.: $\Delta J=0$ or 2 Q from $\gamma(\theta)$ in ($\alpha,4n\gamma$). M2 from decay scheme.
	543.3 ^d 1	100 ^d 10	E1 ^{#c}		
	633.6 1	18.8 24	D		
	879.9 ^d 1				I γ : weak transition.
2985.64	259.7 5	100	D+Q		
3021.45	200.3 ^d 1	100 ^d	D+Q ^{#c}		
3139.5	772.4 5	100	Q		
3203.96	182.5 ^d 1				
	382.8 ^d 1	100 ^d 8			
3255.6	888.5 5	100.0	Q		
3265.88	244.5 ^d 1	75 ^g 13			I γ : others: 41 12 in ($^3\text{He},3n\gamma$); 6.7 14 in ($^{19}\text{F},4n\gamma$); the latter is in severe disagreement.
	444.6 ^d 1	100 ^g 13	M1 [#]	0.0227	
3483.93	280.0 ^d 1	100 ^d	D		
3564.9	1197.7 5	42 17	D+Q		
	1377.3 5	100 25	Q		
3579.63	558.2 ^d 1	100 ^d	D+Q		
3627.34	605.9 ^d 1	100 ^d	D+Q		
3697.90	(71.1)		(E1)	0.637	
	214.0 ^d 1	d			I γ : weak γ ray.
	1330.7 ^d 1	100 ^d 7	Q		
3972.33	345.0 ^d 1	100 ^d	D+Q		
4052.4	354.5 5	58 8	D+Q		
	487.4 5	46 8	D+Q		
	786.7 5	100 20	D		
4100.8	(48.2)				
	128.7 5	1.2 4	D		
	402.7 5	100 5	D+Q		
4276.3	1010.4 5	100	Q		
4316.6	618.7 5	100	Q		
4377.37	1173.4 ^d 1				
4412.4	833.0 5	38 8	D+Q		
	1390.8 5	100 40	Q		
4444.0	864.6 5	20 6			
	1422.4 5	100 40	Q		
4536.8	436.0 ^d 1	100 ^d	D+Q		
4626.3	182.3 5	96 11	D+Q		
	213.9 5	100 11	D+Q		
4834.1	421.7 5	100	D+Q		
4862.8	326.0 ^d 1	100 ^d	D+Q		
4906.3	280.0 5	100	D+Q		
4947.4	630.8 5	100	Q		
5056.2	429.9 5	100	D+Q		
5171.3	308.5 5	100	D+Q		
5222.4	1121.5 5	100	Q		
5283.4	377.1 5	100	D+Q		
5363.8	141.4 5	56 13	D+Q		
	307.7 5	28 6			
	827.0 5	100 23	Q		
5406.2	543.4 5	100			
5558.5	194.7 5	100	D+Q		
5585.9	414.6 5	100	D+Q		
5633.2	685.8 5	100	Q		

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Adopted Levels, Gammas (continued)
 $\gamma(^{139}\text{Pr})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. ‡	Comments
5670.8	1134.0 5	100	Q	
5740.6	457.2 5	100	D+Q	
5824.4	418.2 5	100	D+Q	
5861.9	999.1 5	100 17	Q	
	1325.1 i 5	18 15	(M3+E4)	This transition, due to unexpected high multipolarity, is considered as uncertain.
6039.0	1176.2 5	100	Q	
6118.0	256.1 5	100	D+Q	
6182.9	776.7 5	100	Q	
6282.4	541.8 5	100		
6317.3	278.3 5	100	D+Q	
6371.4	738.2 5	100	Q	
6387.2	204.3 5	100	D+Q	
6399.8	281.8 5	100	D+Q	
6525.4	701.0 5	100		
6719.8	1161.3 5	100	Q	
6736.3	336.5 5	100	D+Q	
6772.6	948.2 5	100	D+Q	
6854.1	(81.5)			
	1029.7 5	100 14	Q	
6916.4	634.0 5	100		
6938.2	551.0 5	100	D+Q	
7219.3	847.9 5	100		
7219.5	365.4 5	100	D+Q	

[†] From 5.5-h ϵ decay or (HI,xn γ), unless otherwise noted.

[‡] From α (K)exp in 5.5-h ϵ decay or DCO ratios in in-beam γ -ray data.

[§] From (p,2n γ) or (α ,4n γ).

[#] From α (exp)'s and γ (θ) in (³He,3n γ).

[@] From (p,2n γ).

[&] From α (exp)'s in 29.7-min or 5.5-h ϵ decay and γ (θ) in (p,2n γ).

^a From (³He,3n γ).

^b From (p,2n γ), (³He,3n γ), or (α ,4n γ).

^c Stretched.

^d From (α ,4n γ).

^e From 29.7-min ϵ decay.

^f From γ (θ) in (α ,4n γ).

^g From (α ,4n γ) delayed.

^hDiscrepant branching ratios (Only those ratios which are discrepant with the adopted values are listed):

1624: I γ (255 γ):I γ (797 γ):I γ (802 γ)=100 7:24 5:64 5 in (p,2n γ).

1722: I γ (199 γ)/I γ (900 γ)=0.285 25 and 0.087 25 in (p,2n γ) and (α ,4n γ), respectively

1834: I γ (810 γ)/I γ (982 γ)=1.5 3, 1.2 4, 1.78 15, and 0.241 25 in (³He,3n γ), (α ,4n γ), (p,2n γ), and 5.5-h ϵ decay.

1926: I γ (1105 γ)/I γ (1075 γ)=0.47 5 in (p,2n γ)

1941: I γ (419 γ)/I γ (219 γ)=0.30 19 in (p,2n γ)

ⁱ Placement of transition in the level scheme is uncertain.

^j Multiply placed.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(E) γ sequence based
on 11/2-

^{139}Nd ϵ Decay (29.7 min) 1975Vy02,1971Bu22,1969Be64

Parent ^{139}Nd : $E=0.0$; $J\pi=3/2+$; $T_{1/2}=29.7$ min 5; $Q(\text{g.s.})=2806$ 28; $\% \epsilon + \% \beta^+$ decay=100.

$^{139}\text{Nd}-J, T_{1/2}$: From ^{139}Nd Adopted Levels.

$^{139}\text{Nd}-Q(\epsilon)$: From 2012Wa38.

1969Be64 measured γ 's, prompt and delayed $\gamma\gamma$ -coincidences (Ge(Li), NaI), and $\gamma(t)$ (NaI).

1971Bu22 measured γ 's and ϵ 's and β^+ 's; chem.

1975Vy02 measured γ 's and β^+ 's (mag spect; Si(Li)); chem.

All data and decay scheme are from 1971Bu22, except as noted. Other: 1988IsZX.

 ^{139}Pr Levels

E(level)	$J\pi^\dagger$	Comments
0.0	5/2+	
113.86 5	7/2+	$g=0.34$ 6 (1983AkZY). g: from $\gamma\gamma(0, H, t)$ with $T_{1/2}=2.6$ ns.
405.04 9	3/2+	
588.82 15	5/2+	
916.90 23	(1/2+, 3/2+, 5/2+)	
1074.03 22	(1/2+, 3/2, 5/2)	
1311.8 4	(1/2+, 3/2, 5/2)	
1328.40 22	(3/2+, 5/2)	
1405.5 5	(1/2+, 3/2, 5/2)	
1449.0 10	(1/2+, 3/2, 5/2)	
1501.2 4	(1/2+, 3/2, 5/2)	
1532.0 10	(1/2+, 3/2, 5/2)	

† From the Adopted Levels.

 β^+, ϵ Data

$E\epsilon$	E(level)	$I\beta^{+\ddagger}$	$I\epsilon^\ddagger$	Log ft	$I(\epsilon+\beta^+)^\dagger$	Comments
(1270 30)	1532.0		0.13 6	7.1 2	0.13 6	
(1300 30)	1501.2		0.63 14	6.4 1	0.63 14	
(1360 30)	1449.0		0.15 6	7.1 2	0.15 6	
(1400 30)	1405.5	0.0009 4	0.61 13	6.5 1	0.61 13	
(1480 30)	1328.40	0.0066 22	2.1 4	6.0 1	2.1 4	
(1490 30)	1311.8	0.0011 4	0.30 9	6.9 2	0.30 9	
(1730 30)	1074.03	0.077 18	4.4 8	5.8 1	4.5 8	
(1890 30)	916.90	0.049 12	1.4 3	6.4 1	1.4 3	
(2220 30)	588.82	0.26 5	2.3 5	6.3 1	2.6 5	
(2400 30)	405.04	0.43 8	2.5 4	6.4 1	2.9 5	
(2810 30)	0.0	24 1	61 2	5.13 2	85 2	

$E\epsilon$: 2792 50 from measured $E\beta^+$ (1975Vy02).

$I(\epsilon+\beta^+)$: 100-summed $\epsilon+\beta^+$ feeding to the excited states. See also comment for $I\gamma$ normalization.

Other: $I(\beta^+)=16.6\%$ 28 from $I\beta^+=2.38\%$ 40 of the 5.5-h decay and IT branching ratio of 14.3% 14 (1971Bu22,1975Vy02). Value of ϵ/β^+ (for g.s.)=2.51 20 (theory), 2.5 (1969Be64), and 2.3 2 (1971Bu22).

† From γ -transition intensity balances for excited states.

‡ Absolute intensity per 100 decays.

^{139}Nd ϵ Decay (29.7 min) 1975Vy02,1971Bu22,1969Be64 (continued) $\gamma(^{139}\text{Pr})$

Coincidences shown on drawing are from 1969Be64. See 1969Be64 for possible coincidences.

$\alpha(\text{K})_{\text{exp}}$: normalized to $\alpha(\text{K})(231\gamma \text{ } ^{139}\text{Nd}; \text{M4})=9.5$.

See 5.5-h ϵ decay for other gammas with $T_{1/2}=29.7$ min or 5.5 h observed but not assigned by 1975Vy02.

$I\gamma$ normalization, $I(\gamma+\text{ce})$ normalization: from $I(\gamma^{\ddagger})=260 \text{ } 40$ relative to $I\gamma(405\gamma)=36.4$, decay scheme, and theoretical

ϵ/β^+ ratios for ϵ, β^+ transition to the ground state.

$E\gamma$	E(level)	$I\gamma^{\ddagger}$	Mult. [†]	δ	α	$I(\gamma+\text{ce})^{\ddagger}$	Comments
113.87 5	113.86	4.6 CA	M1+E2	0.16 10	0.906 22	8.7 8	$E\gamma$: from 5.5-h ϵ decay. $I\gamma$: other: 3.7 3 from $I(\gamma+\text{ce})$ and α . $I(\gamma+\text{ce})$: from intensity balancing. Level not expected to be fed directly in ϵ decay ($\Delta J\pi=2, \text{no}$).
183.5 2	588.82	4.0 4	M1		0.245 10		
^x 220.9 3		0.4 1					
^x 368.0 3		0.7 2					
405.0 1	405.04	36.4	M1		0.0288		$\alpha(\text{K})_{\text{exp}}=0.025 \text{ } 7$.
411.5 2	1328.40	0.8 2					
475.5 3	588.82	6.9 6	M1		0.0191		
485.0 4	1074.03	2.4 4					
588.8 3	588.82	4.2 6					
^x 621.7 3		6.4 7					
669.0 3	1074.03	8.0 10					
^x 696.2 § 3		2.0 4					
916.9 3	916.90	8.0 8					$\alpha(\text{K})_{\text{exp}}=0.0047$.
923.4 3	1328.40	7.0 7					$\alpha(\text{K})_{\text{exp}}=0.0054$.
1074.2 4	1074.03	13.3 14					
1096.5 4	1501.2	2.0 4					
1213.4 8	1328.40	1.7 5					
^x 1221.2 8		1.5 5					
^x 1233.3 § 8		0.7 3					
^x 1246.7 8		1.0 4					
1311.8 4	1311.8	1.6 4					
1328.8 6	1328.40	1.5 4					
1405.5 5	1405.5	3.2 5					
1449 1	1449.0	0.8 3					
^x 1463.4 6		1.7 4					
1500.5 6	1501.2	1.3 4					
1532 1	1532.0	0.7 3					

[†] From Adopted Gammas, mainly based on $\alpha(\text{K})_{\text{exp}}$ in the present dataset, except as noted. The $\alpha(\text{K})_{\text{exp}}$: normalized to $\alpha(\text{K})(231\gamma \text{ } ^{139}\text{Nd}; \text{M4})=9.4$.

[‡] For absolute intensity per 100 decays, multiply by 0.190 27.

§ Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

^{139}Nd ϵ Decay (29.7 min) 1975Vy02,1971Bu22,1969Be64 (continued)

Decay Scheme

 Intensities: I(γ +ce) per 100 parent decays

$^{139}_{60}\text{Nd}_{79}$ 29.7 min
 $3/2^+$ 0.0
 0.0
 $Q^+=2806^{28}$
 $\% \epsilon + \% \beta^+ = 100$

¹³⁹Nd ε Decay (5.50 h) 1975Vy02,1971Bu22,1969Be64

Parent ¹³⁹Nd: E=231.15 5; J_π=11/2-; T_{1/2}=5.50 h 20; Q(g.s.)=2806 28; %ε+%β⁺ decay=87.0 10.

¹³⁹Nd-Q(ε): From 2012Wa38.

¹³⁹Nd-%ε+%β⁺ decay: From I(γ+ce)(231γ in IT decay)+ΣI(γ+ce)(to 113.9 level)+ ΣI(γ+ce)(822.1γ+827.8γ+852γ)=100. It is assumed that there is no direct ε+β⁺ feeding to the g.s. and the 113.87 level. Value of I(γ+ce) for 231γ (in ¹³⁹Nd IT decay) is deduced in two ways: 1. from measured I_γ(231γ)=2.35 20 (average of values from 1971Bu22 and 1969Be64); 2. from I(ceK) data for 231γ, I_γ and I(ceK) data for five strong γ rays (1971Bu22) in ¹³⁹Pr were used to determine an average conversion factor of 43.1 25 to normalize the ce(K) and I_γ data in 1971Bu22 on the same scale, which is then used to obtain I(γ+ce) for 231γ. Values of branching ratios are: 87.2% 11 using measured I_γ of 231γ and 86.6% 15 from measured I(ceK) value of 231γ. Weighted average of the two results is 87.0% 10 for %ε+β⁺, and 13.0 10 for IT decay. Other: %IT=14.3% 14 (1971Bu22) from comparison of ce(K)(165.84γ; ¹³⁹Ce) to ce(K)(231.15γ).

See 29.7-min ε decay for experimental details.

1972Kr24 measured 114γ-708γ(0) and 114γ-738γ(0) (Ge(Li),NaI) and (700-900γ)(900-1100γ)(t) (NaI; =5 half-lives). Chem.

Others: 1964So03, 1968BaZW, 1969Be64, 1969He10, 1972Kr24, 1982PrZV, 1988IsZX.

All data and decay scheme from 1971Bu22, except as noted.

¹³⁹Pr Levels

E(level)	J _π [†]	T _{1/2}	Comments
0.0	5/2+		%ε+%β ⁺ =100.
113.87 5	7/2+	2.60 ns 8	T _{1/2} : from 1968BaZW.
822.00 10	11/2- [‡]	36.8 ns 20	T _{1/2} : from 1972Kr24. Other: 40 ns 2 (1969Be64).
828.09 18	9/2+		
851.96 14	11/2+ [‡]		
1023.94 19	9/2+		
1369.71 12	(9/2-, 11/2-)		
1523.21 11	13/2-		
1584.4?§ 6			
1624.37 11	9/2-		
1722.0?§ 5	15/2-		
1834.06 11	(9/2-, 11/2-)		
1926.98 12	(11/2, 13/2)-		
2048.64 12	9/2-, 11/2-		
2174.55 14	9/2-		
2196.52 12	(9/2-, 11/2-, 13/2-)		
2292.0 4	(9/2, 11/2, 13/2+)		

[†] From the Adopted Levels, except as noted.

[‡] From γγ(0) and multiplicities of deexciting gammas.

§ Suggested by evaluators based on reaction γ data.

β⁺,ε Data

Eε	E(level)	Iβ ⁺ [‡]	Iε [‡]	Log ft	I(ε+β ⁺) [‡]	Comments
(750 30)	2292.0		0.92 18	6.81 10		
(840 30)	2196.52		5.6 4	6.14 5		
(860 30)	2174.55		7.4 6	6.04 5		
(990 30)	2048.64		4.9 4	6.34 5		
(1110 30)	1926.98		12.5 11	6.04 5	12.5 11	
(1200 30)	1834.06	0.0019 18	33.8 16	5.68 4	33.8 16	
(1320§ 30)	1722.0?		0.39 7	7.70 9	0.39 7	
(1410 30)	1624.37	0.017 6	9.9 10	6.36 5	9.9 10	
(1450§ 30)	1584.4?	0.0015 5	0.58 11	7.6 1	0.58 11	
(1510§ 30)	1523.21	0.003 2	0.6 5	7.6 4	0.6 5	
(1670 30)	1369.71	0.013 3	1.1 2	7.5 1	1.1 2	
(2190 30)	851.96	0.21 8	2.1 8	7.4 2	2.3 9	
(2210§ 30)	828.09	0.10 8	0.9 7	7.8 4	1.0 8	
(2220 [†] 30)	822.00	0.66 15	6.1 14	6.96 10	6.8 15	Eε: 2192 50 from measured Eβ ⁺ value. Iβ ⁺ : other: 1.19% 35 (1975Vy02).
(2920§ 30)	113.87	<1.3	<8.7	>8.6 ^{1u}	<10	

[†] 1975Vy02 obtained the same value.

[‡] For intensity per 100 decays, multiply by 1.000 12.

§ Existence of this branch is questionable.

¹³⁹Nd ε Decay (5.50 h) 1975Vy02,1971Bu22,1969Be64 (continued)

 $\gamma(^{139}\text{Pr})$

Coincidences shown on drawing are from 1969Be64 and 1972Kr24. See 1969Be64 for possible coincidences.

$\alpha(\text{K})_{\text{exp}}$: normalized to $\alpha(\text{K})(231\gamma^{139}\text{Nd}; \text{M4})=9.5$.

1975Vy02 reported the following γ 's with $T_{1/2}=5.5$ h or

29.7 min:

$E\gamma$	$I\gamma^\dagger$	$E\gamma$	$I\gamma^\dagger$	$E\gamma$	$I\gamma^\dagger$	$E\gamma$	$I\gamma^\dagger$
204.3 3	0.40 6	558.5 5	0.90 14	1204.2 5	0.25 4	1440.5 5	0.11 3
326.0 4	1.04 15	695.5 4	1.46 23	1250.0 8	0.20 4	1948.0 7	0.05 2
343.1 5	1.55 22	845.5 6	0.22 6	1305.7 6	0.18 3	1960.0 7	0.11 3
419.5 5	0.51 7	870.5 5	0.50 9	1400.0 4	0.22 4	2052.0 7	0.16 5
431.2 6	0.78 14	963.0 5	0.26 7	1412.0 5	0.17 4	2285.5 5	0.06 2
463.8 4	1.15 14	1031.5 5	0.65 9	1421.3 5	0.19 5		

† Relative to $I\gamma(738\gamma)=100$.

$I\gamma$ normalization: From $\Sigma I(\gamma+\text{ce})$ to 113.9 level)+ $\Sigma I(\gamma+\text{ce})(\gamma$ rays to g.s., except the 113.9 γ)=100, assuming no direct feeding of g.s. (none expected for a $\Delta J=3$, yes β transition) and the 113.9 level (as evidenced by γ -transition intensity balance at this level).

$E\gamma$	E(level)	$I\gamma^a$	Mult. †	$\delta^\dagger$	α	Comments
92.91 7	1926.98	2.9 6	M1, E2		2.2 6	$\alpha(\text{K})_{\text{exp}}=1.4$ 5.
101.20 10	1624.37	0.50 15	E2		2.03	$\alpha(\text{K})_{\text{exp}}=1.5$ 7.
113.87 5	113.87	113 13	M1+E2	0.16 10	0.906 22	Mult.: M1, E2 from $\alpha_K(\text{exp})$; $\neq$ M1 from ΔJ . $\alpha(\text{K})_{\text{exp}}=0.86$ 13. K:L1:L2:L3:M:N+=4450 150:685 25:73 7:42 4:119 6: 24.0 25.
147.9 1	2196.52	1.77 23	(E2, M1)		0.48 6	$\alpha(\text{K})_{\text{exp}}=0.36$ 14.
*151.4 2		≤ 0.2				$\alpha(\text{K})_{\text{exp}} \geq 0.45$.
*172.1 2		≤ 0.2				171.2 2, $I\gamma=0.18$ 7 (1975Vy02) probably corresponds to this γ . $\alpha(\text{K})_{\text{exp}} \geq 0.57$.
209.65 7	1834.06	5.1 5	(M1, E2)		0.1629 25	$\alpha(\text{K})_{\text{exp}}=0.16$ 3.
214.6 1	2048.64	1.4 2	E2, M1		0.152 3	$\alpha(\text{K})_{\text{exp}}=0.09$ 4.
254.6 1	1624.37	3.4 4	M1, E2		0.091 6	$\alpha(\text{K})_{\text{exp}}=0.084$ 25.
302.7 4	1926.98	1.60 25	[M1, E2]		0.055 7	
340.5 1	2174.55	1.72 25	M1, E2		0.040 6	$\alpha(\text{K})_{\text{exp}}=0.049$ 12.
362.42 8	2196.52	6.6 5	(E2)		0.0283	$\alpha(\text{K})_{\text{exp}}=0.0185$ 50.
403.75 8	1926.98	6.8 6	(M1)		0.0290	$\alpha(\text{K})_{\text{exp}}=0.032$ 8.
424.3 1	2048.64	2.15 25	M1, E2		0.022 4	$\alpha(\text{K})_{\text{exp}}=0.030$ 10.
*475.5 2		1.75 25				
547.65 10	1369.71	6.7 5	M1		0.01344	$\alpha(\text{K})_{\text{exp}}=0.015$ 4.
572.3 2	2196.52	2.2 4	(M1)		0.01204	$\alpha(\text{K})_{\text{exp}}=0.015$ 8.
601.2 4	1624.37	1.60 25				
673.3 3	2196.52	1.76 20	(M1, E2)		0.0067 15	$\alpha(\text{K})_{\text{exp}}=0.0062$ 20.
701.2 1	1523.21	11.8 12	M1, E2		0.0060 13	$\alpha(\text{K})_{\text{exp}}=0.0074$ 15.
708.1 1	822.00	74.8 32	M2+E3 ‡	+0.07 § 4	0.0199	
732.4 $^\#$ &b 5	1584.4?	1.64 $^\#$ 26				
738.2 3	851.96	100	E2+M3 ‡	+0.20 § 4	0.0056 6	$\alpha(\text{K})_{\text{exp}}=0.0041$ 4; K:L:M+=18.8 19:2.2 25:0.50 8. Mult., δ : stretched E2 from $\gamma(0)$ and $\alpha(\text{K})_{\text{exp}}$ in ($^3\text{He}, 3n\gamma$) are discrepant.
772.5 $^\#$ &b 6	1624.37	1.15 $^\#$ 20				
796.5 3	1624.37	11.9 12	E1		1.38 $\times 10^{-3}$	$\alpha(\text{K})_{\text{exp}}=0.0009$ 3.
802.0 3	1624.37	19.8 20	E2(+M1)	>2.4	0.00360 15	$\alpha(\text{K})_{\text{exp}}=0.0026$ 6; K/L=8.0 24.
809.6 3	1834.06	18.0 18	E1		1.34 $\times 10^{-3}$	$\alpha(\text{K})_{\text{exp}}=0.00105$ 25; K/L=7.5 22.
822.1 3	822.00	4.9 6	E3		0.00744	$\alpha(\text{K})_{\text{exp}}=0.0055$ 17; K/L=7.2 22.
827.8 3	828.09	29.3 15	E2		0.00322	$\alpha(\text{K})_{\text{exp}}=0.0023$ 5; K/L=8.2 19.
852.0 $^\text{b}$	851.96	≤ 0.5	[M3]		0.0263	
*894.8 2		1.00 16	(M1)		0.00408	$\alpha(\text{K})_{\text{exp}}=0.0055$ 24.
900.0 $^\text{b}$ &b 4	1722.0?	1.10 20	E2		0.00267	$\alpha(\text{K})_{\text{exp}}=0.0024$ 4. Mult.: (M1) from α_K ; E2 from $\Delta J\pi$.
910.1 3	1023.94	21.6 11	E2(+M1)	>1.1	0.0029 3	$\alpha(\text{K})_{\text{exp}}=0.0024$ 4; K/L=8.0 19.
982.2 2	1834.06	74.8 22	E1		9.20 $\times 10^{-4}$	$\alpha(\text{K})_{\text{exp}}=0.00074$ 11; K/L=8.5 20.
1006.2 4	1834.06	9.1 7	E1		8.79 $\times 10^{-4}$	$\alpha(\text{K})_{\text{exp}}=0.00072$ 20.
1012.3 3	1834.06	7.8 6	E2, M1		0.0026 5	$\alpha(\text{K})_{\text{exp}}=0.0020$ 5.
1024.9 4	2048.64	4.3 3	E1		8.49 $\times 10^{-4}$	$\alpha(\text{K})_{\text{exp}}=0.00076$ 20.
1075.2 3	1926.98	9.9 7	E1		7.77 $\times 10^{-4}$	$\alpha(\text{K})_{\text{exp}}=0.00060$ 15.

Continued on next page (footnotes at end of table)

^{139}Nd ϵ Decay (5.50 h) 1975Vy02,1971Bu22,1969Be64 (continued) $\gamma(^{139}\text{Pr})$ (continued)

E γ	E(level)	I γ^a	Mult. [†]	$\delta^\ddagger$	α	Comments
1105.3 3	1926.98	7.7 6	E2 (+M1)	>1.5	0.00184 12	$\alpha(\text{K})_{\text{exp}}=0.0013$ 4.
1151.2# ^b 4	2174.55	0.35# 7				
^x 1165.8 5		0.98 15				
1219.6 4	2048.64	4.7 5	E1		6.55×10^{-4}	$\alpha(\text{K})_{\text{exp}}=0.0007$ 3.
1226.7 4	2048.64	3.8 4	M1, E2		0.0017 3	$\alpha(\text{K})_{\text{exp}}=0.0017$ 6.
^x 1234.6 5		1.2 2	M1, E2		0.0017 3	$\alpha(\text{K})_{\text{exp}}=0.0013$ 5.
^x 1245.7 5		0.82 18	E2 (+M1)	≥ 0.5	0.00158 22	$\alpha(\text{K})_{\text{exp}}=0.0011$ 5.
1269.5# ^b 8	2292.0	0.13# 3				
1322.3 3	2174.55	5.3 5	E1		6.26×10^{-4}	$\alpha(\text{K})_{\text{exp}}=0.00041$ 18.
1344.8 5	2196.52	1.3 4				$\alpha(\text{K})_{\text{exp}}=0.0007$ 5.
^x 1364.8 5		0.95 15				Coin with 114 γ but not placed. $\alpha(\text{K})_{\text{exp}}=6.9 \times 10^{-4}$.
1374.7 5	2196.52	1.2 4				
1463.6 5	2292.0	0.9 3				
1470.2 5	2292.0	1.6 4				
1510.5 5	1624.37	0.40 15				
^x 1680.7 5		0.9 2				
2060.9 3	2174.55	13.6 14	E1		8.86×10^{-4}	$\alpha(\text{K})_{\text{exp}}=0.00019$ 5.
^x 2085.0 7		0.15 6				
^x 2201.2 8		0.36 7				

[†] From $\alpha(\text{exp})$'s and conversion electron ratios, except as noted.[‡] From $\alpha(\text{exp})$'s, conversion electron ratios, and $\gamma\gamma(\theta)$ of 1972Kr24.[§] From $\gamma\gamma(\theta)$ of 1972Kr24.

From 1975Vy02.

@ Placement suggested by evaluators based on statement by 1975Vy02 that $\approx 1/2$ of the new gammas observed by them could be placed between existing levels.& Placement suggested by evaluators on the basis of reaction γ data.^a For absolute intensity per 100 decays, multiply by 0.351 8.^b Placement of transition in the level scheme is uncertain.^x γ ray not placed in level scheme.

124Sn(19F,4nγ) 2012Ye06

Includes 128Te(14N,3nγ) from 1980Ba47.

2012Ye06: 124Sn(19F,4nγ), E=80 MeV. Beam from Tandem accelerator at CIAE facility. Target=5.76 mg/cm² 124Sn on a 14.85 mg/cm² Pb substrate. Gamma rays were detected by an array of twelve Compton-suppressed HPGe detectors and two planar HPGe detectors. Measured Eγ, Iγ, γγ-coin, DCO. Deduced high spin states, J, π, configurations, bands, multipolarity. Calculated Total Routhian surfaces (TRS). Systematic comparison of the low-spin levels in N=80 isotones.

1980Ba47: 128Te(14N,3nγ), E=50–60 MeV. Measured excitation functions, γ, prompt and delayed γγ-coincidences, and γ(θ). Authors report levels at 2484 (542.9γ, 762γ), 2730 (245.8γ), 2910 (179.7γ) but the associated γ rays have been placed elsewhere by 2012Ye06.

Other: 1987Dr12.

139Pr Levels

E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]	E(level) [†]	Jπ [‡]
0.0	5/2+	3697.6 [§] 10	25/2-	5632.9 [§] 13	37/2-
113.9 4	7/2+	3971.6 11	(27/2+)	5670.2 12	33/2-
821.8 ^a 4	11/2-	4052.1 10	(25/2-)	5739.9 [#] 14	35/2+
851.8 7	11/2+	4100.3 ^{&} 10	27/2-	5823.8 ^{&} 14	(35/2-)
1522.6 ^a 6	13/2-	4275.8 11	27/2+	5861.3 [@] 12	35/2-
1722.1 ^a 6	15/2-	4316.3 [§] 11	29/2-	6038.4 13	35/2-
1867.8 9	(15/2+)	4411.7 10	27/2+	6117.4 [@] 13	37/2-
1941.4 ^a 8	17/2-	4443.3 [#] 10	27/2+	6182.3 14	(37/2-)
2187.4 ^a 9	19/2-	4536.2 ^{&} 11	29/2-	6281.7 [#] 15	(37/2+)
2277.9 9	19/2-	4625.6 [#] 11	29/2+	6316.7 14	(37/2-)
2367.0 ^a 9	21/2-	4833.4 12	(29/2+)	6371.1 [§] 14	41/2-
2726.0 8	19/2-	4862.2 ^{&} 12	31/2-	6386.6 15	(39/2-)
2761.0 9	19/2-	4905.6 [#] 12	31/2+	6399.2 [@] 14	39/2-
2820.9 9	21/2+	4947.1 [§] 12	33/2-	6524.8 ^{&} 15	(37/2-)
2985.7 10	(21/2-)	5055.5 11	(31/2+)	6719.2 13	(39/2-)
3020.9 10	23/2+	5170.7 13	(33/2-)	6735.7 [@] 15	41/2-
3139.4 11	25/2-	5221.8 11	31/2-	6772.0 14	(37/2-)
3255.5 11	25/2-	5282.7 [#] 13	33/2+	6853.5 14	(39/2-)
3265.4 10	23/2+	5363.2 11	33/2-	6915.7 [#] 15	(39/2+)
3564.7 10	23/2-	5405.6 ^{&} 13	(33/2-)	6937.6 15	(41/2-)
3578.7 10	(25/2+)	5557.9 12	(35/2-)	7218.9 15	(41/2-)
3626.5 10	(25/2+)	5585.3 14	(35/2-)	7219.0 [§] 15	(45/2-)

[†] From least-squares fit to Eγ data.

[‡] From DCO measurements and band structures.

[§] (A): πh_{11/2}⊗v(h_{11/2},1/2[541]).

[#] (B): ΔJ=1 band based on 27/2+. Configuration=πg_{7/2}⊗vh_{11/2}² or πd_{5/2}⊗vh_{11/2}².

[@] (C): π(g_{7/2}d_{5/2}h_{11/2})⊗vh_{11/2}².

[&] (D): π11/2[505]⊗vh_{11/2}².

^a (E): γ cascade based on 11/2-.

γ(139Pr)

DCO ratios correspond to gate on ΔJ=2, M2 transition of 707.9 keV. Expected values are 1.1 for ΔJ=2, quadrupole and 1.67 for ΔJ=1, dipole.

Eγ	E(level)	Iγ	Mult.	α	Comments
(48.2)	4100.3				
(59.9)	2820.9				
(71.1)	3697.6				
(81.5)	6853.5				
113.9 5	113.9	>112.6	[M1]	0.894 17	
128.7 5	4100.3	0.16 4			
141.4 5	5363.2	0.50 11	D+Q		DCO=1.52 17.
179.6 5	2367.0	25.0 9			
182.3 5	4625.6	0.44 5	D+Q		DCO=1.64 22.
194.7 5	5557.9	0.61 12	D+Q		DCO=1.81 20.
199.5 5	1722.1	5.2 9			
200.0 5	3020.9	2.6 5			
204.3 5	6386.6	0.34 5	D+Q		DCO=1.71 15.
213.9 5	4625.6	0.46 5	D+Q		DCO=1.57 12.

Continued on next page (footnotes at end of table)

$^{124}\text{Sn}(^{19}\text{F},4n\gamma)$ 2012Ye06 (continued) $\gamma(^{139}\text{Pr})$ (continued)

E_γ	E(level)	I_γ	Mult.	Comments
219.3 5	1941.4	62.0 9		
244.5 5	3265.4	0.24 5		
246.0 5	2187.4	31.2 10		
256.1 5	6117.4	0.39 5	D+Q	DCO=1.73 8.
259.7 5	2985.7	1.4 2	D+Q	DCO=1.56 15.
278.3 5	6316.7	0.21 4	D+Q	DCO=1.68 12.
280.0 5	4905.6	0.65 13	D+Q	DCO=1.66 20.
281.8 5	6399.2	0.32 9	D+Q	DCO=1.64 8.
307.7 5	5363.2	0.25 5		
308.5 5	5170.7	0.42 6	D+Q	DCO=1.67 9.
326.0 5	4862.2	6.8 4	D+Q	DCO=1.59 4.
336.5 [†] 5	2277.9	16.0 [†] 8		
	6735.7	0.12 [†] 2	D+Q	DCO=1.62 17.
345.1 5	3971.6	0.37 3	D+Q	DCO=1.82 12.
354.5 5	4052.1	1.5 2	D+Q	DCO=1.11 11.
			Mult.: $\Delta J=(0)$ transition.	
365.4 5	7218.9	0.33 5	D+Q	DCO=1.57 14.
377.1 5	5282.7	0.42 6	D+Q	DCO=1.84 7.
402.7 5	4100.3	12.9 6	D+Q	DCO=1.48 5.
414.6 5	5585.3	0.35 5	D+Q	DCO=1.74 12.
418.2 5	5823.8	1.31 9	D+Q	DCO=1.70 10.
421.7 5	4833.4	0.11 4	D+Q	DCO=1.57 20.
429.9 5	5055.5	0.3 1	D+Q	DCO=1.69 15.
435.9 5	4536.2	11.5 4	D+Q	DCO=1.67 4.
444.5 5	3265.4	3.6 6		
453.9 5	2820.9	2.6 7		
457.2 5	5739.9	0.25 3	D+Q	DCO=1.58 12.
483.1 5	2761.0	0.9 2		
487.4 5	4052.1	1.2 2	D+Q	DCO=1.79 20.
541.8 5	6281.7	0.13 3		
543.0 5	2820.9	8.5 12		
543.4 5	5405.6	3.3 2		
551.0 5	6937.6	0.20 7	D+Q	DCO=1.72 22.
557.8 5	3578.7	0.5 1	D+Q	DCO=1.81 13.
605.6 5	3626.5	0.5 2	D+Q	DCO=1.87 13.
618.7 5	4316.3	2.5 3	Q	DCO=1.03 13.
630.8 5	4947.1	0.9 2	Q	DCO=0.96 17.
633.5 5	2820.9	1.6 2	D	DCO=1.47 16.
634.0 5	6915.7	<0.1		
685.8 5	5632.9	0.7 1	Q	DCO=1.01 7.
700.8 5	1522.6	5.5 9		
701.0 5	6524.8	<0.1		
707.9 5	821.8	100.0 4		
737.9 5	851.8	12.6 2		
738.2 5	6371.1	0.16 6	Q	DCO=1.19 11.
772.4 5	3139.4	1.4 2	Q	DCO=1.04 10.
776.7 5	6182.3	0.51 6	Q	DCO=1.06 12.
786.7 5	4052.1	2.6 5	D	DCO=1.76 8.
819.6 5	2761.0	14.5 9	D+Q	DCO=1.72 7.
821.8 5	821.8	4.8 9		
827.0 5	5363.2	0.9 2	Q	DCO=1.29 14.
833.0 5	4411.7	0.19 4	D+Q	DCO=1.68 22.
847.9 5	7219.0	0.14 5		
864.6 5	4443.3	0.10 3		
888.5 5	3255.5	0.4 1	Q	DCO=0.94 11.
900.3 5	1722.1	66 4		
948.2 5	6772.0	0.32 7	D+Q	DCO=1.71 24.
999.1 5	5861.3	0.55 9	Q	DCO=1.02 5.
1003.9 5	2726.0	1.5 3	Q	DCO=1.03 11.
1010.4 5	4275.8	0.24 5	Q	DCO=1.25 17.
1016.0 5	1867.8	12.3 19		
1029.7 5	6853.5	0.64 9	Q	DCO=1.09 11.
1121.5 5	5221.8	0.8 2	Q	DCO=1.29 14.

Continued on next page (footnotes at end of table)

¹²⁴Sn(¹⁹F,4n γ) 2012Ye06 (continued)

$\gamma(^{139}\text{Pr})$ (continued)

E γ	E(level)	I γ	Mult.	Comments
1134.0 5	5670.2	1.0 2	Q	DCO=1.02 10.
1161.3 5	6719.2	0.3 1	Q	DCO=1.25 20.
1176.2 5	6038.4	0.8 1	Q	DCO=1.19 14.
1197.7 5	3564.7	0.5 2	D+Q	DCO=1.63 22.
1325.1 $\frac{1}{2}$ 5	5861.3	0.10 8	[M3+E4]	Mult.: transition considered unlikely by evaluators due to unusual high multipolarity.
1330.6 5	3697.6	19.2 10	Q	DCO=0.98 4.
1377.3 5	3564.7	1.2 3	Q	DCO=1.08 12.
1390.8 5	4411.7	0.5 2	Q	DCO=1.12 10.
1422.4 5	4443.3	0.5 2	Q	DCO=1.16 14.

$\dagger$ Multiply placed; intensity suitably divided.

$\ddagger$ Placement of transition in the level scheme is uncertain.

¹³⁰Te(¹⁴N,5n γ) 2012BhZZ,2001Ch91

2012BhZZ, 2001Ch91: E=75 MeV. Measured E γ , I γ , $\gamma\gamma$, $\gamma\gamma(\theta)$ (DCO) using an array of seven Compton-suppressed HPGe detectors and a multiplicity filter of 14 BGO detectors at IUAC-Pelletron facility. Both references are conference reports with mainly the level schemes provided, and approximate level half-lives in 2012BhZZ. 2011Mu20 is a conference report from the same experiment which gives T_{1/2} for the 822-keV isomer.

Due to the tentative nature of these results, only those levels are indicated as populated in the Adopted dataset, where levels and deexciting transitions match with other independent studies published in peer-reviewed journals. Data here are from level scheme Figure 2 in 2012BhZZ.

¹³⁹Pr Levels

E(level) $\dagger$	J $\pi^{\S}$	T _{1/2} $^{\@}$	Comments
0.0	5/2+		
113.9 5	7/2+		
822.0 $\&$ 5	11/2-	≈ 36 ns	
852.0 7	11/2+		
1523.1 6	13/2+ $\#$		
1722.2 $\&$ 6	15/2-		
1866.7 9	(13/2)+		J π : (15/2)+ in Adopted Levels.
1941.6 $\&$ 8	17/2-		
2187.6 $\&$ 9	19/2-	≈ 9 ns	
2277.6 9	19/2-		
2367.3 $\&$ 9	21/2-		
2761.3 9	19/2-		
2820.6 ^a 9	21/2- $\#$		
3021.0 ^a 10	23/2- $\#$		
3265.2 10	23/2- $\#$		
3301.0 $\ddagger$ ^a 11	25/2-		
3514.8 $\ddagger$ ^a 12	27/2-		
3626.8 11	25/2- $\#$		
3698.0 $\&$ 10	25/2+ $\#$	≈ 12 ns	T _{1/2} : ≈ 10 -15 ns.
3944.5 $\ddagger$ ^a 13	29/2-		
3972.5 11	27/2- $\#$		
4051.2 10	25/2-		
4100.8 $\&$ 10	27/2+ $\#$		
4126.8 $\ddagger$ ^a 14	31/2-		
4536.8 $\&$ 11	29/2+ $\#$		
4862.8 $\&$ 13	31/2+ $\#$		
4926.8 $\ddagger$ 11	(29/2)		
5121.4 $\ddagger$ 13	(31/2)		
5406.3 $\&$ 14	33/2+ $\#$		
5569.0 $\ddagger$ 14	(35/2)		
5706.0 $\ddagger$ 15	(37/2)		
5715.0 $\ddagger$ ^b 14	35/2+		

Continued on next page (footnotes at end of table)

¹³⁰Te(¹⁴N,5n γ) 2012BhZZ,2001Ch91 (continued)

¹³⁹Pr Levels (continued)

E(level) [†]	J π [§]	Comments
5824.8 & 14	35/2-	
6038.3 14	33/2+	J π : (35/2)- in Adopted Levels.
6129.0 [‡] b 15	37/2+	
6183.0 [‡] 14	(35/2)	
6316.0 14	(35/2+)	J π : (37/2)- in Adopted Levels.
6387.0 15	(37/2)	
6648.0 [‡] b 16	(39/2+)	
6854.2 & 15	39/2-	
6883.0 [‡] b 17	(41/2+)	
7218.9 & 16	43/2(-)	
7267.0 b 18	(43/2+)	

[†] From least-squares fit to E γ data, assuming $\Delta(E\gamma)=0.5$ keV for each γ ray.

[‡] Level not given in Adopted Levels. In some cases the deexciting transition shown in this dataset has been relocated in the high-spin investigation by 2012Ye06, which has been mainly adopted by the evaluators.

[§] As listed by 2012BhZZ in their Fig. 2.

[#] Parity is opposite in Adopted Levels.

[@] From $\gamma\gamma(t)$ (2012BhZZ). Value of 36 ns for the 822-keV level is also given in 2011Mu20.

& (A): γ cascade based on 11/2-.

a (B): γ cascade based on 21/2-.

b (C): γ cascade based on 35/2+.

 $\gamma(^{139}\text{Pr})$

E γ	E(level)	E γ	E(level)	E γ	E(level)
(49.6)	4100.8	246.0	2187.6	519.0	6648.0
59.3	2820.6	277.7	6316.0	543.0	2820.6
113.9	113.9	280.0	3301.0	543.5	5406.3
128.3	4100.8	308.7	5715.0	605.8	3626.8
137.0	5706.0	326.0	4862.8	701.1	1523.1
144.7	6183.0	336.0	2277.6	708.1	822.0
162.7	5569.0	345.7	3972.5	738.1	852.0
179.7	2367.3	353.2	4051.2	786.0	4051.2
182.3	4126.8	364.7	7218.9	819.7	2761.3
194.6	5121.4	384.0	7267.0	822.0	822.0
199.1	1722.2	402.8	4100.8	826.0	4926.8
200.4	3021.0	414.0	6129.0	900.2	1722.2
204.0	6387.0	418.5	5824.8	1014.7	1866.7
213.8	3514.8	429.7	3944.5	1029.4	6854.2
219.4	1941.6	436.0	4536.8	1175.5	6038.3
235.0	6883.0	444.6	3265.2	1330.7	3698.0
244.2	3265.2	453.3	2820.6		

¹³⁹La(³He,3n γ) 1980Pi03

Measured: γ 's, excitation functions (E(p)=14.9–20.2 MeV), $\gamma\gamma$ -coincidences, $\gamma(\theta)$, and $\gamma(t)$ (Ge(Li) and Ge) and ce's and ce(t) (mag spect, Si(Li)). See also ¹³⁹La(α ,4n γ) and ¹⁴⁰Ce(p,2n γ).

¹³⁹Pr Levels

E(level)	J $\pi^{\dagger}$	T _{1/2}	Comments
0.0	5/2+		
113.93 5	7/2+		
405.13 8	3/2+		J π : $\neq$ 5/2+,7/2+ from excit and syst of La, Pr, and Sm nuclei.
589.74 11	5/2+		
821.99 8	11/2-	43 ns 2	
827.86 10	9/2+ $\ddagger$		
851.87 10	11/2+ $\S$		
1024.01 18	9/2+		
1369.69 22	9/2-,11/2-		
1523.08 12	13/2-		
1722.17 11	15/2-		
1790.17 23	(13/2)+ $\ddagger$		
1833.69 18	9/2-,11/2-		J π : excit suggests 11/2-.
1867.6 4	(15/2)+ $\S$		
1941.50 12	(17/2)-		
1942.0 5			J π : (15/2+) suggested by 1980Pi03 based on γ to 11/2+ and excit.
2050.1 4			
2187.45 13	(19/2,15/2)-		
2205.8 5			
2278.00 16	(19/2,15/2)-		
2367.09 14	(21/2,17/2,13/2)-		
2761.10 24	(15/2,19/2)-		
2821.18 23	(21/2,17/2,13/2)+		
3021.3 4	(23/2,19/2,15/2)+		
3265.4 4	+		J π : 1980Pi03 suggest (23/2)+ based on M1 γ to (21/2)+.
3627.0?# 4			
3694.4?# 7			
4097.1?# 7			

$\dagger$ From the Adopted Levels. Contributing arguments and other suggested spins and parities from this work given as comments or footnotes.

$\ddagger$ Stretched E2 cascade to 5/2+.

$\S$ Stretched E2 cascade to 7/2+.

Suggested by evaluators based on (α ,4n γ) data of 1988Ar07.

 $\gamma(^{139}\text{Pr})$

$\alpha(\text{K})_{\text{exp}}, \alpha(\text{L})_{\text{exp}}$: normalized to $\alpha(\text{K})(487.1\gamma \text{ } ^{140}\text{Ce}; \text{E2})$.

E γ	E(level)	I γ	Mult. †	$\delta^{\ddagger}$	α	Comments
113.94 5	113.93	106 7	M1		0.893	$\alpha(\text{L})_{\text{exp}}=0.093 \text{ } 20$.
179.64 5	2367.09	7.8 5	M1		0.250	$\alpha(\text{K})_{\text{exp}}=0.241 \text{ } 5$.
184.5 3	589.74	1.8 39				
199.2 4	1722.17	3.0 5	M1		0.188	$\alpha(\text{K})_{\text{exp}}=0.199 \text{ } 4$. $\alpha(\text{K})_{\text{exp}}$: For 199.2 γ +200.2 γ .
200.2 3	3021.3	4.7 8				
219.32 5	1941.50	43 3	M1 (+E2)	<0.1	0.1449	$\alpha(\text{K})_{\text{exp}}=0.130 \text{ } 25$. I γ : 1980Pi03 give 42.9 3; probable typographical error since this would imply $\Delta\text{I}\gamma=0.7\%$.
244.2 3	3265.4	1.1 3				
245.95 5	2187.45	18.8 15	M1 $\ddagger$	$\ddagger$	0.1064	$\alpha(\text{K})_{\text{exp}}=0.103 \text{ } 20$.
259.9 3	2050.1	1.1 2				
336.51 10	2278.00	11.8 10	M1		0.0464	$\alpha(\text{K})_{\text{exp}}=0.044 \text{ } 7$.
338.2 3	2205.8	3.5 7				
402.7 $\S$ @ 2	4097.1?	1.1 2				
405.12 8	405.13	13.3 10	M1		0.0288	$\alpha(\text{K})_{\text{exp}}=0.024 \text{ } 3$.
418.8 4	1941.50	1.4 5				
444.2 3	3265.4	2.7 5	M1		0.0227	$\alpha(\text{K})_{\text{exp}}=0.02 \text{ } 5$.
454.0 4	2821.18	1.0 2				

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¹³⁹La(³He,3n γ) 1980Pi03 (continued)

 $\gamma(^{139}\text{Pr})$ (continued)

E γ	E(level)	I γ	Mult. [†]	$\delta^{\dagger}$	α	Comments
475.81 10	589.74	5.9 9	M1		0.0191	$\alpha(\text{K})_{\text{exp}}=0.016$ 2.
543.2 2	2821.18	4.1 6	E1			$\alpha(\text{K})_{\text{exp}}=0.0023$ 7.
547.7 2	1369.69	5.2 8	M1		0.01343	$\alpha(\text{K})_{\text{exp}}=0.0124$ 25.
589.8 4	589.74	1.8 6	[M1, E2]			
605.7 ^{§@} 2	3627.0?	0.8 2				
701.12 10	1523.08	16.9 16	M1+E2	-0.6 +2-6		$\alpha(\text{K})_{\text{exp}}=0.0041$ 12.
708.06 6	821.99	100	M2		0.0200	$\alpha(\text{K})_{\text{exp}}=0.0165$ 15.
737.96 8	851.87	52.1 40	E2 [#]			$\alpha(\text{K})_{\text{exp}}=0.0038$ 6.
						Mult.: discrepant with E2+M3, $\delta=+0.20$ 4 from $\gamma(\theta)$, $\alpha(\text{K})_{\text{exp}}$, and conversion electron ratios in 5.5-h ϵ decay.
809.5 2	1833.69	8.3 10	E1			$\alpha(\text{K})_{\text{exp}}=0.0019$ 6.
819.6 2	2761.10	5.8 10				
821.9 2	821.99	6.5 12	E3			$\alpha(\text{K})_{\text{exp}}=0.0060$ 6.
827.86 10	827.86	25.6 25	E2 [#]			$\alpha(\text{K})_{\text{exp}}=0.0030$ 6.
900.16 8	1722.17	71.8 50	E2			$\alpha(\text{K})_{\text{exp}}=0.0023$ 2.
909.9 2	1024.01	10.5 10	E2			Mult.: 1980Pi03 give M1+E2 but $\alpha(\text{K})_{\text{exp}}=0.0019$ 4 not consistent with any appreciable M1 admixture.
962.3 2	1790.17	8.4 13	E2 [#]			$\alpha(\text{K})_{\text{exp}}=0.0016$ 5.
982.0 2	1833.69	5.6 10	E1			$\alpha(\text{K})_{\text{exp}}=0.0007$ 3.
1015.7 3	1867.6	15.2 30	E2 [#]			$\alpha(\text{K})_{\text{exp}}=0.0018$ 5.
1090.1 4	1942.0	5.3 11				
1327.3 ^{§@} 6	3694.4?	2.4 5				

[†] From $\gamma(\theta)$ and $\alpha(\text{exp})$'s.

[‡] Discrepant with stretched dipole from $\gamma(\theta)$ in $(\alpha, 4n\gamma)$.

[§] Placed by evaluators on the basis of the $(\alpha, 4n\gamma)$ data of 1988Ar07.

[#] Stretched.

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

¹³⁹La($\alpha, 4n\gamma$): Delayed 1988Ar07

E=47 MeV.

Decay scheme observed for 708 γ delayed gate. All data are from $(\alpha, 4n\gamma)$, except as noted.

¹³⁹Pr Levels

E(level)	J $\pi^{\dagger}$	E(level)	J $\pi^{\dagger}$	E(level)	J $\pi^{\dagger}$
0.0	5/2+	2187.51 12	(19/2, 15/2)-	3265.94 15	(25/2, 21/2, 17/2)
113.94 5	7/2+	2278.00 14	(19/2, 15/2)-	3627.48 16	(25/2, 21/2, 17/2)
822.00 8	11/2-	2367.15 13	(21/2, 17/2)-	3697.86 14	(25/2, 21/2, 17/2)
1523.08 11	13/2-	2761.14 14	(19/2, 15/2)	4100.60 16	
1722.20 10	15/2-	2821.25 13	(21/2, 17/2)+	4536.60 19	
1941.53 11	17/2-	3021.52 14	(23/2, 19/2)+	4862.60 22	

[†] As proposed in 1988Ar07 based on $\gamma(\theta)$ data for prompt γ rays.

 $\gamma(^{139}\text{Pr})$

E γ	E(level)	I γ	E γ	E(level)	I γ	E γ	E(level)	I γ
113.94 5	113.94		245.95 5	2187.51	45 4	543.3 1	2821.25	21 2
179.64 5	2367.15	23 2	326.0 1	4862.60	5 1	605.9 1	3627.48	17 2
199.1 1	1722.20	5 1	336.51 10	2278.00	31 3	701.12 10	1523.08	14 1
200.3 1	3021.52	19 2	402.8 1	4100.60	12 1	819.7 1	2761.14	26 2
219.32 5	1941.53	80 7	436.0 1	4536.60	15 1	900.16 8	1722.20	100 8
244.5 1	3265.94	6 1	444.6 1	3265.94	8 1	1330.7 1	3697.86	24 2

¹³⁹La($\alpha,4n\gamma$): Prompt 1988Ar07,1980Pi03

1980Pi03: E=55 MeV. See ¹³⁹La(³He,3n γ) for experimental details.

1988Ar07: E=47 MeV. Measured γ 's, $\gamma\gamma$ -coincidences, and $\gamma(\theta)$.

Other: 1981NaZJ.

All data are from 1988Ar07, except as noted. See also ¹⁴⁰Ce(p,2n γ).

¹³⁹Pr Levels

E(level)	J $\pi^{\ddagger}$	Comments
0.0	5/2+	
113.94 5	7/2+	
405.12?† 8	3/2+	
822.00 8	11/2-	
827.86 10	9/2+	
851.90 10	11/2+	
1024.04 12	9/2+	
1124.04 12		
1369.20?† 20	9/2-, 11/2-	
1523.08 11	13/2-	
1722.19 10	15/2-	
1790.16?† 20	(13/2)+	
1833.72?† 15	9/2-, 11/2-	
1866.61 14	(15/2)+	
1941.53 11	(17/2)-	
2187.51 12	(19/2, 15/2)-	15/2, 19/2 from $\gamma(\theta)$. $\neq$ 15/2 since 246 γ seen intensely in ($\alpha,4n\gamma$) and feeding from high-spin levels.
2277.99 14	(15/2, 19/2)-	J π : 15/2,19/2 from $\gamma(\theta)$.
2367.15 13	(21/2, 17/2, 13/2)-	J π : 21/2,17/2 from $\gamma(\theta)$ if J π (2188)=19/2. $\neq$ 17/2 from yrast arguments.
2481.41 16	(21/2, 17/2)	J π : from $\gamma(\theta)$.
2741.41 19		
2761.14 14	(15/2, 19/2)-	J π : 15/2,19/2 from $\gamma(\theta)$.
2821.25 13	(21/2, 17/2, 13/2)+	J π : 21/2,17/2 from $\gamma(\theta)$. 1988Ar07 suggest $\pi=(-)$.
2985.65 16		
3021.51 14	(23/2, 19/2, 15/2)+	J π : 23/2,19/2 from $\gamma(\theta)$. $\neq$ 23/2 from yrast arguments. 1988Ar07 suggest $\pi=(-)$.
3204.00 15		
3265.94 15	+§	
3483.93 16		
3579.72 18	§	
3627.48 16	§	
3697.86 14	§	
3972.54 17		
4052.65 16		
4100.60 16		
4377.40 18		
4536.60 19		
4862.60 22		

† Suggested by 1980Pi03.

‡ As proposed in 1988Ar07 based on $\gamma(\theta)$ data.

§ 25/2,21/2,17/2,15/2 from $\gamma(\theta)$. $\neq$ 15/2 since ($\alpha,4n\gamma$) unlikely to directly populate 15/2 at this excitation energy.

 $\gamma(^{139}\text{Pr})$

E γ	E(level)	I γ	Mult.†	α	Comments
60.2 1	2821.25	1.8 1			$A_2=-0.03$ 9; $A_4=-0.05$ 14.
113.94‡ 5	113.94	100	(M1+E2)	1.11 22	$A_2=-0.05$ 3; $A_4=+0.02$ 3.
128.0 1	4100.60	1.5 2	D		$A_2=-0.29$ 8; $A_4=+0.09$ 14.
179.64‡ 5	2367.15	46 3	D@		$A_2=-0.34$ 3; $A_4=+0.02$ 4.
^x 182.5& 1		#			
182.5& 1	3204.00	#			
199.1§ 1	1722.19	14 4	D+Q		$A_2=-0.28$ 6; $A_4=+0.15$ 7.
200.3 1	3021.51	35 5	D+Q		$A_2=-0.26$ 12; $A_4=-0.19$ 14.
214.0 1	3697.86				I γ : weak.
219.32‡ 5	1941.53	117 7	D		$A_2=-0.28$ 3; $A_4=+0.03$ 4.
244.5& 1	3265.94	#			

Continued on next page (footnotes at end of table)

$^{139}\text{La}(\alpha,4n\gamma)$: Prompt 1988Ar07,1980Pi03 (continued) $\gamma(^{139}\text{Pr})$ (continued)

E_γ	E(level)	I_γ	Mult. [†]	Comments
245.95 $\frac{1}{2}$ 5	2187.51	59 4	D@	$A_2=-0.44$ 4; $A_4=+0.03$ 4. Mult.: discrepant with M1+E2, $\delta=-0.07$ 5 from $\gamma(\theta)$ and $\alpha(\text{K})\text{exp}$ in ($^3\text{He},3n\gamma$).
260.0 1	2741.41	weak		
280.0 1	3483.93	20.1 16	D	$A_2=-0.23$ 2; $A_4=+0.04$ 3.
293.9 1	2481.41	3.4 2	D@	$A_2=-0.35$ 7; $A_4=-0.03$ 7.
326.0 1	4862.60	12.3 8	D	$A_2=-0.31$ 3; $A_4=-0.01$ 4.
336.51 $\frac{1}{2}$ 10	2277.99	35 2	D@	$A_2=-0.41$ 3; $A_4=+0.01$ 4.
345.0 1	3972.54	3.6 3	D+Q	$A_2=-0.49$ 7; $A_4=+0.07$ 9.
354.8 1	4052.65	1.5 1	D+Q	$A_2=-0.29$ 9; $A_4=+0.31$ 11.
382.8 1	3204.00	1.3 1		
402.8 1	4100.60	13.9 14		$A_2=+0.28$ 7; $A_4=-0.08$ 8.
405.12 $\frac{1}{2}$ ^a 8	405.12?			I_γ : 2.0 4 (1980Pi03).
418.5 $\frac{5}{2}$ 1	1941.53	6.4 5		
^x 425.6 1				I_γ : weak γ ray. Coin with 114 γ , 199 γ , 219 γ , 701 γ , 708 γ , and 900 γ but not placed by 1988Ar07.
436.0 1	4536.60	19.0 12	D+Q	$A_2=-0.46$ 3; $A_4=+0.04$ 4.
444.6 1	3265.94	16.6 11		$A_2=+0.23$ 3; $A_4=-0.05$ 4.
454.1 1	2821.25	7.1 1	Q	$A_2=+0.20$ 2; $A_4=+0.01$ 3. Mult.: $\Delta J=0$ or 2.
543.3 1	2821.25	30 2	D@	$A_2=-0.34$ 3; $A_4=+0.04$ 4.
547.2 $\frac{3}{2}$ ^a 2	1369.20?			I_γ : 1.6 3 (1980Pi03).
558.2 1	3579.72	8.7 6	D+Q	$A_2=-0.61$ 4; $A_4=+0.06$ 5.
605.9 1	3627.48	6.4 5	D+Q	$A_2=-0.68$ 9; $A_4=+0.05$ 13.
618.5 1	2985.65	4.8 4		$A_2=+0.23$ 9; $A_4=+0.05$ 12.
^x 633.6 $\frac{1}{2}$ 1		#		
633.6 $\frac{1}{2}$ 1	2821.25	#		
701.12 $\frac{1}{2}$ 10	1523.08	10.4 14	D+Q	$A_2=-0.91$ 8; $A_4=+0.11$ 10.
708.06 6	822.00	164 10	M2	$A_2=-0.03$ 3; $A_4=+0.03$ 4. Mult.: from adopted gammas.
737.96 $\frac{1}{2}$ 8	851.90	28 2	(Q)	$A_2=+0.15$ 4; $A_4=-0.02$ 5. Mult.: discrepant with E2+M3, $\delta=+0.20$ 4 from $\gamma(\theta)$, $\alpha(\text{K})\text{exp}$, and conversion electron ratios in 5.5-h ϵ decay.
786.7 1	4052.65	13.5 9	D+Q	$A_2=-0.26$ 5; $A_4=-0.10$ 5.
809.5 $\frac{3}{2}$ ^a 2	1833.72?			I_γ : 1.4 3 (1980Pi03).
819.7 1	2761.14	25 2	D@	$A_2=-0.26$ 6; $A_4=+0.01$ 7.
822.0 $\frac{5}{2}$ 2	822.00	6.7 6	E3	$A_2=-0.03$ 5; $A_4=+0.04$ 6. Mult.: from adopted gammas.
827.86 $\frac{1}{2}$ 10	827.86	6.8 5		$A_2=+0.04$ 7; $A_4=+0.07$ 8.
879.9 $\frac{5}{2}$ ^a 1	2821.25			I_γ : weak.
900.16 $\frac{1}{2}$ 8	1722.19	161 10		$A_2=+0.23$ 3; $A_4=-0.07$ 6. $A_2=+0.23$ 3; $A_4=-0.07$ 6.
910.1 1	1024.04	1.8 12		
962.3 $\frac{3}{2}$ ^a 2	1790.16?			I_γ : 3.8 6 (1980Pi03).
982.0 $\frac{3}{2}$ ^a 2	1833.72?			I_γ : 1.2 3 (1980Pi03).
1010.1 1	1124.04	#		
1014.7 $\frac{5}{2}$ 1	1866.61	#		
1173.4 1	4377.40			I_γ : weak.
1330.7 1	3697.86	23.2 15		$A_2=+0.19$ 3; $A_4=-0.03$ 4.

[†] From $\gamma(\theta)$ and $\alpha(\text{exp})$ values of 1971Bu22 (see ϵ decay data).[‡] From 1980Pi03.[§] Weighted average of results from (p,2n γ) and (α ,4n γ) (1988Ar07).# Member of unresolved doublet; therefore, no I_γ given by 1988Ar07.

@ Stretched.

& Multiply placed.

^a Placement of transition in the level scheme is uncertain.^x γ ray not placed in level scheme.

¹⁴⁰Ce(p,2n γ): Prompt 1988Ar07,1980Pi03

1980Pi03: E=20 MeV. See ¹³⁹La(³He,3n γ) for experimental details.

1988Ar07: E=25 MeV. See ¹³⁹La(α ,4n γ) for experimental details.

All data are from 1988Ar07, except as noted.

¹³⁹Pr Levels

E(level)	J π [†]	T _{1/2}	Comments
0.0	5/2+		
113.93 5	7/2+		
405.12 7	3/2+		
589.42 7	(3/2, 5/2)+		
822.01 7	11/2-	45.5 ns 9	T _{1/2} : from 1979Ke07 (E=20 MeV. 708 γ (t); =10 T _{1/2} 's). Other: 44 ns 4 from analysis of 708 γ (θ ,H,t), =3 T _{1/2} 's. g=+1.20 9 (1979Ke07). g: from 708 γ (θ ,H,t).
827.81 10	9/2+		
851.83 9	11/2+		
917.12? 22	3/2+		
1024.22 13	9/2+		
1369.71 11	9/2-		
1523.13 10	13/2-		
1584.23 22			
1624.51 11	(11/2, 9/2)-		
1722.22 10	15/2-		
1790.12 23			
1833.83 14	(11/2, 9/2)-		
1866.5 4	(9/2, 13/2)+		
1926.93 11	(9/2, 13/2)-		
1941.4? 3			See comment on 1089 γ .
1941.56 10	17/2-		
2029.63 14			
2187.56 14	(19/2, 15/2)-		
2278.16 14	(19/2, 15/2)-		
2367.26 25	(21/2, 17/2)-		
2456.13 17			
2700.53 24			

[†] As proposed in 1988Ar07 based on $\gamma(\theta)$ data for prompt γ rays. See Adopted Levels for recommended assignments.

 $\gamma(^{139}\text{Pr})$

A 97.8 I γ with I γ =1.8 2 placed from 1722 level in 1988Ar07 is omitted here since 1980Pi03 identified a 98 γ as a contaminant from ¹⁴⁰Pr in (³He,3n γ); and also not seen in any other study.

E γ	E(level)	I γ	Mult. [†]	α	Comments
92.9 3	1926.93	$\approx 1.1^{\pm}$	[M1+E2]	2.2 6	
113.94 ^S 5	113.93	100	(M1+E2)	1.11 22	A ₂ =-0.030 3; A ₄ =-0.030 5.
179.7 [#] 2	2367.26	2.0 3			
184.3 1	589.42	6.7 4	(M1)	0.233	A ₂ =-0.14 5; A ₄ =-0.06 8. Mult.: M1 or E2 from α (exp)'s in 29.7-min ϵ decay. D from $\gamma(\theta)$.
199.1 [#] @ 1	1722.22	9.7 6	D		A ₂ =-0.32 11; A ₄ =-0.09 12.
219.32 ^S @ 5	1941.56	19.1 12	D		A ₂ =-0.25 3; A ₄ =+0.03 3.
246.0 [#] 1	2187.56	6.8 4	D		A ₂ =-0.39 8; A ₄ =-0.03 12.
254.8 1	1624.51	8.0 5	D+Q		A ₂ =-0.08 2; A ₄ =-0.05 2.
302.6 2	1926.93	$\approx 0.6^{\pm}$ &			
336.6 1	2278.16	4.3 3	D		A ₂ =-0.35 3; A ₄ =-0.05 4.
(403.75 8)	1926.93	$\approx 3^{\pm}$			Expected from 5.5-h ϵ decay but probably masked by 405 γ doublet.
405.12 ^S f 8	405.12	33a f 2	D+Q ^b		A ₂ =-0.11 2; A ₄ =+0.03 3.
	2029.63	33a f 2	D+Q ^b		A ₂ =-0.11 2; A ₄ =+0.03 3.
418.5 1	1941.56	5.7 9			
475.5 1	589.42	12.7 8			A ₂ =+0.01 1; A ₄ =+0.01 2.
$\times$ 512.0 ^{de} 2		&			
512.0 ^{de} 2	917.12?	&			
547.7 [#] 1	1369.71	9.4 6	D		A ₂ =-0.35 1; A ₄ =+0.07 3.
589.4 1	589.42	6.0 4			A ₂ =-0.13 3; A ₄ =+0.09 4.

Continued on next page (footnotes at end of table)

¹⁴⁰Ce(p,2n γ): Prompt 1988Ar07,1980Pi03 (continued)

 $\gamma(^{139}\text{Pr})$ (continued)

E γ	E(level)	I γ	Mult. [†]	Comments
^x 600.5#d 2		&		
600.5#d 2	1624.51	&		
622.3 1	2456.13	7.8 5	D	A ₂ =-0.05 4; A ₄ =+0.01 6.
670.9 2	2700.53	2.3 1	D	A ₂ =-0.19 15; A ₄ =+0.08 19.
^x 698.3				Coin with 114 γ , 219 γ , and 910 γ but not placed by 1988Ar07.
701.12§ 10	1523.13	15.9 12	D+Q	A ₂ =-0.87 13; A ₄ =+0.10 20.
708.06§ 6	822.01	75 5	M2+E3	Mult.: from Adopted Gammas. $\gamma(0)$ is isotropic.
732.4 2	1584.23	3.2 6		
737.96§ 8	851.83	59 4	Q	A ₂ =+0.18 2; A ₄ =-0.04 3.
796.6 3	1624.51	1.9 4		
802.5 2	1624.51	5.1 4		A ₂ =-0.20 7; A ₄ =-0.02 13.
				Mult.: E2 in table I of 1988Ar07 is inconsistent with negative A ₂ value.
809.5 1	1833.83	12.7 ^c 8	D	A ₂ =+0.13 4; A ₄ =+0.09 6.
822.0# 2	822.01	5.7 5	E3	Mult.: from Adopted Gammas.
				A ₂ =-0.03 1; A ₄ =-0.03 2.
827.8# 1	827.81	37 3	Q	A ₂ =+0.11 2; A ₄ =-0.01 3.
^x 852.0de 3		&		
852.0de 3	851.83	&	[M3]	E γ : highly unlikely transition.
900.16§ 8	1722.22	34 2	(Q)	A ₂ =+0.02 1; A ₄ =-0.08 1.
910.1# 2	1024.22	17.6 10	D+Q	A ₂ =-0.21 1; A ₄ =+0.10 1.
				I γ : 1988Ar07 give 17.6 1; probable typographical error since no $\Delta I\gamma < 6\%$.
917.1e 3	917.12?	2.4 2	D+Q	A ₂ =-0.19 4; A ₄ =+0.15 6.
^x 962.3§d 2		&		
962.3§d 2	1790.12	&		
982.3 2	1833.83	7.2 ^c 4	D	A ₂ =+0.14 8; A ₄ =+0.08 11.
^x 1014.7#d 3		&		A ₂ =-0.38 4; A ₄ =+0.07 4.
1014.7#d 3	1866.5	&	D	A ₂ =-0.38 4; A ₄ =+0.07 4.
1075.2 2	1926.93	4.7 3	D	A ₂ =-0.15 5; A ₄ =-0.05 7.
1089.0e 3	1941.4?	2.7 2		Placed from 1941.5, (17/2)- by 1988Ar07. Alternate placement suggested by evaluators based on (³ He,3n γ) where no 1089 γ was observed to deexcite 1941.5, (17/2)-.
1105.2 3	1926.93	2.2 2	D+Q	A ₂ =-0.59 10; A ₄ =+0.18 12.
1369.7e 2	1369.71	4.8 4		E γ : existence of this transition is considered as questionable by the evaluators since with the given intensity it should have been seen in other studies. This γ is omitted in the Adopted Levels, Gammas dataset. Other explanation may be that this γ defined another level as suggested in the previous evaluation 2001Bu16.
				A ₂ =-0.68 7; A ₄ =+0.09 10.

[†] From $\gamma(0)$ and $\alpha(\text{exp})$ values from 1971Bu22 (see ϵ decay data).

[‡] From branching ratios in 5.5-h ϵ decay and I γ (1075 γ +1105 γ).

[§] From 1980Pi03.

[#] Weighted average of results from (p,2n γ) and (α ,4n γ) (1988Ar07).

[@] Possible multiplet from discrepancy in branching ratio with adopted value.

[&] Member of unresolved doublet; therefore, no I γ given by 1988Ar07.

^a From $\gamma\gamma$ -coin there are two 405.2 γ 's. I γ =30 if corrected for possible presence of 403 γ observed in 5.5-h ϵ decay.

^b D+Q for the doublet.

^c Branching ratios from 1980Pi03 discrepant. I γ (809 γ)/I γ (982 γ)=3.3 6 (1980Pi03), 1.76 15 (1988Ar07).

^d Multiply placed.

^e Placement of transition in the level scheme is uncertain.

^f Multiply placed; undivided intensity given.

^x γ ray not placed in level scheme.

¹⁴⁰Ce(p,2n) γ : Delayed 1988Ar07

E=25 MeV.

Decay scheme observed for 114 γ delayed gate. All data are from (p,2n γ), except as noted.

¹³⁹Pr Levels

E(level)	J $\pi^{\dagger}$	E(level)	J $\pi^{\dagger}$	E(level)	J $\pi^{\dagger}$
0.0	5/2+	1024.04 21	9/2+	1866.6 4	(9/2, 13/2)+
113.94 5	7/2+	1369.70 13	9/2-	1941.50 12	17/2-
589.44 12	(3/2, 5/2)+	1523.10 11	13/2-	2187.50 16	(19/2, 15/2)-
822.00 8	11/2-	1624.50 22	(11/2, 9/2)-	2278.10 16	(19/2, 15/2)-
851.90 10	11/2+	1722.18 11	15/2-		

$\dagger$ As proposed in 1988Ar07 based on $\gamma(\theta)$ data for prompt γ rays. See Adopted Levels for recommended assignments.

$\gamma(^{139}\text{Pr})$

E γ	E(level)	I γ	E γ	E(level)	I γ	E γ	E(level)	I γ
113.94 5	113.94		475.5 1	589.44	12 1	802.5 2	1624.50	12 1
199.1 1	1722.18	8 1	547.7 1	1369.70	25 2	900.16 8	1722.18	53 5
219.32 5	1941.50	58 5	701.12 10	1523.10	44 4	910.1 2	1024.04	36 2
246.0 1	2187.50	14 1	708.06 6	822.00	100 8	1014.7 3	1866.6	24 2
336.6 1	2278.10	19 2	737.96 8	851.90	69 6			

¹⁴¹Pr(p,t) 1972Go25

1972Go25: target J π =5/2+. Measured: $\sigma(\theta=15^{\circ}-65^{\circ}, 5^{\circ} \text{ steps})$; E(p)=40 MeV, E- Δ E telescope, FWHM=50 keV. DWBA analysis.

Other: 1972Ya09: E=52.1 MeV.

J $\pi(^{141}\text{Pr g.s.})=5/2+$.

¹³⁹Pr Levels

E(level)	L †	E(level)	L †	E(level)	L †
0.0	0	1010 20	2	2160 50	(3)
405 10	2	1330 ‡ 20		$\approx$ 2240	(3)
590 10	2	1520 ‡ 20		$\approx$ 2660	
830 § 10	2	1623 20	1, 3 §	$\approx$ 2740	
910 15	2	2050 30	1, 3 §	$\approx$ 2800	

$\dagger$ From characteristic shape and comparison to DWBA.

$\ddagger$ Multiplet.

$\S$ $\sigma(\theta)$ exhibits an odd-L character; both L=1 and L=3 fit the data equally well. L(1623) $\neq$ 1 from adopted J π =9/2-. L(2050) $\neq$ 1 if level corresponds to 2048.7; 9/2-, 11/2-.

$^{142}\text{Nd}(\text{p},\alpha),(\text{pol p},\alpha)$ 2009GuZU,2003GuZU,1980HaZE

2009GuZU, 2003GuZU, 2003GuZV: (pol p, α): E=23.5 MeV. Measured $\sigma(\theta)$, analyzing powers $A_y(\theta)$ using Q3D magnetic spectrograph at Munich, DWBA analysis. Target= $^{142}\text{Nd}_2\text{O}_3$ enriched to 98.26%, thickness=82 $\mu\text{g}/\text{cm}^2$ on 8 $\mu\text{g}/\text{cm}^2$ carbon backing.

1980HaZE: E=17 MeV, measured $\sigma(\theta=6.5^\circ-65^\circ, 12 \text{ angles})$; mag spect, delay-line counter. Levels shown are those observed in the 20° spectra.

1996Gu03: (p, α): E=23.1 MeV; measured $\sigma(\theta)$; deduced angle integrated σ .

Other: 1983Ga04: E=24 MeV, investigated role of unpaired nucleon.

 ^{139}Pr Levels

E(level) [†]	J π [#]	Comments
0.0 [‡]	5/2+	
114 [‡]		E(level): 107 (1980HaZE).
405	3/2+	E(level): 405 (1980HaZE).
590		E(level): 582 (1980HaZE).
624		
828 [‡]	9/2+	E(level): 822 (1980HaZE).
852 [§]	11/2+	
917		E(level): 909 (1980HaZE).
1009		E(level): 1000 (1980HaZE).
1154		E(level): 1147 (1980HaZE).
1312 [§]	1/2-	
1328		E(level): 1328 (1980HaZE).
1449 [§]	3/2-	
1478		E(level): 1493 (1980HaZE).
1492		E(level): 1508 (1980HaZE).
1532		
1623		E(level): 1624 (1980HaZE).
1650 [§]	1/2+	
1762		
1783	13/2+	E(level): 1782 (1980HaZE).
1831		E(level): 1841 (1980HaZE).
1857		
1908	7/2+	E(level): 1910 (1980HaZE).
1926		E(level): 1927 (1980HaZE).
1952 [§]	5/2+	
1975		E(level): 1980 (1980HaZE).
2033		
2050		
2097		E(level): 2098 (1980HaZE).
2127		
2149		E(level): 2144 (1980HaZE).
2205		

[†] From 2003GuZU, unless stated otherwise. From spectral Fig. 1 in 2003GuZV, FWHM seems about 10 keV. The uncertainties are probably about 5 keV.

[‡] Most intensely populated level.

[§] From 2009GuZU.

[#] From $\sigma(\theta)$ and $A_y(\theta)$ with DWBA analysis (2009GuZU).

Adopted Levels, Gammas

Q(β⁻)=-4514 26; S(n)=8068 30; S(p)=6170 30; Q(α)=177 29 2012Wa38.
S(2n)=18573 30, S(2p)=10674 28 (2012Wa38).
Mass measurement: 2000Be42.

¹³⁹Nd Levels

Cross Reference (XREF) Flags

A ¹³⁹Nd IT Decay (5.50 h)
B ¹³⁹Pm ε Decay (4.15 min)
C ⁹⁴Zr(⁴⁸Ca,3nγ)
D ⁹⁶Zr(⁴⁸Ca,5nγ): E=180 MeV
E ⁹⁶Zr(⁴⁸Ca,5nγ): E=195 MeV
F ¹²⁶Te(¹⁸O,5nγ)
G ¹²⁸Te(¹⁶O,5nγ): 2008Xu05
H ¹²⁸Te(¹⁶O,5nγ): 2007Ku12
I ¹⁴⁰Ce(α,5nγ)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
0.0	3/2+	AB DEFGHI	29.7 min 5	%ε+%β ⁺ =100. μ=+0.907 7 (1992Le09,2014StZZ). Q=+0.28 9 (1992Le09,2016St14). RMS charge radius <r ² > ^{1/2} =4.9076 fm 25 (2013An02 evaluation). Jπ: spin from ABMR (1972Ek04); π from log ft=5.2 to 5/2+. T _{1/2} : from 1967La19. μ,Q: laser resonance ionization mass spectroscopy (1992Le09, also 1988Al41); Q is Sternheimer corrected.
95.30 9	(1/2)+	B		Jπ: M1 γ to 3/2+. 1/2 from syst of odd-mass N=79 isotones.
231.16 ⁱ 5	11/2-	A DEFGHI	5.50 h 20	%ε+%β ⁺ =87.0 10; %IT=13.0 10. Jπ: spin from ABMR (1972Ek04); π from M4 γ to 3/2+. T _{1/2} : from 1951St03 (ion chem; β, G-M counter). Others: 5.5 h (1961Bo19), 5.5 h 5 (1963Ko20,1964Gr32). %ε+%β ⁺ ,%IT: deduced by evaluators from measured I _γ and I(ceK) of 231γ and I _γ , I(ceK) data of γ rays from ε+β ⁺ decay to ¹³⁹ Pr. See comments for branching ratio normalization in ¹³⁹ Nd IT decay and in ¹³⁹ Nd ε decay datasets.
402.73 11	(3/2,5/2)+	B E		Jπ: M1+E2 γ to 3/2+; β feeding from (5/2)+ parent.
463.09 12	(3/2)+	B		Jπ: M1+E2 γ to 3/2+; M1 γ to (1/2)+; β feeding from (5/2)+ parent.
675.45 18	(3/2,5/2+)	B		Jπ: γ to (1/2)+; log ft=6.9 for feeding from (5/2+) parent.
756.43 18	(3/2,5/2+)	B		Jπ: γ to (1/2)+ and log ft=6.4 for feeding from (5/2+) parent.
815.65 17	(3/2,5/2,7/2+)	B		Jπ: γ to 3/2+; log ft=6.7 for feeding from (5/2+) parent.
896.54 ⁱ 10	15/2-	DEFGHI		Jπ: ΔJ=2, E2 γ to 11/2-.
932.67 ^d 16	(7/2-)	B E		Jπ: ΔJ=1, dipole γ to (3/2,5/2)+; possible bandhead.
981.42 21		B		
1066.2 4		B		
1098.34 10	(13/2)-	DEFGH		Jπ: ΔJ=1, M1 γ to 11/2-.
1105.0 3		B		
1282.0 5		B		
1319.5 5		B		
1343.89 23	(13/2-)	G I		
1464.47 ^d 19	(11/2-)	E		
1944.24 12	(15/2+)	EFHG		Jπ: π=+ in 2011Bh07. π=(-) suggested in 2007Ku12. ΔJ=2 Q 1713γ to 11/2- favors negative parity, but note that this γ was not seen in 2011Bh07.
1967.42 10	(17/2)-	DEFGHI		
1990.74 11	(15/2+)	EFHG		Jπ: π=- suggested in 2007Ku12.
2021.41 17		B		
2023.28 ^d 15	(15/2-)	E		
2054.03 ⁱ 12	19/2-	DEFGHI		
2107.51 14	(3/2,5/2,7/2)+	B		Jπ: log ft=5.7 1 for feeding from (5/2)+ parent.
2134.8 5		I		
2240.54 20		B		
2246.94 11	(17/2-)	EFHG		Jπ: 2007Ku12 assigned π=- from mult=E1 for 474.6γ from 2721, (19/2+) level in linear polarization measurement. 2008Xu05 also assigned negative parity. 2011Bh07 and 2008Fe02 assigned positive parity. For the 2721 level, all studies assigned 19/2+.
2261.25 20		B		
2289.0 3		B		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{139}Nd Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$	Comments
2340.06 21		B		
2359.23 23		B		
2543.9 4	(19/2-)	F H		
2548.18 ^d 16	(19/2-)	E		
2572.33 11	(19/2)+	DEFGHI		
2616.9 6	(23/2+)	D G I	277 ns 2	%IT=100. T _{1/2} : weighted average of 278 ns 2 (605γ(t),2013Va10) and 272 ns 4 (off-beam 665γ(t) in (α,5nγ)). Other: >141 ns (1977Lu04). Configuration=vh _{11/2} ⁻² ⊗vd _{3/2} ⁻¹ (2013Va10).
2617.35 13	(17/2+)	EFGH		
2623.43 ⁱ 12	(21/2)-	DEF HI		
2712.52 13	(23/2-)	DEFGH		
2721.54 11	(19/2+)	EFGH		
2765.2 4		I		
2804.3 4	(21/2+)	I		
2843.93 [§] 12	(21/2+)	DEFGH		
2902.13 18	(21/2-)	E		
3067.43 [§] 13	(23/2+)	DE GH		
3079.04 13	(21/2+)	EF		
3238.10 18	(23/2+)	EF H		
3301.06 [§] 15	(25/2+)	DEFGH		
3303.12 ^d 18	(23/2-)	E		
3487.11 20	(25/2+)	E		
3496.8 6	(27/2-)	F H		
3532.56 [§] 18	(27/2+)	DEFGH		
3825.13 13	(25/2-)	DEFGH		
3840.24 13	(25/2-)	DEFGH		
3968.56 [§] 20	(29/2+)	DEF H		Reported as 3963.4 keV level in 2008Xu05.
3973.04 ^d 15	(25/2-)	DE		
3980.33 [#] 14	(27/2-)	DEFGH		
3985.15 20	(25/2-)	E		
4167.17 14	(27/2-)	DEF		
4293.04 [#] 15	(29/2-)	DEF H		
4335.16 [§] 20	(31/2+)	DEF H		
4450.6 8	(31/2-)	F H		
4716.46 16	(31/2-)	DEF H		
4756.35 [#] 18	(31/2-)	DEF H		
4804.8 8	(31/2)	H		
4823.16 [§] 25	(33/2+)	EF H		
4856.16 ^g 22	(33/2+)	EF H		Reported as 4850.5 keV level by 2008Xu05.
4857.1 9	(35/2-)	F		
4913.16 ^e 22	(33/2+)	EF H		
4937.15 [@] 22	(31/2-)	E		
4957.76 ^f 22	(35/2+)	E		
5114.16 [§] 23	(35/2+)	E H		
5130.9 6	(33/2-)	F		
5222.2 6	(37/2+)	F		
5250.46 ^g 24	(35/2+)	E		
5289.95 [@] 20	(33/2-)	DEF H		
5385.16 ^e 23	(35/2+)	EF		
5392.55 [#] 20	(33/2-)	DE H		
5441.18 ^{&} 25	(31/2-)	E		
5521.2 3	(35/2+)	EF H		
5550.88 18	(35/2-)	DEF H		
5560.2 ^g 3	(37/2+)	EF H		
5572.71 22	(35/2-)	E		
5612.2 ^{&} 4	(33/2-)	E		
5695.55 [#] 20	(35/2-)	DE H		
5721.1 ^a 3	(35/2-)	E		
5762.36 ^f 24	(39/2+)	E		
5777.16 ^e 25	(37/2+)	EF		
5861.1 ^a 4	(37/2-)	E		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{139}Nd Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	Comments
5873.2& 4	(35/2-)	E	
5883.9@ 3	(35/2-)	E	
5955.7 5	(37/2-)	F	
6017.1 ^a 4	(39/2-)	E	
6070.85 [#] 23	(37/2-)	DE	
6139.06 ^c 20	(37/2-)	DEF	
6186.4 5	(37/2-)	F	
6211.1 ^a 5	(41/2-)	E	
6232.9@ 4	(37/2-)	E	
6258.2 ^e 3	(39/2+)	E	
6267.2& 5	(37/2-)	E	
6288.2 3	(39/2+)	EF	
6428.41 20	(39/2-)	EF	
6472.1 ^a 5	(43/2-)	E	
6488.7 7	39/2-	F	
6490.95 [#] 25	(39/2-)	DE H	
6586.9@ 4	(39/2-)	E	
6673.2 ^f 3	(43/2+)	E	
6730.2& 5	(39/2-)	E	
6771.2 ^g 4	(41/2+)	EF H	
6866.3 ^a 6	(45/2-)	E	
6932.54 ^c 21	(41/2-)	DEF	
7003.4 ^h 3	(41/2-)	DEF	
7018.5 3	(41/2-)	E	
7103.1 ^b 3	(41/2-)	E H	
7166.2& 5	(41/2-)	E	
7341.4 ^a 6	(47/2-)	E	
7343.1 ^b 3	(43/2-)	E	
7633.1 ^b 4	(45/2-)	EF	
7651.1 3	(45/2-)	E	
7702.2 ^f 4	(47/2+)	E	
7718.1 ^h 3	(45/2-)	DE	
7718.74 ^c 23	(45/2-)	EF	
7721.2 4	(47/2+)	E	
8002.1 ^b 4	(47/2-)	E	
8074.1 4	(47/2-)	E	
8149.2 ^f 4	(49/2+)	E	
8336.1 ^b 5	(49/2-)	E	
8361.1 ^h 4	(49/2-)	E	
8745.47 ^c 24	(49/2-)	DE	
9134.22 ^j 24	(49/2-)	E	
9395.1 ^h 4	(53/2-)	E	
9717.05 ^j 25	(53/2-)	E	
10459.0 ^j 3	(57/2-)	E	
10517.1 ^k 4	(57/2-)	E	
11089.2 ^k 4	(61/2-)	E	
11353.1 ^j 3	(61/2-)	E	
11827.2 ^k 4	(65/2-)	E	
12414.6 ^j 3	(65/2-)	E	
12789.1 ^k 4	(69/2-)	E	
13663.4 ^j 4	(69/2-)	E	
13975.3 ^k 4	(73/2-)	E	
15110.6 ^j 4	(73/2-)	E	
15392.2 ^k 5	(77/2-)	E	
16741.6 ^j 4	(77/2-)	E	
17023.3 ^k 5	(81/2-)	E	
18525.6 ^j 4	(81/2-)	E	
18839.3 ^k 5	(85/2-)	E	
20854.3 ^k 6	(89/2-)	E	
x ^l	$J_1 = (51/2)$	E	$J\pi$: estimated by 2011Bh07 from the decay out of the band.
794.00+x ^l 10	J_1+2	E	
1662.01+x ^l 15	J_1+4	E	
2666.01+x ^l 18	J_1+6	E	

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Adopted Levels, Gammas (continued) ^{139}Nd Levels (continued)

E(level) [†]	$J\pi^{\ddagger}$	XREF	Comments
3849.01+x ^l 20	J_1+8	E	
5191.0+x ^l 3	J_1+10	E	
6650.0+x ^l 4	J_1+12	E	
8228.0+x ^l 4	J_1+14	E	
9953.1+x ^l 5	J_1+16	E	
11828.1+x ^l 5	(J_1+18)	E	
y ^m	$J_2=(49/2, 53/2)$	C	E(level), $J\pi$: this level decays through a $\Delta J=1$, 388 γ to the (47/2) level of a band similar to Band #3 and #4 in ^{137}Nd (See 1997Pe06). $J=49/2$ assigned by 2000Pe01. A spin value larger by 2 may be possible if there are possible unobserved transitions.
583.0+y ^m 10		C	
1325.0+y ^m 15		C	
2219.0+y ^m 18		C	
3281.0+y ^m 20		C	
4530.0+y ^m 23		C	
5977.0+y ^m 25		C	
z ⁿ	$J_3\geq(49/2)$	C	E(level): this level decays through a 1122 γ -1033 γ cascade of $\Delta J=2$, E2 transitions to a dipole band, similar to Band #7 in ^{137}Nd (See 1997Pe06).
572.0+z ⁿ 10		C	
1310.0+z ⁿ 15		C	
2273.0+z ⁿ 18		C	
3460.0+z ⁿ 20		C	
4877.0+z ⁿ 23		C	
6508.0+z ⁿ 25		C	

[†] From least-squares fit to $E\gamma$ data. Note that ordering of some of the γ -ray cascades is different in various in-beam γ -ray studies. The evaluators adopt the orderings from 2011Bh07 which is the most detailed study so far, and with the best statistics. The level matching in various datasets has been done from the observation of the matching γ cascades, consequently, actual level energies in some of the datasets are different from the ones given in the present dataset.

[‡] For high-spin ($J\geq 11/2$) states, the assignments are essentially based on $\gamma\gamma(\theta)$ (DCO) data, linear polarization data for a few transitions, and band associations. These are mostly from 2011Bh07 with parentheses added by the evaluators, as strong arguments, in general, seem lacking.

§ (A): $\Delta J=1$ band based on (21/2+) Parity from 2013Va10, it is given as positive in 2011Bh07.

(B): $\Delta J=1$ band based on 27/2-.

@ (C): $\Delta J=1$ band based on 31/2-.

& (D): $\Delta J=1$ band based on 31/2-.

a (E): $\Delta J=1$ band based on 35/2-.

b (F): $\Delta J=1$ band based on 41/2-.

c (G): $\Delta J=2$ band based on 37/2-.

d (H): Band based on 7/2-.

e (I): $\Delta J=1$ band based on 33/2+.

f (J): Band based on 35/2+.

g (K): Band based on 33/2+.

h (L): $\Delta J=2$ γ cascade based on 41/2-.

i (M): γ cascade based on 11/2-.

j (N): $\Delta J=2$ band based on 49/2-. The floating $\Delta J=2$ band based on 11/2- may be signature partner of $\Delta J=2$ band.

k (O): $\Delta J=2$ band based on 57/2-.

l (P): $\Delta J=2$ band.

m (Q): Triaxial band #1. Population intensity=15% 5.

n (R): Triaxial band #2. Population intensity=15% 5.

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Nd})$

Information for 231 γ is from IT decay. Other data are from ε decay or ($^{16}\text{O},5\text{n}\gamma$), ($^3\text{He},4\text{n}\gamma$), and ($\alpha,5\text{n}\gamma$) as indicated in the cross-reference column of the Adopted Levels. See ε decay and ($^{16}\text{O},5\text{n}\gamma$), ($^3\text{He},4\text{n}\gamma$), and ($\alpha,5\text{n}\gamma$) for unplaced gammas.

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult. ‡	$\delta^\S$	α	Comments
95.30	95.3 1	100	M1 (+E2)	<0.18	1.64 3	
231.16	231.15 5	100	M4		14.51	B(M4)(W.u.)=2.7 3.
402.73	307.4 2	2.4 3	[E2]		0.0485	
	402.8 2	100	M1+E2	1.0 5	0.027 3	
463.09	367.8 2	86 6	M1		0.0401	
	463.1 2	100 7	M1+E2	>0.045	0.018 4	
675.45	272.7 4	28 7				
	580.1 3	100 11				
	675.5 3	45 4				
756.43	661.3 4	20.4 22				
	756.5 3	100 8				
815.65	412.5 10	13 7				
	815.8 2	100 8				
896.54	665.4 1	100	E2			
932.67	530.0 2	100	D			
981.42	579.0 6	5.3 14				
	981.6 4	100 7				
1066.2	603.1 4	100 10				
	663.4 6	81 16				
1098.34	867.2 1	100	M1			
1105.0	702.0 10	100 26				
	1105.0 3	49 11				
1282.0	822.0 [#] 10	105 50				
	879.3 4	100 15				
1319.5	856.4 4	100				
1343.89	1112.1 3	100	D+Q			
1464.47	532.0 2	100	Q			
1944.24	845.9 1	100 11	D			
	1047.7 2	17 3	D			
	1713.2 [#] 5	47 8	Q			γ not in 2011Bh07, treated as uncertain by evaluators.
1967.42	622.9 3	11.3 17				γ not in 2011Bh07.
	869.1 1	11 1	Q			
	1070.9 1	100 10	M1			
1990.74	892.4 1	100	D			
2021.41	1205.7 4	26 6				
	1265.1 3	44 7				
	1558.2 5	64 10				
	1618.7 3	100 79				
	2021.3 3	86 7				
2023.28	559.0 2	100 20	Q			
	1792.0 2					
2054.03	86.4 5	8 2	D			γ not in 2011Bh07.
	1157.5 1	100 10	E2			
2107.51	1126.1 3	40 4				
	1174.7 3	24.5 21				
	1292.5 4	39 4				
	1351.1 3	29 3				
	1644.5 3	43 4				
	1704.6 3	100 10				
	2107.3 3	51 6				
2134.8	1238.2 [#] 4	100				
2240.54	1484.1 1	100				
2246.94	256.2 1	100 10	D			
	302.7 1	60 6	D			
	1350.4 2	7.1 12	D+Q			
2261.25	1798.4 4	36 5				
	1858.5 3	100 12				
	2261.1 3	88 12				
2289.0	1473.0 10	84 29				
	1825.9 3	100 16				

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Nd})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	α	Comments
2289.0	1886.2 5	94 16			
2340.06	1358.8 3	33 11			
	1664.6 3	24 4			
	1876.8 3	100 18			
2359.23	1426.3 4	58 14			
	1956.7 6	90 18			
	2359.3 3	100 9			
2543.9	1646.6 5	100	Q		
2548.18	525.0 2	100 23	Q		
	1651.6 2				
2572.33	325.4 1	16.0 16	D		
	581.6 1	15.1 15	Q		
	604.9 1	100 10	E1		
2616.9	(45)				
2617.35	1720.8 1	100	D+Q		
2623.43	569.4 1	100 10	M1		
	656.0 1	20 2	Q		
2712.52	89.1 1	100 10	D		
	167.9 5	25 4	(E2)		Transition not seen in 2011Bh07.
	658.5 5	53 5	Q		
2721.54	104.2 2	13.5 14	D		
	149.2 1	38 4	D		Mult.: $\Delta J=0$ transition.
	474.6 1	100 10	E1		
	730.8 1	19 2	Q		
2765.2	192.9# 3	100			
2804.3	232.0 3	100	D		
2843.93	122.4 1	35 3	D		
	271.6 1	100 10	D		
	597.0 2	9.3 20	Q		
2902.13	58.2 2	100	D		
3067.43	223.5 1	100	D		
3079.04	357.5 1	56 6	D		
	1025.0 1	100 10	D		
3238.10	159.1 5	100	D		
3301.06	233.6 1	100	D		
3303.12	755.0 2	100	Q		
3487.11	249.0 2	100	D		
3496.8	784.3 5	100	E2		
3532.56	231.5 1	100	D		
3825.13	1112.6 1	100 10	(M1)		
	1201.7 1	13.0 13	Q		
	1208				γ from 2013Va10; not in 2011Bh07.
3840.24	602.1 2	12.7 13	D		
	772.8 1	15.6 17	D		762.7 γ in 2007Ku12 not seen in 2011Bh07.
	938.1 2	8.6 9	Q		
	1127.7 1	100 10	M1		
	1216.8 1	29 3	Q		
	1224				γ not in 2011Bh07.
3968.56	436.0 1	100	M1		
3973.04	670.0 2	100 20	D		
	735.0 2				
	905.7 2		D		
	1356				γ not in 2011Bh07.
3980.33	140.1 1	100 10	D		
	155.2 1	35 3	D		
	493.2 2				
	679.2 2	11.4 22	D		
3985.15	682.0 2	100			
4167.17	182.0 2	3.7 7	D		
	194.2 1	100 10	D		
	326.9 1	68 7	M1	0.0545	
	866.1 2	5.4 11	D		
4293.04	312.7 1	100	M1		

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Nd})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]
4335.16	366.6 1	100 10	M1	7103.1	612.2 2	100	D
	802.6 1	64 6	E2	7166.2	436.0 2	100	D
4450.6	953.8 5	100	Q	7341.4	475.1 2	100	D
4716.46	423.4 1	52 5	D	7343.1	240.0 2	100 20	D
	549.3 1	100 10	Q		339.7 2	42 10	D
4756.35	463.3 1	100	M1	7633.1	290.0 1	100	D
4804.8	1308.0 5	100		7651.1	632.6 2	100 20	Q
4823.16	854.6 2	100	Q		647.8 2	80 20	Q
4856.16	521.0 1	100 10	M1	7702.2	1029.0 2	100	Q
	887.6 2	11.2 11	Q	7718.1	714.7 2	100	Q
4857.1	406.5 5	100	Q	7718.74	786.2 1	100	Q
4913.16	578.0 1	100	M1	7721.2	1048.0 2	100	Q
4937.15	644.1 2	100	D	8002.1	369.0 2	100	D
4957.76	622.6 1	100	Q	8074.1	441.0 2	100	D
5114.16	291.0 2	100 10	D	8149.2	428.0 2	48 9	D
	779.0 2	63 6	Q		447.0 2	100 22	D
5130.9	374.6 5	100	D+Q	8336.1	334.0 2	100	D
5222.2	309.0 5	100	Q	8361.1	643.0 2	80 20	Q
5250.46	394.3 1	100	D		710.0 2	100 20	Q
5289.95	352.8 2	15.8 16	D	8745.47	1026.4 1	100	Q
	533.6 1	100 10	(M1)	9134.22	388.6 1	100 10	D
5385.16	271.0 1	100 10	D		1415.8 1	85 9	Q
	472.0 1	99 10	D	9395.1	1034.0 1	100	Q
5392.55	636.2 1	100	M1	9717.05	583.0 1	100 10	Q
5441.18	1274.0 2	100	Q		971.4 1	42 4	Q
5521.2	1186.0 2	100	Q	10459.0	742.0 1	100	Q
5550.88	834.4 1	100	Q	10517.1	1122.0 1	100	Q
5560.2	309.7 1	100	D	11089.2	572.1 1	100	Q
5572.71	856.3 2	100	Q	11353.1	894.0 1	100	Q
5612.2	171.0 2	100	D	11827.2	738.0 1	100	Q
5695.55	303.0 1	100 10	D	12414.6	1061.5 1	100	Q
	405.6 1	53 5	M1	12789.1	961.9 1	100	Q
5721.1	964.8 2	100	Q	13663.4	1248.8 1	100	Q
5762.36	804.6 1	100	Q	13975.3	1186.2 1	100	Q
5777.16	392.0 1	100	D	15110.6	1447.2 1	100	Q
5861.1	140.0 2	100	D	15392.2	1416.9 1	100	Q
5873.2	261.0 2	100	D	16741.6	1631.0 1	100	Q
5883.9	594.0 2	100	D	17023.3	1631.0 2	100	Q
5955.7	404.8 5	100	D+Q	18525.6	1784.0 2	100	Q
6017.1	156.0 2	100	D	18839.3	1816.0 2	100	Q
6070.85	375.3 1	100	D	20854.3	2015.0 2	100	
6139.06	566.4 2	11.7 12	D	794.00+x	794.0 1	100	Q
	588.3 1	100 10	D	1662.01+x	868.0 1	100	Q
6186.4	635.5 5	100	D+Q	2666.01+x	1004.0 1	100	Q
6211.1	194.0 2	100		3849.01+x	1183.0 1	100	Q
6232.9	349.0 2	100	D	5191.0+x	1342.0 2	100	Q
6258.2	481.0 1	100	D	6650.0+x	1459.0 2	100	Q
6267.2	394.0 2	100	D	8228.0+x	1578.0 2	100	Q
6288.2	511.0 1	100	D	9953.1+x	1725.0 2	100	Q
6428.41	877.4 1	100	Q	11828.1+x	1875.0 2	100	
6472.1	261.0 2			583.0+y	583	100	
6488.7	302.3	100 10	D+Q	1325.0+y	742	100	
	533.0 5	31 16	D+Q	2219.0+y	894	100	
6490.95	420.1 1	100	D	3281.0+y	1062	100	
6586.9	354.0 2	100		4530.0+y	1249	100	
6673.2	910.8 1	100	Q	5977.0+y	1447	100	
6730.2	463.0 1	100	D	572.0+z	572	100	
6771.2	1211.0 2	100	Q	1310.0+z	738	100	
6866.3	394.1 2	100		2273.0+z	963	100	
6932.54	504.0 1	35 4	D	3460.0+z	1187	100	
	793.6 1	100 10	Q	4877.0+z	1417	100	
7003.4	512.4 1	100	D	6508.0+z	1631	100	
7018.5	527.6 1	100	D				

Footnotes continued on next page

Adopted Levels, Gammas (continued)

 $\gamma(^{139}\text{Nd})$ (continued)

[†] For low-spin ($J < 11/2$) states, data are from ϵ decay. For high-spin ($J \geq 11/2$), most data are from $^{96}\text{Zr}(^{48}\text{Ca}, 5n\gamma): E = 195 \text{ MeV}$ (2011Bh07), which are the most detailed and comprehensive. Exceptions are noted.

[‡] From ce data in ϵ decay for low-spin states. For high-spin states ($J \geq 11/2$), assignments are from $\gamma\gamma(\theta)(\text{DCO})$ and angular distribution asymmetries, mainly from 2011Bh07 in $^{96}\text{Zr}(^{48}\text{Ca}, 5n\gamma): E = 195 \text{ MeV}$. The E2, M1 and E1 assignments for high-spin levels are from the linear polarization data for selected transitions in $^{126}\text{Te}(^{18}\text{O}, 5n\gamma): 2007\text{Ku12}$. Mult=Q indicates $\Delta J = 2$, quadrupole (most likely E2) and mult=D or D+Q indicates $\Delta J = 1$, dipole or dipole with some quadrupole admixture.

[§] From ce data in ϵ decay.

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

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

 (M) γ cascade based on
11/2-

 (N) $\Delta J=2$ band based on
49/2-.

 (O) $\Delta J=2$ band based on
57/2-.

 (P) $\Delta J=2$ band.

(J1+18)	11828.1+x
J_1+16	9953.1+x
J_1+14	8228.0+x
J_1+12	6650.0+x
J_1+10	5191.0+x
J_1+8	3849.01+x
J_1+6	2666.01+x
J_1+4	1662.01+x
J_1+2	794.00+x
$J_1=(51/2)$	x

(89/2-)	20854.3	(85/2-)	18839.3
(81/2-)	18525.6	(81/2-)	17023.3
(77/2-)	16741.6	(77/2-)	15392.2
(73/2-)	15110.6	(73/2-)	13975.3
(69/2-)	13663.4	(69/2-)	12789.1
(65/2-)	12414.6	(65/2-)	11827.2
(61/2-)	11353.1	(61/2-)	11089.2
(57/2-)	10459.0	(57/2-)	10517.1
(53/2-)	9717.05	(L)(53/2-)	
(49/2-)	9134.22		
(G)(49/2-)			
(G)(45/2-)			

(21/2)-	2623.43
19/2-	2054.03
(17/2)-	
15/2-	896.54
11/2-	231.16
3/2+	

Adopted Levels, Gammas (continued)

(Q) triaxial band #1.

(R) triaxial band #2.

¹³⁹Nd IT Decay (5.50 h) 1971Bu22

Parent ¹³⁹Nd: E=231.15 5; J π =11/2-; T_{1/2}=5.50 h 20; %IT decay=13.0 10.

¹³⁹Nd-%IT decay: From I(γ +ce)(231 γ in IT decay)+ Σ I(γ +ce)(to 113.9 level)+ Σ I(γ +ce)(822.1 γ +827.8 γ +852 γ)=100. It is assumed that there is no direct ϵ + β^+ feeding to the g.s. and the 113.87 level. Value of I(γ +ce) for 231 γ (in ¹³⁹Nd IT decay) is deduced in two ways: 1. from measured I γ (231 γ)=2.35 20 (average of values from 1971Bu22 and 1969Be64); 2. from I(ceK) data for 231 γ , I γ and I(ceK) data for five strong γ rays (1971Bu22) in ¹³⁹Pr were used to determine an average conversion factor of 43.1 25 to normalize the ce(K) and I γ data in 1971Bu22 on the same scale, which is then used to obtain I(γ +ce) for 231 γ . Values of branching ratios are: 87.2% 11 using measured I γ of 231 γ and 86.6% 15 from measured I(ceK) value of 231 γ . Weighted average of the two results is 87.0% 10 for ϵ + β^+ , and 13.0 10 for IT decay. Other: 14.3% 14 (1971Bu22) from comparison of ce(K)(165.84 γ ; ¹³⁹Ce) to ce(K)(231.15 γ).

Measured: E γ , I γ , and ce; ms, chem. See also ¹³⁹Nd ϵ decay (5.5 h).

¹³⁹Nd Levels

E(level)	J $\pi^\dagger$	T _{1/2} [†]	Comments
0.0	3/2+		% ϵ + β^+ =100.
231.15 5	11/2-	5.50 h 20	% ϵ + β^+ =87.0 10; %IT=13.0 10.

[†] From the Adopted Levels.

γ (¹³⁹Nd)

E γ	E(level)	I $\gamma^\dagger$	Mult.	α	I(γ +ce) [†]	Comments
231.15 5	231.15	6.45 CA	M4	14.51	100	I γ : from I(γ +ce) and α . Other: measured I γ =2.3 2 (1971Bu22) relative to 100 for 738.2 γ in ¹³⁹ Pr from 5.5-h ¹³⁹ Nd decay. K:L12:L3:M:N+=1000:251 21:141 17:96 16:29 4 (1971Bu22). Mult.: from K:L12:L3.

[†] For absolute intensity per 100 decays, multiply by 0.130 10.

Decay Scheme

Intensity: I(γ +ce) per
100 parent decays
%IT=13.0 10

^{139}Pm ϵ Decay (4.15 min) 1977De06Parent ^{139}Pm : $E=0.0$; $J\pi=(5/2)^+$; $T_{1/2}=4.15$ min 5; $Q(\text{g.s.})=4514$ 26; $\% \epsilon + \% \beta^+ \text{ decay}=100$. $^{139}\text{Pm}-Q(\epsilon)$: From 2012Wa38.1977De06: measured: γ 's, $\gamma\gamma$ -coincidences, and $\gamma(t)$, $\text{ce}(\text{Si}(\text{Li}))$, $\beta\gamma$ -coincidences ($E/\Delta E$ telescope, $\text{Ge}(\text{Li})$).

Others: 1973VaYZ, 1971Va22, 1968B114.

 ^{139}Nd Levels

E(level)	$J\pi^\dagger$	Comments
0.0	$3/2^+$	$\% \epsilon + \% \beta^+ = 100$.
95.31 9	$(1/2)^+$	
402.77 11	$(3/2, 5/2)^+$	
463.10 12	$(3/2)^+$	
675.46 18	$(3/2, 5/2)^+$	
756.45 18	$(3/2, 5/2)^+$	
815.66 17	$(3/2, 5/2, 7/2)^+$	
932.89 19	$(7/2^-)$	
981.45 21		
1066.2 4		
1105.0 3		
1282.1 5		
1319.5 5		
2021.43 17		
2107.56 14	$(3/2, 5/2, 7/2)^+$	
2240.56 20		
2261.27 20		
2289.0 3		
2340.08 21		
2359.30 24		

 † From the Adopted Levels. β^+, ϵ Data

$E\epsilon$	E(level)	$I\beta^+\%$	$I\epsilon\%$	Log ft	$I(\epsilon+\beta^+)\%^\dagger$	Comments
(2150 30)	2359.30	0.031 7	0.37 7	6.29 9	0.40 8	
(2170 30)	2340.08	0.020 5	0.23 6	6.5 1	0.25 6	
(2230 30)	2289.0	0.011 3	0.11 3	6.9 1	0.12 3	
(2250 30)	2261.27	0.054 11	0.50 9	6.20 8	0.55 10	
(2270 30)	2240.56	0.021 4	0.18 4	6.65 9	0.20 4	
(2410 30)	2107.56	0.32 6	2.0 3	5.66 8	2.3 4	
(2490 30)	2021.43	0.11 3	0.54 17	6.3 1	0.65 20	
(3190 30)	1319.5	0.039 8	0.057 12	7.5 1	0.096 20	
(3230 30)	1282.1	0.042 21	0.06 3	7.4 2	0.10 5	
(3410 30)	1105.0	0.057 14	0.063 16	7.47 11	0.12 3	
(3450 30)	1066.2	0.13 2	0.13 3	7.15 9	0.26 5	
(3530 30)	981.45	0.40 8	0.37 7	6.72 9	0.77 15	
(3580 30)	932.89	0.04 3	0.04 2	7.7 3	0.08 5	
(3700 30)	815.66	0.51 10	0.40 7	6.74 9	0.91 17	
(3760 30)	756.45	1.1 2	0.80 17	6.4 1	1.9 4	
(3840 30)	675.46	0.41 8	0.28 5	6.93 9	0.69 13	
(4050 30)	463.10	4.5 8	2.4 4	6.04 8	6.9 12	$E(\epsilon)=4040$ 120 from measured $E\beta^+$ (1977De06).
(4110 30)	402.77	8.7 14	4.3 7	5.79 8	13.0 21	$E(\epsilon)=4010$ 100 from measured $E\beta^+$ (1977De06).
(4420# 30)	95.31	<0.13	<0.07	>7.8	<0.2	$I(\epsilon+\beta^+)$: γ -transition intensity balance gives -0.2 4 consistent with expected no β feeding, as expected for $\Delta J=2$, $\Delta\pi=\text{no}$.
(4510 ‡ 30)	0.0	53 4	18 1	5.25 4	71 5	$E(\epsilon)=4542$ 40 from measured $E\beta^+$.

 † Uncertainties dominated by uncertainty in direct g.s. feeding. ‡ $E_{\beta^\pm}=3520$ keV 40 from 1983Al06 ($\text{Ge}(\text{HP}), \text{Ge}(\text{Li})$). Other $E_{\beta^\pm}=3450$ keV 50 (1995Ve08; $\text{Ge}(\text{HP})$). $\%$ Absolute intensity per 100 decays.

Existence of this branch is questionable.

^{139}Pm ϵ Decay (4.15 min) $^{1977}\text{De06}$ (continued) $\gamma(^{139}\text{Nd})$ $\alpha(\text{K})_{\text{exp}}$: normalized to $\alpha(\text{K})(420\gamma \text{ } ^{140}\text{Nd}; \text{E3})=0.044$. $\text{I}\gamma$ normalization: from $\text{I}\gamma(403\gamma)=14.5\%$ 23; weighted average based on $\text{I}\gamma(^{139}\text{Nd } 405\gamma; 4.15\text{-min}$ component)/ $\text{I}\gamma(403\gamma)=0.080$ 6 and $\text{I}\gamma(^{139}\text{Nd } 1074\gamma; 4.15\text{-min component})/\text{I}\gamma(403\gamma)=0.026$ 3, $\text{I}\gamma(^{139}\text{Nd } 405\gamma)=7.0\%$ 10 and $\text{I}\gamma(^{139}\text{Nd } 1074\gamma)=2.5\%$ 5, and $\text{T}_{1/2}(^{139}\text{Pm})=4.15 \text{ min } 5$ and $\text{T}_{1/2}(^{139}\text{Nd g.s.})=29.7 \text{ min } 5$.

$\text{E}\gamma$	$\text{E}(\text{level})$	$\text{I}\gamma^{\ddagger}$	Mult. [†]	$\delta^{\dagger}$	α	Comments
95.3 1	95.31	12.3 8	M1 (+E2)	<0.18	1.64 3	$\alpha(\text{K})_{\text{exp}}=1.3$ 3; K/L=8.2 18.
272.7 4	675.46	0.81 20				
307.4 2	402.77	2.4 3	[E2]		0.056 8	
367.8 2	463.10	24.3 15	M1		0.0401	$\alpha(\text{K})_{\text{exp}}=0.040$ 6.
402.8 2	402.77	100	M1+E2	1.0 5	0.027 3	$\alpha(\text{K})_{\text{exp}}=0.022$ 3.
412.5 10	815.66	1.0 5				
463.1 2	463.10	28.1 18	M1+E2	>0.045	0.018 4	$\alpha(\text{K})_{\text{exp}}=0.013$ 5.
530.1 2	932.89	2.4 2	D			Mult.: from Adopted Gammas.
579.0 6	981.45	0.39 10				
580.1 3	675.46	2.9 3				
603.1 4	1066.2	1.0 1				
^x 631.8 4		0.80 9				
661.3 4	756.45	2.8 3				
663.4 6	1066.2	0.81 16				
675.5 3	675.46	1.3 1				
702.0 10	1105.0	0.57 15				
^x 721.0 10		0.38 10				
756.5 3	756.45	13.7 11				
815.8 2	815.66	7.8 2				
822.0 [§] 10	1282.1	0.40 20				
856.4 4	1319.5	0.66 9				
879.3 4	1282.1	0.38 6				
981.6 4	981.45	7.3 5				
^x 1079.9 4		1.0 2				
1105.0 3	1105.0	0.28 6				
1126.1 3	2107.56	2.0 2				
1174.7 3	2107.56	1.2 1				
^x 1193.3 3		1.4 2				
1205.7 4	2021.43	0.37 8				
1265.1 3	2021.43	0.61 9				
1292.5 4	2107.56	1.9 2				
^x 1299.7 3		0.54 6				
1351.1 3	2107.56	1.43 13				
1358.8 3	2340.08	0.36 12				
1426.3 4	2359.30	0.64 15				
1473.0 10	2289.0	0.26 9				
1484.1 1	2240.56	1.40 11				
1558.2 5	2021.43	0.89 14				
^x 1602.9 3		2.9 3				
1618.7 3	2021.43	1.4 11				
1644.5 3	2107.56	2.1 2				
1664.6 3	2340.08	0.26 4				
1704.6 3	2107.56	4.9 5				
1798.4 4	2261.27	0.60 8				
1825.9 3	2289.0	0.31 5				
^x 1849.5 5		0.29 5				
1858.5 3	2261.27	1.7 2				
1876.8 3	2340.08	1.1 2				
1886.2 5	2289.0	0.29 5				
1956.7 6	2359.30	0.99 20				
2021.3 3	2021.43	1.2 1				
2107.3 3	2107.56	2.5 3				
2261.1 3	2261.27	1.5 2				
^x 2351.0 4		0.25 5				
2359.3 3	2359.30	1.1 1				

[†] From $\alpha_{\text{K}}(\text{exp})$ and K/L. δ 's deduced by evaluators. Multipolarities in brackets were assigned in order to obtain the normalization and $\text{I}_{\text{e}+\beta\text{e}}$'s. Same assignments are in the Adopted Gammas.[‡] For absolute intensity per 100 decays, multiply by 0.145 23.

 ^{139}Pm ϵ Decay (4.15 min) 1977De06 (continued)

$\gamma(^{139}\text{Nd})$ (continued)

§ Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

⁹⁴Zr(⁴⁸Ca,3n γ) 2000Pe01

2000Pe01: E=195 MeV, measured E γ , $\gamma\gamma$, DCO, I γ using the 8 π array of 20 Compton suppressed HPGe detectors and an inner ball of 71 BGO scintillators.

The two bands observed by 2000Pe01 decay towards high-spin states which were not previously observed and are not discussed in 2000Pe01. Earlier high-spin level scheme from 1980Mul0 is known only up to 4037 level of possible J π =(31/2).

¹³⁹Nd Levels

E(level)	J π	Comments
y [†]	(49/2, 53/2)	E(level), J π : this level decays through a $\Delta J=1$, 388 γ to the (47/2) level of a band similar to Band #3 and #4 in ¹³⁷ Nd (See 1997Pe06). J=49/2 assigned by 2000Pe01. A spin value larger by 2 may be possible if there are unobserved transitions.
583.0+y [†] 10		
1325.0+y [†] 15		
2219.0+y [†] 18		
3281.0+y [†] 20		
4530.0+y [†] 23		
5977.0+y [†] 25		
z [‡]	J $\geq 49/2$	E(level): this level decays through a 1122 γ -1033 γ cascade of $\Delta J=2$, E2 transitions to a dipole band, similar to Band #7 in ¹³⁷ Nd (See 1997Pe06).
572.0+z [‡] 10		
1310.0+z [‡] 15		
2273.0+z [‡] 18		
3460.0+z [‡] 20		
4877.0+z [‡] 23		
6508.0+z [‡] 25		

[†] (A): Triaxial band #1. Population intensity=15% 5.

[‡] (B): Triaxial band #2.

 $\gamma(^{139}\text{Nd})$

E γ	E(level)	E γ	E(level)	E γ	E(level)
572	572.0+z	894	2219.0+y	1249	4530.0+y
583	583.0+y	963	2273.0+z	1417	4877.0+z
738	1310.0+z	1062	3281.0+y	1447	5977.0+y
742	1325.0+y	1187	3460.0+z	1631	6508.0+z

$^{96}\text{Zr}(^{48}\text{Ca},5n\gamma)$: E=180 MeV 2013Va10

E=180 MeV ^{48}Ca beam from K130 cyclotron at JYFL facility with RITU recoil separator. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coin, $\gamma\gamma(t)$, (recoil) γ coin using JUROGAM array (39 Compton-suppressed Ge detectors, 24 Clovers and 15 coaxial tapered detectors), and GREAT spectrometer (MWPC, DSSD detectors). Deduced lifetimes of isomers.
Level scheme is mainly from 2011Bh07. The 23/2+ isomer is now connected to other levels in 2013Va10.

 ^{139}Nd Levels

E(level)	$J\pi^\dagger$	$T_{1/2}$	Comments
0.0	3/2+		
231.0 § 10	11/2-	5.50 h	% ϵ +% β^+ =87.0 10; %IT=13.0 10. $T_{1/2}$ and decay modes from Adopted Levels.
896.1 § 14	15/2-		
1097.9 14	13/2-		
1966.8 14	17/2-		
2053.5 § 15	19/2-		
2571.4 17	19/2+		
2615.8 17	23/2+	278 ns 2	$T_{1/2}$: 605 $\gamma(t)$ (2013Va10). Configuration= $\nu h_{11/2}^{-2} \otimes \nu d_{3/2}^{-1}$.
2622.8 16	21/2-		
2711.6 § 16	23/2-		
2843.1 ‡ 18	21/2-		
3066.7 ‡ 19	23/2-		
3300.7 ‡ 21	25/2-		
3532.7 ‡ 23	27/2-		
3823.8 17	25/2-		
3839.3 17	25/2-		
3969 ‡ 3	29/2-		
3972.3 18	25/2-		
3979.0 18	27/2-		
4166.5 20	27/2-		
4291.8 19	29/2-		
4336 ‡ 3	31/2-		
4715.6 @ 20	31/2-		
4754.8 # 22	31/2-		
5288.6 # 23	33/2-		
5391.1 # 23	33/2-		
5549.6 @ 22	35/2-		
5694.3 # 24	35/2-		
6069 # 3	37/2-		
6137.6 @ 24	37/2-		
6489 # 3	39/2-		
6932 @ 3	41/2-		
7001 # 3	41/2-		
7718 @ 3	45/2-		
8744 @ 3	49/2-		

† As proposed by 2013Va10 based on band structures and earlier known assignments for low-lying levels.

‡ (A): $\Delta J=1$ band based on 21/2-.

§ (B): γ cascade based on 11/2-.

(C): $\Delta J=1$ band based on 31/2-, 4756.

@ (D): $\Delta J=1$ band based on 31/2-, 4716.

 $\gamma(^{139}\text{Nd})$

$E\gamma$	E(level)	Mult.	Comments
89	2711.6		
140	3979.0		
155	3979.0		
194	4166.5		
224	3066.7		
231	231.0	M4	Mult.: from Adopted Gammas.
232	3532.7		
234	3300.7		
272	2843.1		

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$^{96}\text{Zr}(^{48}\text{Ca},5n\gamma)$: E=180 MeV 2013Va10 (continued) $\gamma(^{139}\text{Nd})$ (continued)

$E\gamma$	E(level)	$E\gamma$	E(level)	$E\gamma$	E(level)
303	5694.3	569	2622.8	906	3972.3
313	4291.8	588	6137.6	1026	8744
367	4336	605	2571.4	1071	1966.8
375	6069	636	5391.1	1112	3823.8
406	5694.3	656	2622.8	1128	3839.3
420	6489	658	2711.6	1157	2053.5
424	4715.6	665	896.1	1208	3823.8
436	3969	786	7718	1216	3839.3
463	4754.8	794	6932	1224	3839.3
512	7001	834	5549.6	1356	3972.3
534	5288.6	867	1097.9		
549	4715.6	869	1966.8		

 $^{96}\text{Zr}(^{48}\text{Ca},5n\gamma)$: E=195 MeV 2011Bh07

2011Bh07: E=195 MeV ^{48}Ca beam was produced at the Vivitron tandem accelerator at IReS, Strasbourg. Target of a self-supporting ^{96}Zr foil of 735 $\mu\text{g}/\text{cm}^2$ thickness. The γ rays were detected by the Euroball array consisting of 30 single, tapered Ge detectors, 15 cluster, and 26 clover composite Ge detectors, each surrounded by a BGO Compton-suppression shield. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin, $\gamma\gamma(\theta)$ (DCO) and angular anisotropy ratios. Deduced levels, J, π , multipolarities. Comparison with cranked-shell model calculations.

 ^{139}Nd Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}$	Comments
0.0	3/2+		
231.00 ⁱ 19	11/2-	5.50 h	%IT=13.0 10; %ε+%β ⁺ =87.0 10. $T_{1/2}$ and decay modes are from Adopted Levels.
402.00 19	5/2+		
896.40 ⁱ 20	15/2-		
932.00 ^d 23	7/2-		
1098.20 20	13/2-		
1464.00 ^d 24	11/2-		
1944.11 21	15/2+		
1967.31 20	17/2-		
1990.61 21	15/2+		
2023.00 ^d 22	15/2-		
2053.91 ⁱ 21	19/2-		
2246.81 21	17/2+		
2548.00 ^d 23	19/2-		
2572.21 21	19/2+		
2617.21 22	17/2+		
2623.31 ⁱ 21	21/2-		
2712.41 22	23/2-		
2721.41 21	19/2+		
2843.81 [§] 21	21/2+		
2902.02 25	21/2-		
3067.32 [§] 22	23/2+		
3078.91 23	21/2+		
3237.99 24	23/2+		
3300.94 [§] 23	25/2+		
3302.98 ^d 25	23/2-		
3487.0 3	25/2+		
3532.44 [§] 25	27/2+		
3825.01 23	25/2-		
3840.12 21	25/2-		
3968.4 [§] 3	29/2+		
3972.92 ^d 23	25/2-		
3980.21 [#] 22	27/2-		
3985.0 3	25/2-		

Continued on next page (footnotes at end of table)

⁹⁶Zr(⁴⁸Ca,5n) γ : E=195 MeV 2011Bh07 (continued)

¹³⁹Nd Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	E(level) [†]	J $\pi^{\ddagger}$	E(level) [†]	J $\pi^{\ddagger}$
4167.06 22	27/2-	6211.1a 5	41/2-	8745.4c 3	49/2-
4293.0# 3	29/2-	6232.9@ 4	37/2-	9134.1j 3	49/2-
4335.0§ 3	31/2+	6258.0e 4	39/2+	9395.0h 4	53/2-
4716.36 25	31/2-	6267.1& 5	37/2-	9717.0j 3	53/2-
4756.3# 3	31/2-	6288.0 4	39/2+	10459.0j 4	57/2-
4823.0§ 3	33/2+	6428.3 3	39/2-	10517.0k 4	57/2-
4856.0g 3	33/2+	6472.1a 6	43/2-	11089.1k 5	61/2-
4913.0e 3	33/2+	6490.9# 4	39/2-	11353.0j 4	61/2-
4937.1@ 3	31/2-	6586.9@ 5	39/2-	11827.1k 5	65/2-
4957.6f 3	35/2+	6673.0f 4	43/2+	12414.5j 4	65/2-
5114.0§ 3	35/2+	6730.1& 5	39/2-	12789.1k 5	69/2-
5250.3g 3	35/2+	6771.0g 4	41/2+	13663.3j 4	69/2-
5289.9@ 3	33/2-	6866.2a 6	45/2-	13975.3k 5	73/2-
5385.0e 3	35/2+	6932.4c 3	41/2-	15110.5j 4	73/2-
5392.5# 3	33/2-	7003.3h 4	41/2-	15392.2k 5	77/2-
5441.1& 3	31/2-	7018.5 4	41/2-	16741.5j 4	77/2-
5521.0 4	35/2+	7103.0b 4	41/2-	17023.2k 5	81/2-
5550.8 3	35/2-	7166.1& 5	41/2-	18525.5j 5	81/2-
5560.0g 3	37/2+	7341.3a 6	47/2-	18839.2k 6	85/2-
5572.6 3	35/2-	7343.0b 4	43/2-	20854.2k 6	(89/2-)
5612.1& 4	33/2-	7633.0b 4	45/2-	x ^l	J=(51/2)
5695.5# 3	35/2-	7651.1 4	45/2-	794.00+x ^l 10	J+2
5721.1a 4	35/2-	7702.1f 4	47/2+	1662.01+x ^l 15	J+4
5762.2f 3	39/2+	7718.0h 4	45/2-	2666.01+x ^l 18	J+6
5777.0e 3	37/2+	7718.6c 3	45/2-	3849.01+x ^l 20	J+8
5861.1a 4	37/2-	7721.1 4	47/2+	5191.0+x ^l 3	J+10
5873.1& 5	35/2-	8002.0b 5	47/2-	6650.0+x ^l 4	J+12
5883.9@ 4	35/2-	8074.0 5	47/2-	8228.0+x ^l 4	J+14
6017.1a 5	39/2-	8149.1f 4	49/2+	9953.1+x ^l 5	J+16
6070.8# 3	37/2-	8336.0b 5	49/2-	11828.1+x ^l 5	(J+18)
6139.0c 3	37/2-	8361.0h 4	49/2-		

[†] From least-squares fit to E γ data.

[‡] As proposed in 2011Bh07 based on angular distribution and DCO data, band associations, and earlier known assignments for low-lying levels.

§ (A): $\Delta J=1$ band based on 21/2+.

(B): $\Delta J=1$ band based on 27/2-.

@ (C): $\Delta J=1$ band based on 31/2-.

& (D): $\Delta J=1$ band based on 31/2-.

a (E): $\Delta J=1$ band based on 35/2-.

b (F): $\Delta J=1$ band based on 41/2-.

c (G): $\Delta J=2$ band based on 37/2-.

d (H): Band based on 7/2-.

e (I): $\Delta J=1$ band based on 33/2+.

f (J): Band based on 35/2+.

g (K): Band based on 33/2+.

h (L): $\Delta J=2$ γ cascade based on 41/2-.

i (M): γ cascade based on 11/2-.

j (N): $\Delta J=2$ band based on 49/2-. The floating $\Delta J=2$ band based on 11/2- may be signature partner of $\Delta J=2$ band.

k (O): $\Delta J=2$ band based on 57/2-.

l (P): $\Delta J=2$ band.

$^{96}\text{Zr}(^{48}\text{Ca}, 5n\gamma): E=195 \text{ MeV} \quad 2011\text{Bh07 (continued)}$ $\gamma(^{139}\text{Nd})$

DCO ratios correspond to gates on $\Delta J=2$, quadrupole transitions. Expected ratios are 1.0 for $\Delta J=2$, quadrupole and 0.5 for $\Delta J=1$, dipole.

R_0 =Angular anisotropy ratio.

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$	Mult. [‡]	Comments
58.2 2	2902.02	0.9 2	D§	$\alpha=1.12$ for E1. $R_0=0.47$.
89.1 1	2712.41	11.6 12	D	$\alpha=1.97$ for M1. $R_0=0.38$. DCO=0.42.
104.2 2	2721.41	2.7 6	D	$\alpha=1.26$ for M1. $R_0=0.45$. DCO=0.40.
122.4 1	2843.81	10.6 11	D	$\alpha=0.797$ for M1. $R_0=0.44$. DCO=0.48.
140.0 2	5861.1	1.1 2	D	$\alpha=0.546$ for M1. DCO=0.37.
140.1 1	3980.21	23.7 24	D	$\alpha=0.545$ for M1. $R_0=0.45$. DCO=0.47.
149.2 1	2721.41	7.5 8	D§	$\alpha=0.457$ for M1. DCO=0.55.
155.2 1	3980.21	8.2 8	D	$\alpha=0.409$ for M1. $R_0=0.56$. DCO=0.47.
156.0 2	6017.1	0.9 2	D	$\alpha=0.403$ for M1. $R_0=0.48$. DCO=0.56.
159.1 2	3237.99	1.4 3	D	$\alpha=0.382$ for M1. $R_0=0.50$. DCO=0.48.
171.0 2	5612.1	1.6 3	D	$\alpha=0.312$ for M1. $R_0=0.39$.
182.0 2	4167.06	0.51 10	D	$\alpha=0.263$ for M1. $R_0=0.57$.
194.0 2	6211.1	0.8 2		
194.2 1	4167.06	13.8 14	D§	$\alpha=0.220$ for M1. $R_0=0.51$. DCO=0.52.
223.5 1	3067.32	48.0	D	$\alpha=0.150$ for M1. $R_0=0.52$. DCO=0.48.
231.0 2	231.00		M4	Mult.: from Adopted Gammas.
231.5 1	3532.44	34.1 35	D	$\alpha=0.137$ for M1. $R_0=0.52$. DCO=0.47.
233.6 1	3300.94	42.0 40	D	$\alpha=0.133$ for M1. $R_0=0.51$. DCO=0.48.
240.0 2	7343.0	3.1 6	D	$R_0=0.6$. DCO=0.55.
249.0 2	3487.0	1.8 4	D	$\alpha=0.112$ for M1. $R_0=0.61$. DCO=0.62.
256.2 1	2246.81	16.9 17	D	$R_0=0.52$. DCO=0.53.
261.0# 2	5873.1	1.12# 22	D	$\alpha=0.099$ for M1. $R_0=0.41$.
	6472.1			
271.0 1	5385.0	6.9 7	D§	$R_0=0.51$. DCO=0.50.
271.6 1	2843.81	30.0 30	D	$R_0=0.52$. DCO=0.56.

Continued on next page (footnotes at end of table)

⁹⁶Zr(⁴⁸Ca,5n γ): E=195 MeV 2011Bh07 (continued)

 $\gamma(^{139}\text{Nd})$ (continued)

E $\gamma^{\dagger}$	E(level)	I $\gamma^{\dagger}$	Mult. ‡	Comments
290.0 1	7633.0	4.1 4	D	R ₀ =0.55. DCO=0.55.
291.0 2	5114.0	3.3 7	D	R ₀ =0.55. DCO=0.53.
302.7 1	2246.81	10.2 10	D	R ₀ =0.56. DCO=0.53.
303.0 1	5695.5	15.2 15	D	R ₀ =0.56. DCO=0.52.
309.7 1	5560.0	4.1 4	D	R ₀ =0.51. DCO=0.53.
312.7 1	4293.0	44.2 44	D	R ₀ =0.50. DCO=0.51.
325.4 1	2572.21	7.5 8	D	R ₀ =0.42. DCO=0.56.
326.9 1	4167.06	9.4 10	D	R ₀ =0.50. DCO=0.49.
334.0 2	8336.0	2.5 5	D	DCO=0.47.
339.7 2	7343.0	1.3 3	D	R ₀ =0.60. DCO=0.59.
349.0 2	6232.9	1.21 24	D	R ₀ =0.42.
352.8 2	5289.9	1.5 3	D	DCO=0.53.
354.0 2	6586.9	0.95 20		
357.5 1	3078.91	4.1 4	D	R ₀ =0.55. DCO=0.6.
366.6 1	4335.0	18.8 19	D	R ₀ =0.43. DCO=0.48.
369.0 2	8002.0	2.1 4	D	DCO=0.58.
375.3 1	6070.8	17.6 18	D	R ₀ =0.51. DCO=0.52.
388.6 1	9134.1	8.1 8	D [§]	R ₀ =0.57. DCO=0.53.
392.0 1	5777.0	7.1 7	D	R ₀ =0.54. DCO=0.52.
394.0 2	6267.1	0.9 2	D	DCO=0.42.
394.1 2	6866.2			
394.3 1	5250.3	5.2 5	D	R ₀ =0.52. DCO=0.53.
402.0 2	402.00	1.2 24	D	DCO=0.58.
405.6 1	5695.5	8.0 8	D	R ₀ =0.53. DCO=0.51.
420.1 1	6490.9	15.8 16	D	R ₀ =0.56. DCO=0.51.
423.4 1	4716.36	11.5 12	D	R ₀ =0.46. DCO=0.48.
428.0 2	8149.1	1.1 2	D	DCO=0.51.
436.0 [#] 1	3968.4	33.0 [#] 33	D	R ₀ =0.55. DCO=0.52.
436.0 [#] 2	7166.1	3.1 [#] 6	D	R ₀ =0.53.
441.0 2	8074.0	2.6 5	D	R ₀ =0.55. DCO=0.52.
447.0 2	8149.1	2.3 5	D	R ₀ =0.56. DCO=0.52.
463.0 1	6730.1	3.6 4	D	R ₀ =0.62.
463.3 1	4756.3	34.0 35	D	R ₀ =0.51. DCO=0.52.
472.0 1	5385.0	6.8 7	D	R ₀ =0.57. DCO=0.5.
474.6 1	2721.41	20.0 20	D	R ₀ =0.57. DCO=0.53.
475.1 2	7341.3	0.8 2	D	DCO=0.45.
481.0 1	6258.0	4.4 5	D	DCO=0.68.
493.2 2	3980.21			
504.0 1	6932.4	6.5 7	D	R ₀ =0.54. DCO=0.52.

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⁹⁶Zr(⁴⁸Ca,5n) γ : E=195 MeV 2011Bh07 (continued)

 $\gamma(^{139}\text{Nd})$ (continued)

$E_{\gamma}^{\dagger}$	E(level)	$I_{\gamma}^{\dagger}$	Mult. ‡	Comments
511.0 1	6288.0	4.5 5	D	$R_0=0.50$. DCO=0.43.
512.4 1	7003.3	10.6 11	D	$R_0=0.52$. DCO=0.52.
521.0 1	4856.0	7.1 7	D	$R_0=0.48$. DCO=0.52.
525.0 2	2548.00	1.3 3	Q	DCO=1.03.
527.6 1	7018.5	5.2 5	D	$R_0=0.6$. DCO=0.55.
530.0 2	932.00	1.0 2	D	DCO=0.73.
532.0 2	1464.00	1.0 2	Q	DCO=0.82.
533.6 1	5289.9	9.5 10	D	$R_0=0.50$. DCO=0.54.
549.3 1	4716.36	22.0 22	Q	$R_0=0.98$. DCO=1.03.
559.0 2	2023.00	1.0 2	Q	DCO=0.94.
566.4 2	6139.0	2.2 5	D	$R_0=0.48$. DCO=0.56.
569.4 1	2623.31	33.0 33	D	$R_0=0.51$. DCO=0.50.
572.1 1	11089.1	18.6 19	Q	$R_0=1.18$. DCO=0.83.
578.0 1	4913.0	10.8 11	D	$R_0=0.62$. DCO=0.67.
581.6 1	2572.21	7.1 7	Q	$R_0=0.93$. DCO=0.88.
583.0 1	9717.0	20.2 20	Q	DCO=0.92.
588.3 1	6139.0	18.8 19	D	DCO=0.56.
594.0 2	5883.9	1.4 3	D	DCO=0.62.
597.0 2	2843.81	2.8 6	Q	DCO=0.82.
602.1 2	3840.12	3.1 6	D	$R_0=0.62$. DCO=0.64.
604.9 1	2572.21	47.0 50	D	$R_0=0.69$. DCO=0.66.
612.2 2	7103.0	1.9 4	D	DCO=0.59.
622.6 1	4957.6	8.7 9	Q	$R_0=0.83$. DCO=0.85.
632.6 2	7651.1	1.5 3	Q	$R_0=0.82$. DCO=0.86.
636.2 1	5392.5	17.6 18	D	$R_0=0.54$. DCO=0.52.
643.0 2	8361.0	1.2 3	Q	DCO=0.83.
644.1 2	4937.1	2.3 5	D	$R_0=0.59$. DCO=0.67.
647.8 2	7651.1	1.2 3	Q	DCO=1.11.
656.0 1	2623.31	6.6 7	Q	$R_0=0.82$. DCO=1.01.
658.5 1	2712.41	6.2 6	Q	$R_0=0.83$. DCO=0.82.
665.4 1	896.40	100 10	Q	$R_0=1.13$. DCO=1.02.
670.0 2	3972.92	0.85 17	D	DCO=0.61.
679.2 2	3980.21	2.7 6	D	$R_0=0.71$. DCO=0.7.
682.0 2	3985.0	0.34 7		
710.0 2	8361.0	1.5 3	Q	DCO=0.84.
714.7 2	7718.0	1.3 3	Q	DCO=0.81.
730.8 1	2721.41	3.8 4	Q	DCO=0.8.
735.0 2	3972.92			
738.0 1	11827.1	17.8 18	Q	$R_0=0.87$. DCO=0.95.
742.0 1	10459.0	20.1 20	Q	DCO=0.88.

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$^{96}\text{Zr}(^{48}\text{Ca}, 5n\gamma): E=195 \text{ MeV} \quad 2011\text{Bh07 (continued)}$ $\gamma(^{139}\text{Nd})$ (continued)

$E_{\gamma}^{\dagger}$	E(level)	$I_{\gamma}^{\dagger}$	Mult. ‡	Comments
755.0 2	3302.98	2.8 6	Q	$R_0=0.9$. DCO=1.02.
772.8 1	3840.12	3.8 4	D	$R_0=0.75$. DCO=0.77.
779.0 2	5114.0	2.1 4	Q	$R_0=0.95$. DCO=0.89.
786.2 1	7718.6	24.6 25	Q	$R_0=1.00$. DCO=0.93.
793.6 1	6932.4	18.6 19	Q	$R_0=0.93$. DCO=1.03.
794.0 1	794.00+x	3.9 4	Q	$R_0=0.92$. DCO=1.03.
802.6 1	4335.0	12.1 12	Q	$R_0=0.86$. DCO=0.85.
804.6 1	5762.2	6.1 6	Q	$R_0=0.87$. DCO=0.96.
834.4 1	5550.8	28.0 28	Q	$R_0=0.89$. DCO=0.91.
845.9 1	1944.11	6.4 7	D	DCO=0.61.
854.6 2	4823.0	3.5 7	Q	$R_0=0.79$. DCO=0.83.
856.3 2	5572.6	3.1 6	Q	DCO=0.86.
866.1 2	4167.06	0.74 15	D	
867.2 1	1098.20	38.1 38	D	$R_0=0.55$. DCO=0.59.
868.0 1	1662.01+x	3.7 4	Q	$R_0=0.96$. DCO=0.93.
869.1 1	1967.31	5.1 5	Q	$R_0=1.0$. DCO=1.08.
877.4 1	6428.3	7.0 7	Q	$R_0=0.93$. DCO=1.05.
887.6 2	4856.0	0.80 16	Q	$R_0=0.93$. DCO=0.89.
892.4 1	1990.61	26.1 26	D	DCO=0.77.
894.0 1	11353.0	19.1 19	Q	$R_0=1.08$. DCO=0.89.
905.7 2	3972.92			
910.8 1	6673.0	3.8 4	Q	$R_0=0.91$. DCO=1.15.
938.1 2	3840.12	2.1 4	Q	$R_0=0.87$. DCO=0.89.
961.9 1	12789.1	15.6 16	Q	$R_0=1.09$. DCO=0.99.
964.8 2	5721.1	0.80 16	Q	$R_0=0.84$.
971.4 1	9717.0	8.5 9	Q	$R_0=0.87$. DCO=0.96.
1004.0 1	2666.01+x	4.7 5	Q	$R_0=0.91$. DCO=0.87.
1025.0 1	3078.91	7.3 7	D	DCO=0.58.
1026.4 1	8745.4	20.1 20	Q	$R_0=0.96$. DCO=1.1.
1029.0 2	7702.1	1.7 3	Q	$R_0=1.1$.
1034.0 1	9395.0	6.8 7	Q	$R_0=0.95$. DCO=1.02.
1047.7 2	1944.11	1.1 2	D §	DCO=0.78.
1048.0 2	7721.1	1.8 3	Q	DCO=0.99.
1061.5 1	12414.5	15.5 15	Q	$R_0=1.10$. DCO=0.97.
1070.9 1	1967.31	47.8 48	D	$R_0=0.46$. DCO=0.52.
1112.6 1	3825.01	7.7 8	D	$R_0=0.59$. DCO=0.59.

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$^{96}\text{Zr}(^{48}\text{Ca}, 5n\gamma)$: E=195 MeV 2011Bh07 (continued) $\gamma(^{139}\text{Nd})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. ‡	Comments
1122.0 1	10517.0	5.7 6	Q	$R_0=0.94$. $\text{DCO}=0.92$.
1127.7 1	3840.12	24.4 25	D	$R_0=0.41$. $\text{DCO}=0.49$.
1157.5 1	2053.91	41.7 42	Q	$R_0=1.03$. $\text{DCO}=1.05$.
1183.0 1	3849.01+x	3.6 4	Q	$R_0=0.97$. $\text{DCO}=1.02$.
1186.0 2	5521.0	0.9 2	Q	$R_0=1.01$.
1186.2 1	13975.3	9.6 10	Q	$R_0=1.20$. $\text{DCO}=1.17$.
1201.7	3825.01	1.0 2	Q	$R_0=1.01$. $\text{DCO}=1.03$.
1211.0 2	6771.0	1.5 3	Q	$\text{DCO}=0.97$.
1216.8 1	3840.12	7.1 7	Q	$R_0=1.07$. $\text{DCO}=1.03$.
1248.8 1	13663.3	9.5 10	Q	$R_0=1.18$. $\text{DCO}=1.06$.
1274.0 2	5441.1	2.8 6	Q	$R_0=0.86$.
1342.0 2	5191.0+x	3.5 7	Q	$\text{DCO}=1.04$.
1350.4 2	2246.81	1.2 2	D	$\text{DCO}=0.8$. Evaluators' note: $\text{DCO}=0.8$ seems too large for $\Delta J=1$, dipole.
1415.8 1	9134.1	6.9 7	Q	$\text{DCO}=1.01$.
1416.9 1	15392.2	6.9 7	Q	$R_0=1.07$. $\text{DCO}=1.05$.
1447.2 1	15110.5	7.2 7	Q	$\text{DCO}=1.11$.
1459.0 2	6650.0+x	2.3 5	Q	$R_0=1.12$. $\text{DCO}=1.07$.
1578.0 2	8228.0+x	1.5 3	Q	$\text{DCO}=1.26$.
1631.0# 1	16741.5	4.0# 4	Q	$R_0=1.07$. $\text{DCO}=1.08$.
1631.0# 2	17023.2	3.5# 7	Q	$\text{DCO}=1.02$.
1651.6 2	2548.00			
1720.8 1	2617.21	9.7 10	D	$\text{DCO}=0.74$.
1725.0 2	9953.1+x	1.1 2	Q	$R_0=1.19$.
1784.0 2	18525.5	2.2 5	Q	$R_0=1.15$.
1792.0 2	2023.00			
1816.0 2	18839.2	2.1 4	Q	$\text{DCO}=1.07$.
1875.0 2	11828.1+x			
2015.0 2	20854.2	1.3 3		

† Uncertainties are: $\Delta E\gamma=0.1$ keV for $I\gamma>3.5$ and 0.2 keV for $I\gamma\leq 3.5$, corresponding $\Delta I\gamma=10\%$ and 20% (private communication with authors of 2011Bh07).

‡ Assignments are based on DCO ratios and angular anisotropies. Since such measurements are insensitive to parity assignment, the evaluators assign mult=Q for stretched quadrupoles (E2 assigned in 2011Bh07), and mult=D for $\Delta J=1$ transitions (M1 or E1 assigned in 2011Bh07). As indicated, there are only six $\Delta J=0$, dipole transitions (two assumed E1 and four M1).

$\S$ $\Delta J=0$, dipole transition.

Multiply placed; intensity suitably divided.

$^{126}\text{Te}(^{18}\text{O},5n\gamma)$ 2008Fe02

2008Fe02: E=75 MeV beam provided by Tandem accelerator at IPN Orsay. Measured $E\gamma$, $\gamma\gamma(t)$ with one clover and three co-axial Ge detectors with BGO Compton suppression. Evidence of a 272-ns isomer above 19/2+ level is reported.

The level scheme reported by 2008Fe02 is apparently deduced from experiments carried out for ^{140}Nd (2006Pe25,2005Pe24). Details of gamma-ray data are not provided by 2008Fe02.

 ^{139}Nd Levels

E(level) [†]	J π [‡]	T _{1/2}	Comments
0.0	3/2+		
231.0 § 10	11/2-	5.50 h 20	%IT=13.0 10. T _{1/2} : from Adopted Levels.
896.0 § 13	15/2-		
1098.0 # 13	13/2-		
1943.9 14	15/2+		
1966.9 # 14	17/2-		
1990.1 15	15/2+		
2053.3 § 15	19/2-		
2246.5 15	17/2+		
2571.9 15	19/2+		
2571.9+x		272 ns 4	E(level): only the transitions below the 2572, 19/2+ level are delayed (2008Fe02). The authors could observe neither any delayed transition populating the 2572, 19/2+ level nor K x-rays of Nd. T _{1/2} : apparent half-life from 1071 γ (t) (2008Fe02). The 605-keV transition from 2572 level and 665-keV transition from 896 level were also delayed, but the statistics in 2008Fe02 experiment were not adequate for lifetime determination.
2618.2 @ 15	17/2+		
2622.6 # 15	21/2-		
2711.3 § 16	23/2-		
2721.3 @ 15	19/2+		
2843.6 @ 16	21/2-		
3067.6 @ 19	23/2+		
3301.6 @ 22	25/2+		
3533.6 @ 24	27/2+		
3824.2 18	25/2-		
3839.0 # 17	25/2-		
3980.1 18	27/2-		

[†] From least-squares fit to $E\gamma$ data, assuming 1 keV uncertainty for each γ ray.

[‡] As proposed by 2008Fe02 based on yrast population of levels, band structures and earlier known assignments for low-lying levels.

§ (A): Band based on 11/2-.

(B): Band based on 13/2-.

@ (C): Band based on 17/2+.

 $\gamma(^{139}\text{Nd})$

E γ	E(level)	Mult.	Comments
89	2711.3		
103	2721.3		
122	2843.6		
141	3980.1		
149	2721.3		
156	3980.1		
224	3067.6		
(231)	231.0	M4	Mult.: from Adopted Gammas.
232	3533.6		
234	3301.6		
256	2246.5		
272	2843.6		
303	2246.5		
325	2571.9		
475	2721.3		
569	2622.6		
582	2571.9		
605	2571.9		

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¹²⁶Te(¹⁸O,5n γ) 2008Fe02 (continued)

$\gamma(^{139}\text{Nd})$ (continued)

E γ	E(level)	E γ	E(level)	E γ	E(level)
656	2622.6	869	1966.9	1128	3839.0
658	2711.3	892	1990.1	1157	2053.3
665	896.0	1048	1943.9	1216	3839.0
846	1943.9	1071	1966.9	1722	2618.2
867	1098.0	1113	3824.2		

¹²⁸Te(¹⁶O,5n γ): 2008Xu05 2008Xu05

2008Xu05: E=90 MeV beam provided by HI-13 accelerator at China Institute of Atomic Energy. Enriched target. Measured E γ , I γ , $\gamma\gamma$, $\gamma\gamma(0)$ (DCO) using an array of 14 Ge detectors with Compton suppression. Comparisons with triaxial rotor model calculations.

1978Gi11: E=90 MeV. Measured E γ , I γ , $\gamma\gamma$, $\gamma(0)$. Nine levels and 10 γ rays reported up to (29/2+).

See also separate dataset from 2007Ku12 using the same reaction at 85 MeV.

The level schemes proposed in 2008Xu05 and 2007Ku12 are in general agreement, except in two places. 1. The ordering of γ rays in band #4, reported by 2007Ku12 is 463.0 $\rightarrow$ 636.0 $\rightarrow$ 303.2 $\rightarrow$ 419.9 $\rightarrow$ 375.6 $\rightarrow$ 611.7, with 535.5 γ and 405.2 γ in parallel to 636.0 γ and 303.2 γ . 2. An 868.8 γ from 1967.4 to 1098.6 is not seen by 2007Ku12. Other gamma rays seen by 2007Ku12 have been confirmed in 2008Xu05, in addition to several new gamma rays reported by 2008Xu05.

¹³⁹Nd Levels

All band configurations are tentative according to 2008Xu05.

E(level) [†]	J π [@]	T _{1/2}	Comments
0.0	3/2+		
231.15 $\&$ 5	11/2-	5.50 h 20	% ϵ +% β^+ =87.0 10; %IT=13.0 10. T _{1/2} and decay modes from Adopted Levels. Configuration= $\nu h_{11/2}^{-1} \otimes (0^+$ of even-even core).
896.2 $\&$ 4	15/2-		
1098.6 $\#$ 4	13/2-		
1343.3	(13/2-)		E(level): level from 1978Gi11.
1944.4 $\S$ 4	15/2-		
1967.4 $\S$ 5	17/2-		
1990.2 $\ddagger$ 5	15/2-		
2053.8 $\S$ 5	19/2-		
2246.2 $\ddagger$ 4	17/2-		
2542.8 $\ddagger$ 6	19/2-		
2571.9 ^a 5	19/2+		
2617.1 6	(17/2-)		
2622.6 $\ddagger$ 5	21/2-		
2710.7 $\ddagger$ 5	23/2-		
2720.3 ^a 5	(19/2+)		Possible configuration= $\nu(h_{11/2}^{-2} s_{1/2})$.
2842.3 ^a 6	21/2+		Possible configuration= $\nu(h_{11/2}^{-2} s_{1/2})$.
3074.8 ^a 7	23/2+		Possible configuration= $\nu h_{11/2}^{-1} \otimes \pi(h_{11/2} d_{5/2}^{-1})$.
3078.9 6	(21/2-)		
3238.0 7	(23/2-)		
3297.3 ^a 7	25/2+		Possible configuration= $\nu h_{11/2}^{-1} \otimes \pi(h_{11/2} d_{5/2}^{-1})$.
3495.0 ^c 7	27/2-		
3527.4 ^a 9	27/2+		Possible configuration= $\nu h_{11/2}^{-1} \otimes \pi(h_{11/2} g_{7/2}^{-1})$.
3728.8 7	(25/2-)		
3823.2 7	25/2-		
3838.5 ^e 7	25/2-		
3963.4 ^a 10	29/2+		Possible configuration= $\nu h_{11/2}^{-1} \otimes \pi(h_{11/2} g_{7/2}^{-1})$ coupled to 2+ of even-even core.
3977.9 ^e 6	27/2-		
4164.5 ^b 8	(29/2-)		
4289.5 ^e 8	29/2-		
4329.4 ^a 10	31/2+		Possible configuration= $\nu h_{11/2}^{-1} \otimes \pi(h_{11/2} g_{7/2}^{-1})$ coupled to 2+ of even-even core.
4448.8 ^c 9	31/2-		
4713.0 ^b 8	(31/2-)		
4720.9 ^d 11	33/2+		
4752.1 ^e 9	31/2-		

Continued on next page (footnotes at end of table)

¹²⁸Te(¹⁶O,5nγ): 2008Xu05 2008Xu05 (continued)

¹³⁹Nd Levels (continued)

E(level) [†]	Jπ [@]	Comments
4818.1 11	(31/2+)	
4850.5 ^a 11	33/2+	
4855.3 ^c 10	35/2-	
4907.8 11	33/2+	
5110.4 11	(33/2+)	
5126.7 ^e 10	33/2-	
5160.7 ^a 12	35/2+	
5216.8 12	37/2+	
5230.2 ^d 12	35/2+	
5285.3 10	(33/2-)	
5516.5 11		
5546.0 ^e 12	35/2-	
5547.0 ^b 9	(35/2-)	
5701.6 ^d 13	37/2+	
5950.8 12	37/2-	
6134.8 ^b 10	(37/2-)	
6181.5 ^e 12	37/2-	
6372.4 13	(39/2+)	
6423.7 10	(39/2-)	E(level): connected to band based on (21/2-).
6483.8 13	39/2-	
6928.2 ^b 11	(41/2-)	
6995.0 ^f 14	41/2-	
7234.1 ^f 15	43/2-	
7523.6 ^f 15	45/2-	
7714.6 ^b 12	(45/2-)	
7892.1 ^f 16	47/2-	
x ^g	J	E(level): x>4 MeV from possible feeding of 3963, 29/2+ level according to level scheme shown by 2008Xu05.
193.1+x ^g 5	J+1	
452.8+x ^g 7	J+2	
846.3+x ^g 9	J+3	
1308.3+x ^g 10	J+4	

[†] From least-squares fit to Eγ data.

[‡] Possible member of multiplet formed by coupling of vh_{11/2}⁻¹ with 6+ state of even-even core.

[§] Possible member of multiplet formed by coupling of vh_{11/2}⁻¹ with 4+ state of even-even core.

[#] Possible member of multiplet formed by coupling of vh_{11/2}⁻¹ with 2+ state of even-even core.

[@] As proposed in 2008Xu05 on the basis of DCO measurements and band structures.

[&] (A): Structure built on vh_{11/2}⁻¹ Possible oblate structure with γ=-60°.

^a (B): γ cascade based on 19/2+.

^b (C): γ cascade based on (29/2-).

^c (D): γ cascade based on 19/2-. Possible oblate structure with γ=-60°.

^d (E): Band based on 33/2+. Possible oblate structure with γ=-60°.

^e (F): vh_{11/2}⁻³.

^f (G): π(g_{7/2}⁻¹h_{11/2})⊗v(d_{3/2}h_{11/2}⁻²).

^g (H): vd_{3/2}⊗vh_{11/2}⁻². In 2011Bh07, this structure is connected to the main level scheme with a different ordering of the transitions.

γ(¹³⁹Nd)

The DCO ratios seem to correspond to gates on ΔJ=2, quadrupole transitions. Expected values of DCO are: ≈0.9 for ΔJ=2, quadrupole, and ≈0.5 for a ΔJ=1, dipole transition.

A₂ and A₄ data are from 1978Gi11.

Eγ [†]	E(level)	Iγ [‡]	Mult. [§]	α	Comments
86.4 5	2053.8	2.9 6	D+Q		DCO=0.48 8.
88.1 5	2710.7	12.3 1	D+Q		DCO=0.56 7.
103.2 5	2720.3	4.5 5			
122.0 5	2842.3	14.5 2	D+Q		DCO=0.40 6.
139.4 5	3977.9	15.2 1	D+Q		DCO=0.68 8.
148.4 5	2720.3	7.1 3	D+Q		DCO=0.65 11.
					Mult.: ΔJ=0 transition.

Continued on next page (footnotes at end of table)

$^{128}\text{Te}(^{16}\text{O},5\text{n}\gamma): 2008\text{Xu05} \quad 2008\text{Xu05 (continued)}$ $\gamma(^{139}\text{Nd})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger}$	Mult. [§]	α	Comments
154.7 5	3977.9	5.5 3	D+Q		DCO=0.55 9.
159.1 5	3238.0	4.0 4			
167.9 5	2710.7	3.1 5	Q		DCO=0.87 14.
193.1 5	193.1+x	7.3 4			
222.5 5	3297.3	38.7 1	D+Q		DCO=0.58 8. $A_2=-0.41$ 10; $A_4=+0.10$ 11.
230.1 5	3527.4	33.8 1	D+Q		DCO=0.66 7. $A_2=-0.65$ 6; $A_4=+0.07$ 6.
(231.15 5)	231.15		M4	14.51	$E\gamma$, Mult.: from Adopted Gammas.
232.5 5	3074.8	41.1 1	D+Q		DCO=0.68 6. $A_2=-0.32$ 5; $A_4=-0.12$ 20.
239.1 5	7234.1	0.6 3	D+Q		DCO=0.30 6.
249.1 5	3977.9	2.6 4			
256.0 5	2246.2	3.9 3	D+Q		DCO=0.47 14.
259.7 5	452.8+x	4.1 5			
270.4 5	2842.3	28.2 2	D+Q		DCO=0.58 8. $A_2=-0.36$ 1; $A_4=-0.06$ 6.
289.5 5	7523.6	0.6 8	D+Q		DCO=0.58 10.
301.8 5	2246.2	8.9 3	D+Q		DCO=0.58 6.
302.3 5	6483.8	5.1 7	D+Q		DCO=0.58 6.
309.0 5	5216.8	3.2 5	Q		DCO=0.87 8.
310.2 5	5160.7	4.9 3	D+Q		DCO=0.61 9.
311.6 5	4289.5	25.1 1	D+Q		DCO=0.60 13.
325.7 5	2571.9	2.9 5			
326.0 5	4164.5	2.6 6	Q		DCO=0.81 9.
358.6 5	3078.9	2.7 5			Mult.: 2008Xu05 list (M1), but their $\Delta(J\pi)$ assignment requires E1.
366.0 5	4329.4	17.6 1	D+Q		DCO=0.57 14.
368.5 5	7892.1	0.4 8	D+Q		DCO=0.41 13.
374.6 5	5126.7	9.8 2	D+Q		DCO=0.55 10.
391.5 5	4720.9	4.3 4	D+Q		DCO=0.59 14.
393.5 5	846.3+x	4.1 3			
404.8 5	5950.8	3.0 8	D+Q		DCO=0.48 3.
406.5 5	4855.3	2.1 7	Q		DCO=1.07 8.
419.3 5	5546.0	8.2 4	D+Q		DCO=0.52 9.
423.5 5	4713.0	4.7 7	D+Q		DCO=0.50 6.
436.0 5	3963.4	24.9 1	D+Q		DCO=0.52 4.
462.0 5	1308.3+x	2.0 8			
462.6 5	4752.1	19.8 2	D+Q		DCO=0.45 2.
471.4 5	5701.6	1.6 7	D+Q		DCO=0.52 3.
474.1 5	2720.3	12.8 2	D		DCO=0.68 9.
490.8 5	3728.8	2.7 4			
504.5 5	6928.2	0.7 8	D+Q		DCO=0.57 6.
509.3 5	5230.2	1.9 6	D+Q		DCO=0.62 9.
511.2 5	6995.0	3.6 4	D+Q		DCO=0.53 7.
521.1 5	4850.5	6.8 3	D+Q		DCO=0.41 11.
533.0 5	6483.8	1.6 8	D+Q		DCO=0.40 4.
533.2 5	5285.3	5.3 2	D+Q		DCO=0.46 10.
548.5 5	4713.0	2.4 4	D+Q		DCO=0.51 7.
568.8 5	2622.6	30.2 1	D+Q		DCO=0.48 2.
578.4 5	4907.8	4.0 5	Q		DCO=0.85 8.
587.8 5	6134.8	2.8 4	D+Q		DCO=0.56 6.
604.5 5	2571.9	38.9 2	D		DCO=0.66 4. $A_2=+0.06$ 10; $A_4=+0.03$ 10.
624.0	1967.4	10.0 20			$E\gamma$, $I\gamma$: from 1978Gi11. $A_2=+0.10$ 15; $A_4=+0.1$ 2.
635.5 5	6181.5	4.8 5	D+Q		DCO=0.41 4.
655.2 5	2622.6	3.2 5			
656.9 5	2710.7	4.3 3			
665.0 5	896.2	100.0	Q		DCO=0.93 4. $A_2=+0.27$ 7; $A_4=+0.07$ 11.
680.6 5	3977.9	1.8 7			
781.0 5	5110.4	3.9 5			
784.3 5	3495.0	7.2 3	Q		DCO=1.09 14.

Continued on next page (footnotes at end of table)

¹²⁸Te(¹⁶O,5n γ): 2008Xu05 2008Xu05 (continued)

 $\gamma(^{139}\text{Nd})$ (continued)

E $\gamma^{\dagger}$	E(level)	I $\gamma^{\ddagger}$	Mult. §	Comments
786.4 5	7714.6	1.1 7	Q	DCO=0.98 9.
793.4 5	6928.2	2.3 5	Q	DCO=0.90 12.
802.0 5	4329.4	6.5 3	Q	DCO=1.06 13.
834.0 5	5547.0	5.3 3	Q	DCO=1.12 8.
845.8 5	1944.4	6.6 3	D+Q	DCO=0.64 5.
854.7 5	4818.1	4.1 7		
867.4 5	1098.6		D+Q	DCO=0.33 10.
868.8 5	1967.4		Q	DCO=1.05 7.
876.7 5	6423.7	2.1 8	Q	DCO=0.84 6.
891.6 5	1990.2	12.9 1	D+Q	DCO=0.44 6.
953.8 5	4448.8	3.2 6	Q	DCO=0.80 11.
1025.1 5	3078.9	3.1 7		
1071.2 5	1967.4	40.8 2	D+Q	DCO=0.36 9.
				A ₂ =-0.63 6; A ₄ =+0.07 6.
1112.1	1343.3	4.0 15	D	A ₂ =-0.53 20; A ₄ =+0.02 10.
				E γ , I γ : from 1978Gi11.
1112.5 5	3823.2	6.9 6	D+Q	DCO=0.38 4.
1127.8 5	3838.5	24.0 5	D+Q	DCO=0.21 3.
1157.6 5	2053.8	37.9 2	Q	DCO=0.87 10.
				A ₂ =+0.27 4; A ₄ =+0.05 5.
1187.1 5	5516.5	2.5 7		
1211.7 5	6372.4	3.2 6		
1350.0 5	2246.2	4.1 4		
1646.6 5	2542.8	3.8 4	Q	DCO=1.12 13.
1713.2 5	1944.4	3.1 5	Q	DCO=1.89 10.
1720.9 5	2617.1	9.1 3	D+Q	DCO=0.43 8.

† Uncertainty of 0.5 keV for each E γ is assigned based on a general statement in the text of the 2008Xu05 paper.

‡ The evaluators note that uncertainties for some of the intensities are unrealistically low, e.g. 0.3% for 230.1 γ . Although not stated by 2008Xu05, it seems that the quoted uncertainties are only statistical.

§ Assignments are based on DCO ratios. Since the DCO ratios are insensitive to parity assignment, the evaluators assign mult=Q for stretched quadrupoles (E2 assigned in 2008Xu05), and mult=D or D+Q for $\Delta J=1$ transitions (M1+E2 or E1 assigned in 2008Xu05). The assignments in 2008Xu05 implied simply on their J π assignments are not adopted by the evaluators. As indicated in a comment, there is only one $\Delta J=0$ transition at 148.4 keV from 2720 level. All DCO ratios from 2008Xu05.

¹²⁸Te(¹⁶O,5n γ): 2007Ku12 2007Ku12

2007Ku12: E=85 MeV beam provided by 14-UD Pelletron accelerator and Bhabha Atomic Research Centre. Enriched target.

Measured E γ , I γ , $\gamma\gamma(0)$, $\gamma\gamma(0)$ (DCO), $\gamma(\text{lin pol})$ using six Compton-suppressed Clover Ge detectors at angles of 30°,

90°, 130°, 230°, 270° and 330°. An array of 14 NaI(Tl) detectors was used as a multiplicity filter.

¹³⁹Nd Levels

E(level) †	J π	T _{1/2}	Comments
0.0	3/2+		vd _{3/2} orbital.
231.0 ‡ 3	11/2-	5.50 h 20	T _{1/2} : from Adopted Levels.
			%IT=13.0 10.
			vh _{11/2} ⁻¹ ⊗(0+ of e-e core).
896.4 ‡ 4	15/2-		vh _{11/2} ⁻¹ ⊗(first 2+ of e-e core).
1098.9 4	13/2-		vh _{11/2} ⁻¹ ⊗(first 2+ of e-e core).
1944.0 5	15/2(-)		vh _{11/2} ⁻¹ ⊗(second 2+ of e-e core).
1967.4 5	17/2-		vh _{11/2} ⁻¹ ⊗(first 4+ of e-e core).
1990.6 5	15/2-		
2053.8 ‡ 5	19/2-		vh _{11/2} ⁻¹ ⊗(first 4+ of e-e core).
2246.4 5	17/2(-)		
2542.9 6	19/2-		
2571.9 § 5	19/2+		
2616.4 6	17/2		J π : 17/2(-) in figure 1 of 2007Ku12, 17/2 in authors' table I, the latter should be the assignment according to e-mail reply of Aug 8, 2007 from R. Palit.

Continued on next page (footnotes at end of table)

¹²⁸Te(¹⁶O,5nγ): 2007Ku12 2007Ku12 (continued)

¹³⁹Nd Levels (continued)

E(level) [†]	Jπ	Comments
2622.9 [‡] 5	21/2-	vh _{11/2} ⁻¹ ⊗(first 6+ of e-e core).
2712.0 [‡] 5	23/2-	vh _{11/2} ⁻¹ ⊗(first 6+ of e-e core).
2720.9 5	19/2(+)	
2843.4 [§] 5	21/2+	
3076.9 [§] 6	23/2+	
3079.0 6	(21/2)	
3237.9 7	(23/2)	
3300.3 [§] 6	25/2+	
3495.8 7	27/2-	
3531.5 [§] 7	27/2+	
3730.5 7	(25/2)	
3824.2 [‡] 6	25/2-	
3839.6 [#] 6	25/2-	
3967.3 [§] 7	29/2+	
3979.9 [#] 6	27/2-	
4292.5 [#] 7	29/2-	
4333.8 [§] 8	31/2+	
4449.5 9	31/2-	
4715.5 8	(31/2)	Jπ: (29/2) in figure 1 of 2007Ku12, (31/2-) in authors' table I. According to e-mail reply of Aug 8, 2007 from R. Palit Jπ should be (31/2).
4755.5 [#] 8	31/2-	
4803.8 9	(31/2)	
4822.0 9	(31/2+)	
4855.1 9	33/2+	
4912.2 [§] 9	33/2+	
5114.7 9	33/2+	
5165.3 10	(35/2+)	
5289.0 9	33/2-	
5391.5 [#] 9	33/2-	
5520.7 9	(35/2+)	
5549.5 10	(35/2)	Jπ: (31/2) in figure 1 of 2007Ku12, (35/2-) in authors' table I. According to e-mail reply of Aug 8, 2007 from one of the authors, Jπ should be (35/2).
5694.7 [#] 10	35/2-	
6114.6 [#] 10	37/2-	
6377.0 12	(39/2)	Jπ: (39/2) in figure 1 of 2007Ku12, (39/2+) in authors' table I. According to e-mail reply of Aug 8, 2007 from one of the authors, Jπ should be (39/2).
6490.2 [#] 10	39/2-	
7101.9 [#] 12	(41/2)	

[†] From least-squares fit to Eγ data.

[‡] (A): Band built on vh_{11/2}⁻¹. Triaxial rotor plus particle configuration.

[§] (B): π[h_{11/2}²g_{7/2}]²⊗vh_{11/2}.

[#] (C): πh_{11/2}²⊗vh_{11/2}⁻¹. Tentative assignment as a magnetic-dipole rotational band. Crosses π[h_{11/2}²g_{7/2}²]²⊗vh_{11/2} configuration at 33/2-.

γ(¹³⁹Nd)

DCO's obtained with gate on 665.4-keV transition with ΔJ=2, quadrupole, unless noted otherwise.

Eγ [†]	E(level)	Iγ	Mult.	Comments
86.4 5	2053.8	3.1 5	[M1]	
89.0 3	2712.0	14.43 23	D	DCO=0.49 6.
104.5 5	2720.9	5.22 18	D	DCO=0.54 9.
122.5 3	2843.4	16.2 3	D	DCO=0.61 6.
140.3 3	3979.9	16.4 3	D	DCO=0.41 5.
149.0 5	2720.9	8.56 24	D	DCO=0.71 13.
				Mult.: ΔJ=0 transition.
155.7 5	3979.9	6.49 19	D	DCO=0.56 11.
158.9 5	3237.9	4.2 3		
169.2 5	2712.0	2.0 3		
223.4 3	3300.3	40.8 8	D	DCO=0.62 4.
231.0 3	231.0		M4	Mult.: from Adopted Gammas.

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$^{128}\text{Te}(^{16}\text{O},5n\gamma)$: 2007Ku12 2007Ku12 (continued) $\gamma(^{139}\text{Nd})$ (continued)

$E\gamma^\dagger$	E(level)	I_γ	Mult.	Comments
231.2 3	3531.5	35.5 11	D	DCO=0.61 5.
233.6 3	3076.9	43.9 14	D	DCO=0.68 7.
249.4 5	3979.9	2.99 15		
255.8 $\frac{1}{2}$ 5	2246.4	8.50 23	D	DCO=0.85 17.
271.4 3	2843.4	30.7 7	D	DCO=0.71 7.
302.4 5	2246.4	7.26 23		
303.2 5	5694.7	8.3 4	D	DCO=0.61 8.
310.2 5	5165.3	4.9 3		
312.6 3	4292.5	27.7 6	M1	DCO=0.52 5. POL=-0.05 2.
325.5 $\frac{1}{2}$ 5	2571.9	3.42 15	D	DCO=0.96 19.
358.1 5	3079.0	2.88 17		
366.5 3	4333.8	18.8 3	M1	DCO=0.54 8. POL=-0.13 3.
375.6 3	6490.2	10.23 18	(M1)	DCO=0.41 6. POL=-0.02 2.
405.7 5	5694.7	6.17 19	M1	DCO=0.56 11. POL=-0.04 2.
419.9 3	6114.6	11.7 5	D	DCO=0.41 6.
423.0 $\frac{1}{2}$ 5	4715.5	5.40 23	D	DCO=1.15 12.
435.8 3	3967.3	29.2 4	M1	DCO=0.44 4. POL=-0.12 3.
448.4 $\frac{1}{2}$ 5	3979.9	<2		
463.0 5	4755.5	22.1 5	M1	DCO=0.44 7. POL=-0.04 2.
474.5 $\frac{1}{2}$ 3	2720.9	13.72 25	E1	DCO=1.05 14. POL=+0.09 4.
492.7 5	3730.5	2.65 23		
521.3 5	4855.1	9.87 18	M1	DCO=0.64 11. POL=-0.15 6.
533.5 5	5289.0	9.34 23	(M1)	DCO=0.50 5. POL=-0.010 11.
569.0 3	2622.9	31.2 7	M1	DCO=0.42 5. POL=-0.030 16.
578.4 5	4912.2	7.0 3	M1	DCO=0.57 17. POL=-0.19 5.
601.8 $\frac{1}{2}$ 5	3839.6	2.80 19		
604.5 3	2571.9	40.7 11	E1	DCO=0.68 6. POL=+0.07 3.
611.7 5	7101.9	3.5 3		
636.0 3	5391.5	11.4 3	M1	DCO=0.51 8. POL=-0.12 5.
655.4 5	2622.9	3.3 3		
658.3 5	2712.0	4.5 8		
665.4 $\frac{1}{2}$ 3	896.4	100	E2	DCO=2.11 14. POL=+0.14 3.
679.6 5	3979.9	2.0 4		
761.0 $\frac{1}{2}$ 5	4292.5			DCO<2.0.
762.7 5	3839.6	3.0 6		
780.9 5	5114.7	4.1 4		
783.8 5	3495.8	8.16 23	E2	DCO=0.87 16. POL=+0.10 3.
802.3 5	4333.8	6.81 17	E2	DCO=0.87 17. POL=+0.13 5.
834.0 5	5549.5	6.0 6	Q	Initial level energy=4715.6 listed in table I of 2007Ku12 is a misprint according to e-mail reply from one of the authors. DCO=1.3 4.
845.1 5	1944.0	5.9 4		
854.7 5	4822.0	3.91 23		
867.9 $\frac{1}{2}$ 3	1098.9	21.7 4	M1	DCO=0.83 9. POL=-0.06 2.
891.7 $\frac{1}{2}$ 3	1990.6	13.1 3	(M1)	DCO=1.04 13. POL=-0.02 3.

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$^{128}\text{Te}(^{16}\text{O},5n\gamma)$: 2007Ku12 2007Ku12 (continued) $\gamma(^{139}\text{Nd})$ (continued)

$E\gamma^\dagger$	E(level)	I_γ	Mult.	Comments
953.7 5	4449.5	3.9 3	Q	DCO=1.02 18.
1025.2 5	3079.0	3.5 3		
1071.0 3	1967.4	43.5 13	M1	DCO=0.39 4. POL=-0.07 2.
1112.2 5	3824.2	6.65 17	(M1)	DCO=0.49 10. POL=-0.01 2.
1127.6 3	3839.6	15.6 3	M1	DCO=0.37 6. POL=-0.12 7.
1157.4 3	2053.8	38.1 12	E2	DCO=1.10 8. POL=+0.08 3.
1186.9 5	5520.7	2.9 3		
1211.7 5	6377.0	3.17 23		
1308.0 5	4803.8	2.3 4		
1350.0 5	2246.4	4.3 2		
1646.5 5	2542.9	4.4 5	Q	DCO=1.18 8.
1713.0 ‡ 5	1944.0	3.0 3	Q	DCO=2.2 5.
1720.0 5	2616.4	9.6 8	D	DCO=0.48 10.

† Uncertainty assigned as 0.3 keV for $I_\gamma > 10$ and 0.5 keV for $I_\gamma < 10$, based on a general statement by 2007Ku12.

‡ DCO obtained with gate on 233.6-keV transition with $\Delta J=1$, dipole or dipole+quadrupole.

§ DCO obtained with gate on 312.6-keV transition with $\Delta J=1$, dipole or dipole+quadrupole.

$^\#$ Placement of transition in the level scheme is uncertain.

 $^{140}\text{Ce}(\alpha,5n\gamma)$ 1980Mu10,1977Lu04

Includes $^{140}\text{Ce}(^3\text{He},4n\gamma)$ from 1977Lu04.

1980Mu10: $E\alpha=85$ MeV. Measured γ 's, $\gamma\gamma$ -coincidences, $\gamma(\theta)$, and $\gamma(t)$.

1977Lu04: $E(^3\text{He})=38$ and 42 MeV, $E\alpha=45-59$ MeV. Measured excitation functions, γ 's, $\gamma\gamma(\theta)$.

Others: 1977Lu04, 1973HaWA.

All data are from 1980Mu10, except as noted.

 ^{139}Nd Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\ddagger$	Comments
0.0	3/2+ §		
231.15 15	11/2- §	5.50 h 20	$T_{1/2}$: from Adopted Levels.
896.0 3	15/2-		
1343.4 3	(13/2-)		
1966.5 4	(17/2-)		
2053.4 5	19/2-		
2134.8 3			
2570.9 6	(19/2-)		
2570.9+x		≥ 141 ns	
2622.2 3	(21/2)		
2763.8 3			
2802.9 7	(21/2+)		
3024.7 7	(23/2+)		
3253.7 8	(25/2)		
3524.0 8	(27/2)		
3889.8 3	(29/2)		
4037.4 5			

† From 1980Mu10 based on $\gamma(\theta)$ data and the assumption that $(\alpha,5n\gamma)$ primarily populates yrast type states, except as noted.

‡ From off-beam delayed coincidence spectrum of the 665 γ .

§ From the Adopted Levels.

¹⁴⁰Ce(α,5nγ) 1980Mu10,1977Lu04 (continued)

γ(¹³⁹Nd)

205.5γ (Iγ(α,5nγ)=5.5 11, not observed in (³He,4nγ); placement from possible 1102 level not confirmed by later work), 871.6γ (Iγ(α,5nγ)=13 4, Iγ(³He,4nγ)=10 3; placement from 896 level not confirmed by later work), and 1291.0γ (Iγ(α,5nγ)=15 4, Iγ(³He,4nγ)=12 4; placement from 1967 level not confirmed by later work) were observed by 1977Lu04 only.

Eγ	E(level)	Iγ [†]	Mult. [‡]	δ	Comments
(x)	2570.9+x				Off-beam delayed coin spectra of γ's deexciting the 2571 show a weak delayed component.
^x 138.4@ 3		10.7 16			A ₂ =-0.28 8; A ₄ =+0.10 12.
147.6@ 3	4037.4	5.1 8			A ₂ =+0.26 13; A ₄ =-0.03 19.
192.9§@ 3	2763.8	7.0§ 10			A ₂ =-0.04 11; A ₄ =+0.05 17.
221.8# 3	3024.7	42# 5	D		A ₂ =-0.38 7; A ₄ =+0.04 11.
229.0§ 3	3253.7	31§ 60	D		A ₂ =-0.25 10; A ₄ =+0.04 15.
(231.15 15)	231.15		M4		A ₂ =-0.25 10; A ₄ =+0.04 15.
232.0# 3	2802.9	50# 8	D		Eγ,Mult.: from Adopted Gammas.
270.3 3	3524.0	30.0 13	D		A ₂ =-0.27 6; A ₄ =+0.05 9.
^x 311.6§@ 3		6.5§ 65			A ₂ =-0.33 8; A ₄ =+0.06 12.
^x 327.5#@ 3		15# 9			A ₂ =-0.39 7; A ₄ =+0.04 11.
365.8@ 3	3889.8	14.7 18	D		A ₂ =-0.25 7; A ₄ =+0.14 12.
435.5#@ 4	2570.9	8.9 22	D		A ₂ =-0.40 10; A ₄ =+0.07 15.
					A ₂ =-0.48 8; A ₄ =+0.02 12.
					Iγ: corrected for contamination.
^x 520.1@ 3					
568.8@ 3	2622.2	44 5	D		A ₂ =-0.33 7; A ₄ =+0.05 11.
604.4 4	2570.9	40 4	D+Q		A ₂ =-0.24 6; A ₄ =+0.09 9.
622.9 3	1966.5	6.9 10			A ₂ =+0.01 20; A ₄ =-0.10 30.
665.0 3	896.0	100 10	Q		A ₂ =+0.28 4; A ₄ =-0.03 6.
1070.9 4	1966.5	61 6	D(+Q)	<0.0	A ₂ =-0.66 4; A ₄ =+0.02 6.
1112.1 3	1343.4	10.0 12	D+Q		A ₂ =-0.45 16; A ₄ =+0.24 24.
1157.4 3	2053.4	54 7	Q		A ₂ =+0.25 6; A ₄ =-0.04 9.
					Mult.: stretched.
1238.2@ 4	2134.8	10.3 12			A ₂ =+0.47 20; A ₄ =-0.04 30.

[†] From 1980Mu10 renormalized to Iγ(665γ)=100 by evaluators.

[‡] From γ(θ) (theory of 1967Ya05 used for comparison).

§ Unresolved from a line in ¹³⁸Nd.

Contaminated.

@ Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

Adopted Levels, Gammas

Q(β⁻)=-5120 17; S(n)=10630 30; S(p)=2771 18; Q(α)=1010 18 2012Wa38.

S(2n)=19570 19, S(2p)=8877 16 (2012Wa38).

While band structures here are adopted from 2011Zh47, differences between the studies by 2011Zh47 and 2009Dh01 carried out using identical reactions and similar γ-ray counting systems are pointed out as follows:

1. The yrast band reported by 2011Zh47 consisting of E_γs 966.3 - 800.7 - 874.8 - 942.6 - 663.0 - 781.3 - 916.8 is reported in 2009Dh01 as E_γs 967 - 876 - 801 - 663 - 781 - 943 - 1036. In addition, E_γ 1036 keV at the top of the band is not observed by 2011Zh47.
2. The sequence of E_γs 237.8 - 139.0 - 212.0 - 268.6 - 228.0 in 2011Zh47, is observed as 238 - 212 - 138 - 268 - 228 by 2009Dh01.
3. The band number 9 of 2011Zh47 consisting of E_γs 244.3 - 274.4 - 320.2 - 369.5 - 432.4 - 497.0 which was found not connected to any other level of ¹³⁹Pm, was observed to be connected to band number 1 in 2009Dh01.
4. Band 4 of 2011Zh47 of E_γs 104.2 - 329.6 - 316.7 - 473.0 - 533.0 - 657.7 is reported by 2009Dh01 as 104.0 - 329 - 316 - 473 - 454 - 1009 - 533.
5. Band 5 of 2011Zh47 consisting of E_γs: 224.4 - 262.1 - 454.3 - 394.5 - 602.1 - 313.3 has been reported by 2009Dh01 as 262 - 224 - 394 - 313.

¹³⁹Pm Levels

Bands: adopted from 2011Zh47.

Levels 188.7, 654.7, 1405.8, 2352.4 have been assigned the configuration π3/2[541], α=-1/2 in 1987Xu01.

Levels 778.9, 1375.9, 1405.8, 2190.9 have been assigned configuration π3/2[541], α=+1/2 in 1987Xu01.

Cross Reference (XREF) Flags

A ¹³⁹Pm IT Decay (180 ms)

B ¹³⁹Sm ε Decay (2.57 min)

C ¹³⁹Sm ε Decay (10.7 s)

D ¹¹⁶Cd(²⁷Al,4nγ): 1987Xu01

E ¹¹⁶Cd(²⁷Al,4nγ): 2011Zh47

F ¹¹⁶Cd(²⁷Al,4nγ): 2009Dh01

E(level)	Jπ [†]	XREF	T _{1/2} [‡]	Comments
0.0	(5/2)+	ABCDEF	4.15 min 5	%ε+%β ⁺ =100. Jπ: allowed ε decay to 3/2+. 5/2+ from systematics of Z=61, N<86 nuclei. T _{1/2} : from 1977De06 (γ's). Other: 4.0 min 2 (1968Bl14). %IT=100; %ε+%β ⁺ <0.05. Jπ: E3 γ to (5/2)+. T _{1/2} : from 10.7-s ε decay. Upper limit for %ε+%β ⁺ deduced from systematics of log ft values in 1998Si17: for ΔJ=0, Δπ=no, centroid log ft=6.1 with a width of 0.9 for 352 cases of odd-A nuclei. Minimum log ft=4.1 for such transitions gives %ε+%β ⁺ <0.7.
188.7 [§] 3	(11/2)-	A CDEF	180 ms 20	Jπ: ≥5/2 from lack of direct ε feeding from (1/2+). Probably 5/2,7/2 since the level is fed by γ's from other low-spin levels. π=+ from syst of N=78 nuclei.
227.96 12	(5/2+, 7/2+)	B		Jπ: E2(+M1) γ to (5/2)+. log ft=6.4 via 1/2+.
273.73 9	(3/2)+	B		Jπ: E2 γ to (5/2)+. log ft=5.6 via 1/2+.
306.69 9	(1/2, 3/2)+	B		Jπ: M1(+E2) γ to (3/2)+. log ft=6.8 via 1/2+.
462.66 11	(1/2, 3/2)+	B		
589.48 14		B		
596.31 12	(1/2, 3/2)+	B		Jπ: M1, E2 γ to (5/2)+. log ft=6.1 via 1/2+.
654.6 [§] 4	(15/2-)	DEF		
655.30 17		B		
721.36 18	(1/2, 3/2)+	B		Jπ: M1(+E2) γ to (3/2)+. log ft=6.5 via 1/2+.
782.03 9	(1/2, 3/2)+	B		Jπ: M1, E2 γ's to (3/2)+ and (5/2)+. log ft=5.8 via 1/2+.
785.7 [#] 4	(13/2-)	DEF		E(level): level reported at 778.9 keV in 1987Xu01 and 2009Dh01 with reversed ordering of the 590-597 γ cascade.
855.7 4		B		
862.19 18		B		
885.59 23		B		
925.85 18		B		
929.59 17		B		
1015.75 15		B		
1111.4 3		B		
1126.87 22		B		
1183.76 17		B		
1207.4 3		B		
1284.5 [@] 5	(15/2-)	E		
1366.3 3		B		
1376.1 [#] 4	(17/2-)	DEF		

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Adopted Levels, Gammas (continued) ^{139}Pm Levels (continued)

E(level)	$J\pi^{\dagger}$	XREF	Comments
1406.1 $\frac{1}{2}^+$ 4	(19/2-)	DEF	
1441.87 16		B	
1461.59 25		B	
1463.1 3		B	
1502.1 3		B	
1526.65 23		B	
1595.8 4		B	
1666.4 3		B	
1714.0 $\frac{1}{2}^+$ 4	(15/2+)	DEF	
1719.9 4		B	
1896.1 11		F	
1902.9@ 4	(19/2-)	E	
1951.9 $\frac{1}{2}^+$ 4	(17/2+)	DEF	
1981.8 3		B	
2043.7 3		B	
2074.6 4		B	
2090.7 $\frac{1}{2}^+$ 4	(19/2+)	E	Reported as 2163 keV level (19/2+) in 1987Xu01.
2107.7 $\frac{1}{2}^+$ 4	(19/2+)	DEF	
2190.8 $\frac{1}{2}^+$ 4	(21/2-)	DEF	
2210.01 19		B	
2302.6 $\frac{1}{2}^+$ 4	(21/2+)	DEF	
2352.5 $\frac{1}{2}^+$ 4	(23/2-)	DEF	
2518.3 $\frac{1}{2}^+$ 5	(21/2+)	EF	
2571.3 $\frac{1}{2}^+$ 4	(23/2+)	DEF	
2614.7 6		E	
2691.3 $\frac{1}{2}^+$ 4	(23/2+)	DEF	
2768.4@ 5	(23/2-)	EF	
2799.3 $\frac{1}{2}^+$ 5	(25/2+)	DEF	
2964.8 $\frac{1}{2}^+$ 4	(25/2+)	DEF	
3024.5 5		DE	
3158.0 $\frac{1}{2}^+$ 4	(25/2-)	DEF	
3200.2 $\frac{1}{2}^+$ 4	(25/2-)	E	
3236.1 3		B	
3262.4 $\frac{1}{2}^+$ 4	(27/2-)	DEF	
3281.4 $\frac{1}{2}^+$ 4	(27/2+)	DEF	
3307.6 11		F	
3390.6 6		EF	
3417.0 $\frac{1}{2}^+$ 4	(27/2-)	DEF	
3417.0+x		F	
3459.9 6		E	
3488.4 5		E	
3526.5 11		F	
3531.8 6		E	
3559.1 $\frac{1}{2}^+$ 4	(29/2+)	DEF	
3592.0 $\frac{1}{2}^+$ 4	(29/2-)	DEF	
3611.3 7		E	
3679.5 5		F	
3749.5@ 5	(27/2-)	E	
3863.7 5		F	
3908.7 $\frac{1}{2}^+$ 4	(31/2-)	DEF	
3987.0 11		F	
4056.4 $\frac{1}{2}^+$ 5	(31/2+)	EF	Reported as 4155.3 keV (31/2+) in 1987Xu01.
4083.3 6		EF	
4086.0+x		F	
4089.6 5		F	
4224.4 7		E	
4279.6 6		E	
4336.5 4		F	
4381.7 $\frac{1}{2}^+$ 4	(33/2-)	DEF	
4383.3 $\frac{1}{2}^+$ 4	(31/2-)	DEF	
4409.5 4		F	
4418.4 $\frac{1}{2}^+$ 5	(33/2+)	DEF	
4467.5 5		F	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{139}Pm Levels (continued)

E(level)	$J\pi^\dagger$	XREF	Comments
4487.1 5		F	
4503.6 5		E	
4542.3 6		E	
4878.3+x		F	
4914.6& 5	(35/2-)	EF	Reported as 4833.3 keV (35/2-) in 1987Xu01.
4923.2 7		EF	
4932.2 ^b 6	(35/2+)	EF	Reported as 5259.3 in 2009Dh01.
5039.7 5		F	
5092.3 8		E	
5105.9 5		F	
5183.2 ^a 5	(35/2-)	E	Reported as 5258.8 keV (35/2-) in 1987Xu01.
5184.0& 4	(35/2-)	E	
5236.1 6		E	
5248.8 6		EF	
5249.1 7		E	
5306.2 5		F	
5336.9 7		E	
5407.5 ^a 5	(37/2-)	E	
5442.0+x		F	
5505.5 ^c 6	(37/2+)	DEF	
5516.7 5		F	
5572.3& 7	(37/2-)	E	
5635.8 7		E	
5669.6 ^a 6	(39/2-)	E	
5728.2 5		F	
5992.8 12		E	
5996.8 ^b 8	(39/2+)	E	Reported as 5874.8 (39/2+) in 2009Dh01.
6058.8& 4	(39/2-)	DEF	The 874.8 – 800.7 cascade, decaying out of this level was reported in reverse order in 1987Xu01.
6123.9 ^a 7	(41/2-)	E	
6220.3 7		E	
6340.9+x		F	
6518.4 ^a 8	(43/2-)	E	
6704.9 8		EF	
6719.3 8		E	Reported as 6722.9 (43/2-) in 2009Dh01.
7001.4& 4	(43/2-)	E	Reported as 6722.4 (43/2-) in 1987Xu01.
7094.4 6		E	
7120.5 ^a 9	(45/2-)	E	
7433.8 ^a 10	(47/2-)	E	
7664.4& 4	(47/2-)	E	Reported as 7503 keV (47/2-) in 1987Xu01 and 2009Dh01.
8445.7& 5	(51/2-)	DEF	
9177.5 6		EF	
9362.5& 8	(55/2-)	E	Reported as 9480 keV (55/2-) in 1987Xu01 and 2009Dh01.
9481.5 6		F	
9901.0 8		E	
10592		D	1112 keV E_γ , was observed in 1987Xu01 but authors were uncertain.
y ^e	J	E	
244.3+y ^e 5	J+1	E	
518.7+y ^e 6	J+2	E	
838.9+y ^e 7	J+3	E	
1208.4+y ^e 8	J+4	E	
1640.8+y ^e 8	J+5	E	
2137.8+y ^e 9	J+6	E	

[†] For low-spin ($J < 11/2$) states, assignments are from multiplicities deduced from $\epsilon\epsilon$ data in 2.57-min ϵ decay, combined with $\log ft$ values. For high-spin ($J \geq 11/2$) data, the assignments are based on angular correlation (DCO) and angular distribution data (ADO ratios) from mainly ($^{27}\text{Al}, 4n\gamma$) (2011Zh47), combined with band associations.

[‡] From $\gamma(t)$ in ($^{27}\text{Al}, 4n\gamma$), except as noted.

[§] (A): Yrast, $\Delta J=2$ band based on 11/2-. Two sharp band crossings are observed at $\hbar\omega=0.39$ and 0.45 MeV, first corresponding to alignment of $h_{11/2}$ neutron pair and the second due to alignment of $h_{11/2}$ proton pair.

(B): $\Delta J=2$ band based on 13/2-.

@ (C): $\Delta J=2$ band based on 15/2-.

Adopted Levels, Gammas (continued) ^{139}Pm Levels (continued)

& (D): $\Delta J=1$ band based on 25/2-. Possible magnetic-dipole rotational band with tentative configuration $(\pi h_{11/2}) \otimes (\nu h_{11/2})^{-2}$ (2011Zh47).

a (E): $\Delta J=1$ band based on 35/2-. Possible magnetic-dipole rotational band with tentative configuration $(\pi h_{11/2}) \otimes (\nu h_{11/2})^{-4}$ (2011Zh47).

b (F): $\Delta J=2$ band based on 19/2+.

c (G): $\Delta J=2$ band based on 21/2+.

d (H): $\Delta J=1$ band based on 15/2(+).

e (I): γ sequence.

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

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [†]	δ	$\alpha^{\S}$	I(γ +ce)	Comments
188.7	188.7 $\frac{3}{2}^+$	100 $\frac{3}{2}^+$	E3 $\frac{3}{2}^+$		1.494 24		B(E3)(W.u.)=0.27 4.
227.96	228.0 2	100	[M1, E2]		0.143 13		
273.73	273.7 2	100	E2 (+M1)	≥ 0.94	0.078 6		
306.69	33.0 1		(M1)		6.00 10	8.9 12	
	306.7 2	100 7	E2		0.0507		
462.66	188.9 1	100 6	M1 (+E2)	≤ 1.0	0.256 5		
	234.6 3	41 14					
589.48	315.7 2	73 12					
	361.5 3	27 8					
	589.5 2	100 12					
596.31	322.6 3	11.4 23					
	368.4 3	3.6 14					
	596.3 2	100 9	M1, E2		0.010 3		
654.6	465.9 1	100	Q				
655.30	381.4 4	3.0 10					
	427.5 4	5.0 20					
	655.3 2	100 15					
721.36	447.5 2	100	M1 (+E2)	≤ 0.84	0.0243 21		
782.03	319.2 3	9.0 27					
	475.3 2	36 4					
	508.5 3	68 16	M1, E2		0.015 4		
	554.2 3	10.5 21					
	782.0 1	100 16	M1, E2				
785.7	597.0 3	100	D				
855.7	582.0 3	100					
862.19	588.4 4	3.8 19					
	862.2 2	100 12					
885.59	578.9 4	30 10					
	611.7 3	40 15					
	886.0 5	100 20					
925.85	329.5 4	28 11					
	463.1 3	89 22					
	619.2 3	100 22					
	652.2 3	72 22					
929.59	333.4 4	15 5					
	467.0 3	19 5					
	622.9 4	6.3 25					
	655.8 2	100 15					
1015.75	419.7 3	15 4					
	709.0 4	8 3					
	741.9 3	100 14					
	1015.7 2	62 10					
1111.4	648.8 3	100 27					
	837.6 4	27 7					
1126.87	853.1 3	21 5					
	1126.9 3	100 27					
1183.76	587.3 4	6.1 20					
	720.7 4	10 4					
	877.2 3	20 4					
	910.1 2	100 14					
1207.4	744.8 3	100 17					
	933.6 4	67 17					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Pm})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [†]	Comments
1284.5	498.9 5	100		
1366.3	770.0 3	100 20		
	1138.2 4	80 40		
1376.1	590.4 3	23.7 20	Q	
	721.5 1	100 6	D	
1406.1	751.4 1	100	Q	
1441.87	720.4 4	14 5		
	1135.2 2	100 18		
	1168.1 3	86 14		
	1441.9 3	64 18		
1461.59	679.3 4	38 15		
	1188.0 3	100 23		
1463.1	741.4 4	38 13		
	1156.7 4	100 38		
1502.1	1228.3 4	50 17		
	1274.1 3	100 34		
1526.65	930.1 3	100 16		
	1220.2 3	28 8		
1595.8	1322.1 3	100		
1666.4	1359.7 3	39 11		
	1392.6 4	100 22		
1714.0	1059.4 3	100	D	
1719.9	1446.2 4	100		
1896.1	490.0	100		
1902.9	526.8 3	100 7	D	
	618.4 5	43 7	Q	
	1248.1 5	26.2 24		
1951.9	237.8 5	11.4 19	(D)	
	1297.3 1	100 3	D	
1981.8	1392.2 5	3.1 11		
	1675.2 3	100 17		
2043.7	1322.3 4	27 9		
	1770.0 3	100 27		
2074.6	1768.0 4	100 34		
	1800.7 5	23 6		
2090.7	139.0 3	100 12		
	714.6 5	20.7 24		
2107.7	701.6 1	100 4	D	
	731.5 5	10.1 15		
2190.8	784.6 1	95 12	D	
	814.8 1	100 14	Q	
2210.01	1903.2 3	28 7		
	1936.6 5	21 7		
	1982.0 5	12 5		
	2210.0 3	100 14		
2302.6	212.0 1	100 7	(D)	γ transition observed only in 2011Zh47.
	896.0 3	52 4	D	
2352.5	946.5 1	100	Q	
2518.3	1112.2 3	100	(D)	
2571.3	268.6 1	100	D	
2614.7	1208.6 5	100		
2691.3	338.5 5	22.2 15	D	
	583.7 1	100 5	Q	
2768.4	865.4 3	100	Q	
2799.3	228.0 3	100 6	D	
	497.1 2	57 10		γ transition observed only in 1987Xu01.
2964.8	393.3 3	54 8	D	
	446.4 5	22 3	(Q)	
	612.3 1	100 6	D	
	661.8 5	<8.4		
3024.5	225.1			γ transition observed only in 1987Xu01.
	453.2 3			
3158.0	805.7 3	25 4	D	γ transition observed only in 2011Zh47.

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Pm})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [†]	Comments
3158.0	967.1 1	100 5	Q	
3200.2	847.8 5	<48		
	1009.4 3	100 5	Q	
3236.1	2929.0 10	24 12		
	2962.4 3	100 24		
3262.4	62.1 5			γ transition observed only in 2011Zh47.
	104.2 3	22 3	D	
	909.9 1	100 5	Q	
3281.4	590.1 1	100	Q	
3307.6	955.1	100		
3390.6	591.3 3	100		
3417.0	1064.5 1	100	Q	
3459.9	1107.4 5	100		
3488.4	523.5 5	100		
3531.8	732.5 3	100		
3559.1	277.9 5	<6.2		
	594.3 1	100 7	Q	
3592.0	329.6 1	100	D	
3611.3	586.8 5	100		
3679.5	1327.0 3	100		
3749.5	981.0 3	100	Q	
3863.7	601.3 3	100		
3908.7	316.7 1	100 6	D	
	646.2 5	10.3 23	Q	
3987.0	570.0	100		
4056.4	497.4 5	50 5	D	
	567.9 5	20 4		
	775.0 3	100 7	Q	
4083.3	551.4 5	31 3		
	692.7 3	100 11		
4086.0+x	669.0 1	100	(Q)	
4089.6	672.6 3	100		
4224.4	943.0 5	100		
4279.6	687.5 5	100		
4336.5	744.5 1	100		
4381.7	473.0 1	100 4	D	
	790	<12		
4383.3	633.7 3	30.1 24	Q	
	966.3 1	100 5	Q	
4409.5	850.4 2	100 24		
	883.0	<59		
4418.4	859.3 3	100	Q	
4467.5	1050.5 3	100		
4487.1	928.0 3	100		
4503.6	911.6 5			
	1086.7 5	100		
4542.3	1125.3 5	100		
4878.3+x	792.3 2	100		
4914.6	533.0 3	100 11	D	
	1005.6 5	25 2		
4923.2	1014.5 3	100	D	
4932.2	875.8 3	100	Q	
5039.7	658.0 3	100		
5092.3	1009.0 5	100		
5105.9	696.4 1	100		
5183.2	800 1	>69		
	801.6 3	100 11	D	
	903.5 5	15 2		
	1274.3 5	31.5 19	Q	
5184.0	800.7 1	100	Q	
5236.1	854.5 5	100 7		
	1327.4 5	60 33		
5248.8	745.2 5	100		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Pm})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. [‡]	Comments
5249.1	830.7 5	100		
5306.2	922.9 3	100		
5336.9	955.2 5	100		
5407.5	224.4 3	100 12	D	
	492.9 5	12 7		
5442.0+x	563.7 2	100		
5505.5	1087.1 3	100	Q	
5516.7	1608.0 3	100		
5572.3	657.7 5	100	(D)	
5635.8	1254.1 5	100		
5669.6	262.1 3	100	D	
5728.2	622.3 2	100		
5992.8	744 1	100		
5996.8	1064.6 5	100	(Q)	
6058.8	874.8 1	100	Q	
6123.9	454.3 3	100	D	
6220.3	971.5 5	92 25		
	1036 1	100 25		
6340.9+x	898.9 3	100		
6518.4	394.5 3	100	D	
6704.9	1199.4 5	100		
6719.3	1213.8 5	100		
7001.4	781 1	37 3		
	942.6 1	100 7	Q	
7094.4	1035.5 5	100		
7120.5	602.1 5	100	(D)	
7433.8	313.3 5	100	(D)	
7664.4	569.8 5	<11. 2		
	663.0 1	100 6	Q	
8445.7	781.3 3	100	Q	γ from 2011Zh47. In 1987Xu01, this level was shown to depopulate by a 942 γ .
9177.5	731.8 3	100		
9362.5	916.8 5	100	(Q)	
9481.5	1035.8 2	100		
9901.0	723.5 5	100		
244.3+y	244.3 5	100		
518.7+y	274.4 3	100	D	
838.9+y	320.2 3	100	D	
1208.4+y	369.5 3	100	D	
1640.8+y	432.4 3	100	D	
2137.8+y	497.0 3	100	(D)	

[†] For low-spin ($J < 11/2$) levels, values are from 2.57-min ϵ decay. For high-spin ($J \geq 11/2$), values are from ($^{27}\text{Al}, 4\text{n}\gamma$):2011Zh47, which is considered by the evaluators as more reliable as the authors, in response to evaluators' queries, have considered, in detail, differences between their previous publication 2010Zh12 and 2009Dh01, culminating in 2011Zh47 publications with data details sent as private communication to the evaluators.

[‡] From 10.7-s ϵ decay.

[§] Theoretical values from BrIcc code. If $\delta(\text{M2/E1})$ not given, value overlaps those for M1 and E2.

Adopted Levels, Gammas (continued)(A) Yrast, $\Delta J=2$ band based
on 11/2-.(B) $\Delta J=2$ band based on
13/2-(C) $\Delta J=2$ band based on
15/2-(D) $\Delta J=1$ band based on
25/2-. $^{139}_{61}\text{Pm}_{78}$

Adopted Levels, Gammas (continued)(E) $\Delta J=1$ band based on
35/2-.(F) $\Delta J=2$ band based on 19/2+(G) $\Delta J=2$ band based on 21/2+(H) $\Delta J=1$ band based on
15/2(+)

Adopted Levels, Gammas (continued)

(I) γ sequence

$J+6$	$2137.8+\gamma$
$J+5$	$\downarrow 1640.8+\gamma$
$J+4$	$\downarrow 1208.4+\gamma$
$J+3$	$\downarrow 838.9+\gamma$
$J+2$	$\downarrow 518.7+\gamma$
$J+1$	$\downarrow 244.3+\gamma$
J	$\downarrow \gamma$

^{139}Pm IT Decay (180 ms)

Parent ^{139}Pm : $E=188.7\ 3$; $J\pi=(11/2)^-$; $T_{1/2}=180\ \text{ms}\ 20$; %IT decay=100.

^{139}Pm -%IT decay: %IT=100; % ϵ +% β^+ <0.05.

All data are from Adopted Levels, Gammas, except as noted.

 ^{139}Pm Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\dagger$	Comments
0.0	$(5/2)^+$	4.15 min 5	% ϵ +% β^+ =100.
188.7 3	$(11/2)^-$	180 ms 20	%IT=100; % ϵ +% β^+ <0.05.

† From Adopted Levels.

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

E_γ	E(level)	$I_\gamma^{\ddagger\dagger}$	Mult.	α	$I(\gamma+\text{ce})^\ddagger$
188.7 3	188.7	40.1 CA	E3	1.494 24	100

† From $I(\gamma+\text{ce})$ and α .

‡ Absolute intensity per 100 decays.

Decay Scheme

Intensity: $I(\gamma+\text{ce})$ per
100 parent decays
%IT=100

^{139}Sm ϵ Decay (2.57 min) 1982De06

Parent ^{139}Sm : $E=0.0$; $J\pi=1/2^+$; $T_{1/2}=2.57\ \text{min}\ 10$; $Q(\text{g.s.})=5120\ 17$; % ϵ +% β^+ decay=100.

^{139}Sm - $Q(\epsilon)$: From 2012Wa38.

1982De06: measured low-energy E_γ , I_γ , and x rays, $\gamma(t)$, $\gamma\gamma$ -coincidences (Ge(Li),Ge), ce, and $\beta\gamma$ -coincidences (Ge,Ge(Li)).

Others: 1973VaYZ, 1975Va14, 1987BrZQ.

 ^{139}Pm Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\dagger$	Comments
0.0	$(5/2)^+$	4.15 min 5	% ϵ +% β^+ =100.
227.96 12	$(5/2^+, 7/2^+)$		
273.73 9	$(3/2)^+$		
306.69 9	$(1/2, 3/2)^+$		
462.66 11	$(1/2, 3/2)^+$		
589.48 14			
596.31 12	$(1/2, 3/2)^+$		
655.30 17			
721.36 18	$(1/2, 3/2)^+$		
782.03 9	$(1/2, 3/2)^+$		
855.7 4			

Continued on next page (footnotes at end of table)

¹³⁹Sm ε Decay (2.57 min) 1982De06 (continued)

¹³⁹Pm Levels (continued)

E(level)	Jπ [†]	E(level)	Jπ [†]	E(level)	Jπ [†]
862.19 18		1207.4 3		1666.4 3	
885.59 23		1366.3 3		1719.9 4	
925.85 18		1441.87 16		1981.8 3	
929.59 17		1461.59 25		2043.7 3	
1015.75 15		1463.1 3		2074.6 4	
1111.4 3		1502.1 3		2210.01 19	‡
1126.87 22		1526.65 23		3236.1 3	‡
1183.76 17		1595.8 4			

[†] From the Adopted Levels.

[‡] (1/2+,3/2+) suggested by 1982De06 not adopted by evaluators.

β⁺,ε Data

Eε	E(level)	Iβ [‡]	Iε [‡]	Log ft	I(ε+β ⁺) [‡]	Comments
(1884 17)	3236.1	0.022 5	0.75 17	5.7 1	0.77 17	
(2910 17)	2210.01	0.72 9	1.8 2	5.70 6	2.5 3	
(3045 17)	2074.6	0.14 4	0.27 8	6.6 1	0.41 12	
(3076 17)	2043.7	0.18 4	0.33 8	6.5 1	0.51 12	
(3138 17)	1981.8	0.50 9	0.85 15	6.09 8	1.35 23	
(3400 17)	1719.9	0.08 4	0.10 4	7.1 2	0.18 8	
(3454 17)	1666.4	0.43 8	0.48 9	6.42 9	0.91 17	
(3524 17)	1595.8	0.22 5	0.22 6	6.8 1	0.44 11	
(3593 17)	1526.65	0.60 9	0.57 8	6.38 7	1.17 17	
(3618 17)	1502.1	0.17 4	0.16 4	7.0 1	0.33 8	
(3657 17)	1463.1	0.21 6	0.19 6	6.9 1	0.40 12	
(3658 17)	1461.59	0.35 7	0.31 6	6.67 9	0.66 13	
(3678 17)	1441.87	1.14 14	0.98 12	6.17 6	2.12 25	
(3754 17)	1366.3	0.37 10	0.29 7	6.7 1	0.66 17	
(3913 17)	1207.4	0.66 10	0.44 6	6.57 7	1.10 16	
(3936 17)	1183.76	1.5 2	0.94 12	6.24 6	2.4 3	
(3993 17)	1126.87	0.30 7	0.19 4	7.0 1	0.49 11	
(4009 17)	1111.4	0.43 9	0.26 6	6.8 1	0.69 15	
(4104 17)	1015.75	3.2 3	1.7 2	6.02 5	4.9 5	
(4190 17)	929.59	2.7 3	1.4 2	6.13 6	4.1 5	
(4194 17)	925.85	1.3 2	0.64 10	6.47 8	1.9 3	
(4234 17)	885.59	0.84 13	0.40 7	6.68 8	1.24 20	
(4258 17)	862.19	1.36 16	0.65 7	6.48 6	2.01 23	
(4264 17)	855.7	0.22 5	0.11 3	7.3 1	0.33 8	
(4338 17)	782.03	10.7 12	4.7 5	5.63 6	15.4 17	
(4399 17)	721.36	2.09 16	0.87 7	6.38 4	2.96 22	
(4465 17)	655.30	2.8 4	1.1 2	6.29 7	3.9 6	
(4524 17)	596.31	5.0 7	1.9 2	6.07 6	6.9 9	
(4531 17)	589.48	2.8 3	1.0 1	6.33 5	3.8 4	
(4657 17)	462.66	1.0 4	0.35 15	6.8 2	1.4 6	
(4813 [†] 17)	306.69	22.6 14	6.7 4	5.57 4	29.3 18	Measured E(ε)=5120 150.
(4846 17)	273.73	3.9 14	1.1 4	6.4 2	5.0 18	
(4892 [§] 17)	227.96	<0.6	<0.2	>7.2	<0.8	Iβ ⁺ ,Iε,I(ε+β ⁺): upper limit with 90% confidence level has been estimated by evaluators for I(ε+β ⁺)<0.4 (from gamma-ray transition intensity balance).

[†] Other Eβ+=3.6 MeV 3 (1975Va14. βγ-coin; scin,Ge(Li)).

[‡] Absolute intensity per 100 decays.

[§] Existence of this branch is questionable.

^{139}Sm ϵ Decay (2.57 min) 1982De06 (continued) $\gamma(^{139}\text{Pm})$

I_γ normalization: from $\Sigma I_\gamma(1+\alpha)(\text{to g.s.})=100$. $I_{\epsilon+\beta^+}(\text{to g.s.})\leq 1.5\times 10^{-4}$ from $\log ft\geq 11$ for $\Delta J\pi=2$, no. Amount of growth of ^{139}Sm γ 's observed completely accounted for by assuming no feeding of ^{139}Pm g.s. (1982De06); estimated uncertainty=5%.

E_γ	E(level)	I_γ°	Mult.#	δ	$\alpha^\dagger$	$I(\gamma+\text{ce})^\&$	Comments
33.0 1	306.69	$\frac{1}{2}$	(M1) §		6.00 10	7.3 $\frac{1}{2}$ 10	
188.9 1	462.66	7.4 4	M1 (+E2)	≤ 1.0	0.256 5		$\alpha(\text{K})_{\text{exp}}=0.23$ 3.
228.0 2	227.96	8.2 5	[M1, E2]		0.143 13		
234.6 3	462.66	3.0 10					
273.7 2	273.73	100	E2 (+M1)	≥ 0.94	0.078 6		$\alpha(\text{K})_{\text{exp}}=0.063$ 7; K/L=5.4 8.
306.7 2	306.69	78 5	E2		0.0507		$\alpha(\text{K})_{\text{exp}}=0.040$ 5; K/L=5.0 6.
315.7 2	589.48	3.8 6					
319.2 3	782.03	1.7 5					
322.6 3	596.31	2.5 5					
329.5 4	925.85	0.5 2					
333.4 4	929.59	1.2 4					
361.5 3	589.48	1.4 4					
368.4 3	596.31	0.8 3					
381.4 4	655.30	0.3 1					
419.7 3	1015.75	1.1 3					
427.5 4	655.30	0.5 2					
447.5 2	721.36	8.8 5	M1 (+E2)	≤ 0.84	0.0243 21		$\alpha(\text{K})_{\text{exp}}=0.028$ 9.
463.1 3	925.85	1.6 4					
467.0 3	929.59	1.5 4					
475.3 2	782.03	6.8 7					
508.5 3	782.03	13 3	M1, E2		0.015 4		$\alpha(\text{K})_{\text{exp}}=0.015$ 5.
554.2 3	782.03	2.0 4					
578.9 4	885.59	0.6 2					
582.0 3	855.7	0.9 2					
587.3 4	1183.76	0.3 1					
588.4 4	862.19	0.2 1					
589.5 2	589.48	5.2 6					
596.3 2	596.31	22 2	M1, E2		0.010 3		$\alpha(\text{K})_{\text{exp}}=0.010$ 3.
611.7 3	885.59	0.8 3					
619.2 3	925.85	1.8 4					
622.9 4	929.59	0.5 2					
648.8 3	1111.4	1.5 4					
652.2 3	925.85	1.3 4					
655.3 2	655.30	9.9 15					
655.8 2	929.59	7.9 12					
679.3 4	1461.59	0.5 2					
709.0 4	1015.75	0.6 2					
720.4 4	1441.87	0.3 1					
720.7 4	1183.76	0.5 2					
741.4 4	1463.1	0.3 1					
741.9 3	1015.75	7.3 10					
744.8 3	1207.4	1.8 3					
770.0 3	1366.3	1.0 2					
782.0 1	782.03	19 3	M1, E2		0.0053 13		$\alpha(\text{K})_{\text{exp}}=0.0055$ 14.
837.6 4	1111.4	0.4 1					
853.1 3	1126.87	0.23 5					
862.2 2	862.19	5.3 6					
877.2 3	1183.76	1.0 2					
886.0 5	885.59	2.0 4					
910.1 2	1183.76	4.9 7					
930.1 3	1526.65	2.5 4					
933.6 4	1207.4	1.2 3					
1015.7 2	1015.75	4.5 7					
1126.9 3	1126.87	1.1 3					
1135.2 2	1441.87	2.2 4					
1138.2 4	1366.3	0.8 4					
1156.7 4	1463.1	0.8 3					
1168.1 3	1441.87	1.9 3					
1188.0 3	1461.59	1.3 3					
1220.2 3	1526.65	0.7 2					

Continued on next page (footnotes at end of table)

^{139}Sm ϵ Decay (2.57 min) 1982De06 (continued) $\gamma(^{139}\text{Pm})$ (continued)

E_γ	E(level)	$I_\gamma^\oplus$	E_γ	E(level)	$I_\gamma^\oplus$	E_γ	E(level)	$I_\gamma^\oplus$
1228.3 4	1502.1	0.3 1	1441.9 3	1441.87	1.4 4	1936.6 5	2210.01	0.9 3
1274.1 3	1502.1	0.6 2	1446.2 4	1719.9	0.5 2	1982.0 5	2210.01	0.5 2
1322.1 3	1595.8	1.2 3	1675.2 3	1981.8	3.6 6	2210.0 3	2210.01	4.3 6
1322.3 4	2043.7	0.3 1	1768.0 4	2074.6	0.9 3	2929.0 10	3236.1	0.4 2
1359.7 3	1666.4	0.7 2	1770.0 3	2043.7	1.1 3	2962.4 3	3236.1	1.7 4
1392.2 5	1981.8	0.11 4	1800.7 5	2074.6	0.21 5			
1392.6 4	1666.4	1.8 4	1903.2 3	2210.01	1.2 3			

[†] Theoretical values using BrIcc code. If $\delta(E2/M1)$ not given value overlaps those for M1 and E2.

[‡] $I_\gamma=5.4$ 7 given in table I not consistent with $I(\gamma+ce)$ given in figure 6. $I(\gamma+ce)$ is consistent with the discussion of 1982De06 and $\beta\gamma$ -coin which indicates a direct feeding of 274 level.

[§] If γ were E2, I_γ would be too small to be observed since $\alpha(E2)=217$.

[#] From Adopted Gammas.

[@] For absolute intensity per 100 decays, multiply by 0.365 10.

[&] Absolute intensity per 100 decays.

^{139}Sm ϵ Decay (2.57 min) 1982De06 (continued)

Decay Scheme

Intensities: I(γ + ϵ) per 100 parent decays

^{139}Sm ϵ Decay (2.57 min) 1982De06 (continued)

Decay Scheme (continued)

 Intensities: I(γ + ϵ) per 100 parent decays

^{139}Sm ϵ Decay (10.7 s) 1983Al06,1975Va14

Parent ^{139}Sm : $E=457.38\ 23$; $J\pi=11/2^-$; $T_{1/2}=10.7\ \text{s}\ 6$; $Q(\text{g.s.})=5120\ 17$; $\% \epsilon + \% \beta^+$ decay = 6.3 5.

$^{139}\text{Sm}-Q(\epsilon)$: From 2012Wa38.

$^{139}\text{Sm}-\% \epsilon + \% \beta^+$ decay: from $I_\gamma(190.1\gamma(^{139}\text{Sm})+188.7\gamma)=100$ and $I_\gamma(188.7\gamma)/I_\gamma(190.1\gamma)=0.068\ 5$ (1975Va14).

1975Va14 (also 1973VaYZ): measured E_γ and $\gamma(t)$, $\beta\gamma$ -coincidences (scin,Ge(Li)), and ce.

Other: 1987BrZQ.

All data are from 1975Va14, except as noted.

 ^{139}Pm Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\dagger$	Comments
0.0	(5/2)+	4.15 min 5	$\% \epsilon + \% \beta^+ = 100$.
188.7 3	(11/2)-	180 ms 20	$\% \text{IT} = 100$; $\% \epsilon + \% \beta^+ < 0.05$.

† From Adopted Levels.

 β^+, ϵ Data

E_ϵ	E(level)	$I\beta^{+\dagger}$	$I\epsilon^\dagger$	Log ft	$I(\epsilon + \beta^+)^\dagger$	Comments
(5389 17)	188.7	5.3 4	1.0 1	5.32 6	6.3 5	E_ϵ : 5760 180 from $E_{\beta^+}=4740+180-130$ (1983Al06, Ge(HP), Ge(Li)). $I(\epsilon + \beta^+)$: estimated from observation that no γ 's other than the 189 γ were observed. Feeding of 189 level by possible unknown higher levels estimated to be less than one-half of the β -decay of 10.7-s ϵ decay because no other γ 's than 189 γ observed in 10.7-s ϵ decay.

† For intensity per 100 decays, multiply by 1.00 8.

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

E_γ	E(level)	$I_\gamma^\dagger$	Mult.	α	$I(\gamma + \text{ce})^\dagger$	Comments
188.7 3	188.7	40.1	E3	1.494 24	100	I_γ : from $I(\gamma + \text{ce})=100$ and $\alpha=1.494$. Mult.: from $K/L=1.02\ 7$.

† For absolute intensity per 100 decays, multiply by 0.063 5.

Decay Scheme

$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2011Zh47 2011Zh47,2011ZhZU

2011Zh47 (also 2010Zh12): E=120 MeV; Measured $E\gamma$, $I\gamma$, DCO, $\gamma\gamma$ -coin using 12 Compton suppressed Ge detectors at the HI-13 accelerator. Deduced levels, J, π , possible magnetic dipole rotational band.

2011ZhZU: priv. comm. from N.T. Zhang, first author of 2011Zh47 in response to query by B. Singh.

 ^{139}Pm Levels

E(level) [†]	J π [§]	T _{1/2}	Comments
0.0 [‡]	(5/2+) [‡]		
188.7 [‡] # 3	11/2- [‡]	180 ms 20	%IT=100; %e+% β^+ <0.05. T _{1/2} and decay mode from Adopted Levels.
654.6# 4	15/2-		
785.7@ 4	13/2-		
1284.5& 5	15/2-		
1376.1@ 4	17/2-		
1406.1# 4	19/2-		
1714.0 ^e 4	15/2(+)		
1902.9& 4	19/2-		
1951.9 ^e 4	17/2(+)		
2090.8 ^e 4	19/2(+)		
2107.6 ^c 4	19/2+		
2190.8@ 4	21/2-		
2302.8 ^e 4	21/2(+)		
2352.5# 4	23/2-		
2518.3 ^d 5	21/2+		
2571.4 ^e 4	23/2(+)		
2614.7 6			
2691.3 ^c 4	23/2+		
2768.4& 5	23/2-		
2799.4 ^e 5	25/2(+)		
2964.8 ^d 4	25/2+		
3024.6 5			
3157.9 ^a 4	25/2-		
3200.2@ 4	25/2-		
3262.4 ^a 4	27/2-		
3281.4 ^c 4	27/2+		
3390.7 6			
3417.0# 4	27/2-		
3459.9 6			
3488.4 5			
3531.9 6			
3559.1 ^d 4	29/2+		
3592.0 ^a 4	29/2-		
3611.4 7			
3749.5& 5	27/2-		
3908.7 ^a 4	31/2-		
4056.4 ^c 5	31/2+		
4083.4 6			
4224.4 7			
4279.6 6			
4381.7 ^a 4	33/2-		
4383.3# 4	31/2-		
4418.4 ^d 5	33/2+		
4503.6 5			
4542.3 6			
4914.6 ^a 5	35/2-		
4923.2 5			
4932.2 ^c 6	35/2+		
5092.4 8			
5183.2 ^b 5	35/2-		
5184.0# 4	35/2-		
5236.1 6			
5248.8 7			
5249.1 7			
5336.9 7			
5407.5 ^b 5	37/2-		
5505.5 ^d 6	37/2+		

Continued on next page (footnotes at end of table)

¹¹⁶Cd(²⁷Al,4n γ): 2011Zh47 2011Zh47,2011ZhZU (continued)

¹³⁹Pm Levels (continued)

E(level) [†]	J π [§]	E(level) [†]	J π [§]	E(level) [†]	J π [§]
5572.3 ^a 7	(37/2-)	6704.9 8		9362.5 [#] 8	(55/2-)
5635.8 7		6719.3 8		9901.0 8	
5669.6 ^b 6	39/2-	7001.4 [#] 4	43/2-	0+x ^f	
5992.8 13		7094.4 6		244.3+x ^f 5	
5996.8 ^c 8	(39/2+)	7120.5 ^b 9	(45/2-)	518.7+x ^f 6	
6058.8 [#] 4	39/2-	7433.8 ^b 10	(47/2-)	838.9+x ^f 7	
6123.9 ^b 7	41/2-	7664.4 [#] 5	47/2-	1208.4+x ^f 8	
6220.2 8		8445.7 [#] 5	51/2-	1640.8+x ^f 8	
6518.4 ^b 8	43/2-	9177.5 6		2137.8+x ^f 9	

[†] From least-squares fit to E γ data.

[‡] From Adopted Levels.

[§] As proposed in 2011Zh47 from yrast population, $\gamma\gamma(\theta)$ (DCO) measurements, and band structures.

[#] (A): Yrast, $\Delta J=2$ band based on 11/2-. Two sharp band crossings are observed at $\hbar\omega=0.39$ and 0.45 MeV, first corresponding to alignment of $h_{11/2}$ neutron pair and the second due to alignment of $h_{11/2}$ proton pair.

@ (B): $\Delta J=2$ band based on 13/2-.

& (C): $\Delta J=2$ band based on 15/2-.

a (D): $\Delta J=1$ band based on 25/2-. Possible magnetic-dipole rotational band with tentative configuration $(\pi h_{11/2})\otimes(vh_{11/2})^{-2}$ (2011Zh47).

b (E): $\Delta J=1$ band based on 35/2-. Possible magnetic-dipole rotational band with tentative configuration $(\pi h_{11/2})\otimes(vh_{11/2})^{-4}$ (2011Zh47).

c (F): $\Delta J=2$ band based on 19/2+.

d (G): $\Delta J=2$ band based on 21/2+.

e (H): $\Delta J=1$ band based on 15/2(+).

f (I): γ sequence.

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

DCO(Q) and DCO(D) indicate gate on $\Delta J=2$, quadrupole and $\Delta J=1$, dipole, respectively. All DCO and R(ADO) values are from 2011ZhZU Expected DCO values are 1.0 for $\Delta J=2$, quadrupole and 0.6 for $\Delta J=1$, dipole, respectively, for gate on $\Delta J=2$, quadrupole. If the gate is on $\Delta J=1$, dipole, then expected DCO is 1.5 for $\Delta J=2$, quadrupole and 0.9 for $\Delta J=1$, dipole.

E γ [†]	E(level)	I γ [†]	Mult. [‡]	Comments
62.1 5	3262.4			
104.2 3	3262.4	5.2 8		
139.0 3	2090.8	8.2 10		
188.7 3	188.7		E3	E γ ,Mult.: from Adopted Gammas.
212.0 1	2302.8	19.0 14	(D)	DCO(Q)=0.77 5.
				R(ADO)=1.04 9.
224.4 3	5407.5	6.9 8	D	DCO(D)=1.12 16.
				R(ADO)=0.98 10.
228.0 3	2799.4	8.5 10	D	DCO(Q)=0.72 3.
				R(ADO)=0.98 6.
237.8 5	1951.9	2.4 6		R(ADO)=1.14 19.
244.3 5	244.3+x	<2.2		
262.1 3	5669.6	8.2 9	D	DCO(D)=1.08 18.
				R(ADO)=0.85 4.
268.6 1	2571.4	22.0 24	D	DCO(Q)=0.67 8.
				R(ADO)=0.84 7.
274.4 3	518.7+x	4.4 10	D	DCO(Q)=0.62 5.
				R(ADO)=0.62 10.
277.9 5	3559.1	<1.0		
^x 288.0 5		2.4 3		
313.3 5	7433.8	2.2 6	(D)	DCO(D)=0.81 10.
				R(ADO)=0.82 8.
316.7 1	3908.7	20.6 21	D	DCO(Q)=0.61 5.
				R(ADO)=0.85 10.
320.2 3	838.9+x	5.4 10	D	DCO(Q)=0.61 12.
				R(ADO)=0.61 13.
329.6 1	3592.0	36.4 32	D	DCO(Q)=0.61 3.
				R(ADO)=0.82 4.

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$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2011Zh47 2011Zh47,2011ZhZU (continued) $\gamma(^{139}\text{Pm})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. ‡	Comments
$^x333.1\ 5$		0.6 1		
338.5 5	2691.3	2.9 2	D	Mult.: $\Delta J=0$ transition. DCO(Q)=0.86 13. R(ADO)=1.90 34.
$^x360.4\ 3$		3.5 6	D	DCO(Q)=0.45 6. R(ADO)=0.87 12.
369.5 3	1208.4+x	5.0 8	D	DCO(Q)=0.51 11. R(ADO)=0.98 8.
393.3 3	2964.8	6.0 6	D	DCO(D)=0.77 8. R(ADO)=0.96 9.
394.5 3	6518.4	3.7 4	D	DCO(D)=0.80 18. R(ADO)=0.79 14.
$^x401.2\ 5$		1.2 1		R(ADO)=0.91 16.
432.4 3	1640.8+x	5.2 5	D	DCO(Q)=0.50 7. R(ADO)=0.78 10.
446.4 5	2964.8	2.9 4	(Q)	DCO(Q)=0.85 28. R(ADO)=1.8 6.
453.2 3	3024.6	5.0 9		DCO(D)=0.68 10. R(ADO)=0.67 9.
454.3 3	6123.9	4.8 8	D	DCO(D)=0.98 14. R(ADO)=0.61 11.
465.9 1	654.6	157 9	Q	DCO(Q)=1.05 17. R(ADO)=1.81 9.
473.0 1	4381.7	14.3 10	D	DCO(Q)=0.47 4. R(ADO)=0.62 5.
492.9 5	5407.5	0.8 5		
497.0 3	2137.8+x	3.6 2	(D)	R(ADO)=0.67 26.
497.4 5	4056.4	2.8 3	D	DCO(Q)=0.56 11. R(ADO)=0.45 12.
498.9 5	1284.5	1.5 2		
523.5 5	3488.4	2.2 2		
526.8 3	1902.9	4.2 3	D	R(ADO)=0.52 9.
533.0 3	4914.6	4.8 5	D	DCO(Q)=0.62 14. R(ADO)=0.69 10.
551.4 5	4083.4	1.1 1		
$^x563.8\ 5$		2.4 2		
567.9 5	4056.4	1.1 2		
569.8 5	7664.4	<1.4		
583.7 1	2691.3	13.1 12	Q	DCO(Q)=1.06 17. R(ADO)=1.58 13.
586.8 5	3611.4	1.0 2		
590.1 1	3281.4	12.0 6	Q	DCO(Q)=1.07 7. R(ADO)=1.66 10.
590.4 3	1376.1	4.6 4	Q	DCO(Q)=1.04 15. R(ADO)=1.34 27.
591.3 3	3390.7	3.9 3		R(ADO)=1.16 14.
594.3 1	3559.1	16.2 12	Q	DCO(Q)=0.97 6. R(ADO)=1.58 7.
597.0 3	785.7	5.2 4	D	DCO(Q)=0.54 8. R(ADO)=0.73 14.
602.1 5	7120.5	<2.6	(D)	DCO(D)=0.93 42. R(ADO)=0.83 23.
612.3 1	2964.8	13.1 8	D	DCO(Q)=0.58 4. R(ADO)=0.78 5.
618.4 5	1902.9	1.8 3	Q	R(ADO)=1.44 43.
$^x622.3\ 5$		2.9 2		
633.7 3	4383.3	3.8 3	Q	DCO(Q)=0.87 22. R(ADO)=1.31 27.
646.2 5	3908.7	1.9 4	Q	R(ADO)=1.31 30.
657.7 5	5572.3	1.5 2	(D)	R(ADO)=0.70 21.
661.8 5	2964.8	<1.1		
663.0 1	7664.4	12.5 7	Q	DCO(Q)=0.91 9. R(ADO)=1.42 23.

Continued on next page (footnotes at end of table)

$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2011Zh47 2011Zh47,2011ZhZU (continued) $\gamma(^{139}\text{Pm})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. ‡	Comments
$^{\times}668.8\ 3$		$3.4\ 3$		
$687.5\ 5$	4279.6	<3.0		DCO(D)=0.97 20. R(ADO)=0.62 10. R(ADO)=1.62 29.
$692.7\ 3$	4083.4	$3.6\ 4$		
$^{\times}695.8\ 3$		$3.3\ 2$		
$701.6\ 1$	2107.6	$13.0\ 7$	D	Mult.: $\Delta J=0$ transition. DCO(Q)=1.07 6. R(ADO)=1.67 23.
$^{\times}705.8\ 5$		<3.0		
$714.6\ 5$	2090.8	$1.7\ 2$		
$721.5\ 1$	1376.1	$19.4\ 10$	D	DCO(Q)=0.42 6. R(ADO)=0.41 4.
$^{\times}723.5\ 5$		<1.9		
$723.5\ 5$	9901.0	<1.9		
$731.5\ 5$	2107.6	$1.4\ 2$		
$731.8\ 3$	9177.5	$3.1\ 4$		R(ADO)=0.61 2.
$732.5\ 3$	3531.9	$4.7\ 4$		R(ADO)=1.13 17.
$744\ 1$	5992.8	<2.1		
$745.2\ 5$	5248.8	<2.1		
$751.4\ 1$	1406.1	100.0	Q	DCO(Q)=0.93 3. R(ADO)=1.50 5. DCO(Q)=0.94 11. R(ADO)=1.25 20.
$775.0\ 3$	4056.4	$5.6\ 4$	Q	
$781\ 1$	7001.4	$4.3\ 4$		
$781.3\ 3$	8445.7	$7.6\ 4$	Q	DCO(Q)=1.03 9. R(ADO)=1.54 14.
$784.6\ 1$	2190.8	$11.4\ 7$	D	DCO(Q)=0.44 6. R(ADO)=0.47 4.
790	4381.7			
$^{\times}792.8\ 3$		$3.2\ 2$		
$800\ 1$	5183.2	>3.7		
$800.7\ 1$	5184.0	<14.9	Q	DCO(Q)=1.03 5. R(ADO)=1.62 14. DCO(D)=0.85 17. R(ADO)=0.78 5. DCO(Q)=0.44 14. R(ADO)=0.51 6. DCO(Q)=0.90 15. R(ADO)=1.54 21.
$801.6\ 3$	5183.2	$5.4\ 6$	D	
$805.7\ 3$	3157.9	$3.3\ 5$	D	
$814.8\ 1$	2190.8	$12.1\ 5$	Q	
$830.7\ 5$	5249.1	$1.5\ 2$		
$847.8\ 5$	3200.2	<3.7		
$^{\times}850.3\ 5$		$2.0\ 1$		
$854.5\ 5$	5236.1	$1.5\ 1$		
$859.3\ 3$	4418.4	$8.6\ 6$	Q	DCO(Q)=1.00 11. R(ADO)=1.48 18. DCO(Q)=1.10 17. R(ADO)=1.48 29. DCO(Q)=1.04 12. R(ADO)=1.43 15. DCO(Q)=1.14 25. R(ADO)=1.37 13.
$865.4\ 3$	2768.4	$5.5\ 5$	Q	
$874.8\ 1$	6058.8	$14.5\ 8$	Q	
$875.8\ 3$	4932.2	$4.0\ 3$	Q	
$^{\times}881.3\ 5$		$2.9\ 2$		
$896.6\ 3$	2302.8	$9.6\ 6$	D	DCO(Q)=0.52 10. R(ADO)=0.81 14.
$^{\times}897.7\ 5$		<1.2		
$903.5\ 5$	5183.2	$0.8\ 1$		
$909.9\ 1$	3262.4	$23.6\ 12$	Q	DCO(Q)=0.87 9. R(ADO)=1.26 14.
$911.6\ 5$	4503.6			
$916.8\ 5$	9362.5	$2.4\ 3$	(Q)	R(ADO)=1.69 31.
$942.6\ 1$	7001.4	$11.5\ 7$	Q	DCO(Q)=0.87 8. R(ADO)=1.44 17.
$943.0\ 5$	4224.4	$1.5\ 3$		

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$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2011Zh47 2011Zh47,2011ZhZU (continued) $\gamma(^{139}\text{Pm})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. ‡	Comments
946.5 1	2352.5	65.7 23	Q	DCO(Q)=0.93 4. R(ADO)=1.40 15.
955.2 5	5336.9	1.0 1		
966.3 1	4383.3	12.6 6	Q	DCO(Q)=0.95 8. R(ADO)=1.51 13.
967.1 1	3157.9	13.9 7	Q	DCO(Q)=0.90 9. R(ADO)=1.51 15.
971.5 § 5	6220.2	1.1 3		
981.0 3	3749.5	4.1 3	Q	R(ADO)=1.54 23.
1005.6 5	4914.6	1.2 1		
1009.0 5	5092.4	2.4 2		
1009.4 3	3200.2	7.6 4	Q	DCO(Q)=0.92 8. R(ADO)=1.28 11.
1014.5 3	4923.2	3.1 3	D	DCO(Q)=0.56 8. R(ADO)=0.52 8.
1035.5 5	7094.4	1.4 2		
1036 1	6220.2	1.2 3		
1059.4 3	1714.0	3.6 2	D	R(ADO)=1.58 24. Mult.: $\Delta J=0$ transition.
1064.5 1	3417.0	18.8 8	Q	DCO(Q)=0.96 6. R(ADO)=1.40 12.
1064.6 5	5996.8	1.4 2	(Q)	R(ADO)=1.30 16.
^x 1082.8 5		1.0 1		
1086.7 5	4503.6	0.6 1		
1087.1 3	5505.5	3.9 1	Q	DCO(Q)=0.82 15. R(ADO)=1.11 15.
1107.4 5	3459.9	1.4 2		
1112.2 3	2518.3	4.1 3	(D)	R(ADO)=0.81 10.
1125.3 5	4542.3	0.7 1		
1199.4 5	6704.9			
1208.6 5	2614.7	1.6 1		
1213.8 5	6719.3			
1248.1 5	1902.9	1.1 1		
1254.1 5	5635.8			
1274.3 5	5183.2	1.7 1	Q	R(ADO)=1.50 10.
1297.3 1	1951.9	25.7 11	D	DCO(Q)=0.63 3. R(ADO)=0.72 5.
1327.4 5	5236.1	0.9 5		

† From 2011ZhZU, where the energy uncertainty was stated to be within 0.5 keV. The evaluators assign 0.1 keV for $I\gamma>10$, 0.3 for $I\gamma=3-10$ and 0.5 keV for $I\gamma<3$ as well as when $I\gamma$ not given. Uncertainty of 1 keV is assigned when $E\gamma$ is stated to the nearest keV.

‡ Assigned by the evaluators based on DCO and ADO data. Mult=Q indicates $\Delta J=2$, quadrupole (most likely E2) and mult=D indicates $\Delta J=1$, dipole transition.

§ Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2009Dh01 2009Dh01

E=120 MeV; measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin, $\gamma\gamma(\theta)(\text{DCO})$ using Gamma Detector Array consisting of twelve 23% Compton-suppressed n-type HPGe detectors and a multiplicity filter consisting of 14 hexagonal BGO detectors. Comparison with tilted axis cranked calculations.

 ^{139}Pm Levels

E(level) [†]	J π [§]	T _{1/2}	Comments
0.0 [‡]	(5/2+) [‡]		
188.7 ^{‡b} 3	11/2- [‡]	180 ms 20	%IT=100; % ϵ +% β^+ <0.05. T _{1/2} and decay mode from Adopted Levels.
654.6 ^b 4	15/2-		
779.3 ^c 4	13/2-		
1376.2 ^c 4	17/2-		
1405.9 ^b 4	19/2-		
1714.4 [@] 4	15/2(+)		
1895.9 11			
1952.3 [@] 4	17/2(+)		
2107.5 ^a 4	19/2+		
2164.1 [@] 4	19/2(+)		
2190.9 ^c 4	21/2-		
2242.0 4			
2302.6 [@] 4	21/2(+)		
2352.4 ^b 4	23/2-		
2518.4 4	21/2+		
2571.1 [@] 4	23/2(+)		
2691.2 ^a 4	23/2+		
2768.7 5			
2799.0 [@] 4	25/2(+)		
2964.7 ^{&} 4	25/2+		
3119.1 [@] 4	27/2(+)		
3158.1 ^c 4	25/2-		
3262.0 ^f 4	27/2-		
3281.3 ^a 4	27/2+		
3307.5 11			
3367.5 5			
3393.5 [@] 4	29/2(+)		
3402.6 5			
3416.9 ^b 4	27/2-		
3416.9+x ^e			
3491.8 4			
3526.0 ^d 11			
3558.6 ^{&} 4	29/2+		
3591.5 ^f 4	29/2-		
3679.4 5			
3763.0 [@] 5	31/2(+)		
3863.3 5			
3908.0 ^f 4	31/2-		
3986.9 11			
4056.4 ^a 4	31/2+		
4082.3 4			
4085.94+x ^e 10			
4089.5 5			
4123.2 [@] 5	33/2(+)		
4336.0 4			
4380.7 ^f 4	33/2-		
4383.8 ^b 4	31/2-		
4409.0 ^d 4			
4417.9 ^{&} 4	33/2+		
4467.4 5			
4486.6 5			
4555.9 [@] 5	35/2(+)		
4834.4 ^f 4	35/2-		
4878.24+x ^e 23			
4922.9 4			
4932.0 ^a 4	35/2+		
4956.6 [@] 6	37/2(+)		

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¹¹⁶Cd(²⁷Al,4n γ): 2009Dh01 2009Dh01 (continued)

¹³⁹Pm Levels (continued)

E(level) [†]	J π [§]	E(level) [†]	J π [§]	E(level) [†]	J π [§]
5038.7 5		5727.7 ^d 5		6704.6 ^{&} 5	(41/2+)
5105.4 ^d 5		5843.7 ^f 4	(37/2-)	6722.9 ^b 4	43/2-
5162.0 11		5874.8 ^a 5	(39/2+)	6724.9 ^d 5	
5248.8 5		5943.5 ^g 4	41/2(-)	6875.2 ^g 5	47/2(-)
5259.4 ^b 4	35/2-	5971.8 4		6939.1 ^a 6	(43/2+)
5283.9 5		6060.1 ^b 4	39/2-	7504.2 ^b 4	47/2-
5306.7 5		6109.2 5		7918.6 ^{&} 11	(45/2+)
5441.9+x ^e 3		6167.6 ^g 5	43/2(-)	8447.0 ^b 5	51/2-
5505.6 ^{&} 5	37/2+	6340.8+x ^e 5		9179.1 [#] 5	
5516.0 5		6376.6 ^f 5	(39/2-)	9363.4 [#] 6	
5681.6 ^g 4	39/2(-)	6561.8 ^g 5	45/2(-)	9482.8 ^b 5	55/2-

[†] From least-squares fit to E γ data. Reduced $\chi^2=2.9$ as compared to critical $\chi^2=2.0$.

[‡] From Adopted Levels, as also the decay modes for the 180-ms isomer.

[§] As proposed in 2009Dh01 based on yrast population of levels, $\gamma\gamma(\theta)$ (DCO) measurements, and band associations.

[#] Level connected with yrast band based on 11/2- isomer.

@ (A): 3-qp, $\Delta J=1$ band based on 15/2(+). Possible Configuration= $\pi h_{11/2} \otimes \nu s_{1/2} \otimes \nu h_{11/2}$ or $\pi h_{11/2} \otimes \nu d_{3/2} \otimes \nu h_{11/2}$.

& (B): 3-qp $\Delta J=2$ band based on 25/2+. Possible configuration= $\pi g_{7/2} \otimes \pi h_{11/2}^2$ or $\pi d_{5/2} \otimes \pi h_{11/2}^2$.

a (C): 3-qp $\Delta J=2$ band based on 19/2+. Possible configuration= $\pi g_{7/2} \otimes \pi h_{11/2}^2$ or $\pi d_{5/2} \otimes \pi h_{11/2}^2$.

b (D): Yrast band based on 11/2- isomer.

c (E): Band based on 13/2-.

d (F): γ cascade-1.

e (G): γ cascade-2.

f (H): Magnetic-dipole rotational band-1. Probable configuration= $\pi h_{11/2} \otimes \nu h_{11/2}^{-2}$.

g (I): Magnetic-dipole rotational band-2. Probable configuration= $\pi h_{11/2}^3 \otimes \nu h_{11/2}^{-2}$.

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

DCO ratios are for 153°-99° geometry and gates are on $\Delta J=2$, quadrupole transitions, unless otherwise indicated.

E γ	E(level)	I γ	Mult. [†]	Comments
103.8 1	3262.0	3.1 4	D	DCO=0.9 3. DCO for $\Delta J=1$, dipole gate.
138.5 1	2302.6	8.9 2	D	DCO=0.55 10.
188.7 3	188.7		E3	E γ , Mult.: from Adopted Gammas.
211.8 1	2164.1	13.2 6	D	DCO=0.61 11.
224.1 1	6167.6	4.2 3	D	DCO=1.25 21. DCO for $\Delta J=1$, dipole gate.
227.8 1	2799.0	4.9 3	(D)	DCO=0.7 3.
237.8 1	1952.3	1.9 3	(D)	DCO=0.7 4.
261.9 1	5943.5	4.7 6	D	DCO=1.2 3. DCO for $\Delta J=1$, dipole gate.
268.4 1	2571.1	14.1 9	D	DCO=0.62 9.
274.4 1	3393.5	3.7 4	D	DCO=0.45 25.
313.4 1	6875.2	1.4 2	(D)	DCO=0.6 3.
316.5 1	3908.0	12.7 8	D	DCO=1.10 9. DCO for $\Delta J=1$, dipole gate.
320.1 1	3119.1	4.8 3	(D)	DCO=0.6 3.
329.4 1	3591.5	18.5 9	D	DCO=0.45 5.
338.5 2	2691.2	1.9 7		
360.2 2	4123.2	2.9 5	D	DCO=0.4 3.
369.4 2	3763.0	3.5 6	(D)	DCO=0.5 4.
388.7 1	2691.2	2.4 3		
393.7 1	2964.7	5.3 4	(D)	DCO=0.7 3.
394.2 1	6561.8	1.6 3	D	DCO=0.67 21.
400.7 2	4956.6	1.0 6	(D)	DCO=0.7 4.
402.8 3	3367.5	0.9 5		
432.7 2	4555.9	2.5 9	D	DCO=0.5 3.
446.2 1	2964.7	1.7 6	(Q)	DCO=1.0 6.
453.7 1	4834.4	4.8 6	D	DCO=1.1 3. DCO for $\Delta J=1$, dipole gate.
465.9 1	654.6	100	Q	DCO=0.96 6.

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$^{116}\text{Cd}(^{27}\text{Al},4n\gamma): 2009\text{Dh01} \quad 2009\text{Dh01 (continued)}$ $\gamma(^{139}\text{Pm})$ (continued)

E_γ	E(level)	I_γ	Mult. [†]	Comments
472.7 1	4380.7	8.3 3	D	DCO=0.85 12. DCO for $\Delta J=1$, dipole gate.
490.0	1895.9	<1.0		
497.1 2	2799.0	2.8 5		E_γ : poor fit, level energy difference=496.4.
526.7 2	2768.7	3.2 8		
532.9 2	6376.6	2.9 7	(D)	DCO=0.8 5.
563.7 2	5441.9+x	2.7 5		
570.0	3986.9	<1.0		
583.7 1	2691.2	7.3 4	(Q)	DCO=1.1 4.
590.1 1	3281.3	8.0 3	Q	DCO=1.1 3.
590.5 $\frac{1}{2}$ 2	779.3	1.6 $\frac{1}{2}$ 3		
	4082.3	1.6 $\frac{1}{2}$ 3		
593.9 1	3558.6	11.4 4	Q	DCO=1.17 12.
596.8 2	1376.2	1.4 3		
601.3 3	3863.3	2.2 9		
612.2 1	2964.7	8.6 8	D	DCO=0.6 3. DCO for $\Delta J=1$, dipole gate.
622.3 2	5727.7	2.0 4		
633.9 1	3402.6	2.5 6		
646.2 2	3908.0	1.9 5		
658.0 3	5038.7	0.9 4		
662.8 1	6722.9	7.1 5	(Q)	DCO=0.8 3.
669.0 1	4085.94+x	4.4 6	(Q)	DCO=0.9 5.
672.6 3	4089.5	1.9 8		
687.9# 2	5971.8	0.8 1		
692.7 1	3491.8	3.4 4		
696.4 1	5105.4	2.7 5		
701.6 1	2107.5	7.4 6	(D)	DCO=0.9 4.
721.7 1	1376.2	13.8 9	D	DCO=0.45 12.
732.1 1	9179.1	2.2 1	(Q)	DCO=0.8 5.
744.5 1	4336.0	2.3 4		
751.3 1	1405.9	65.4 8	Q	DCO=1.02 6.
775.1 1	4056.4	3.6 5		
781.3 1	7504.2	7.8 6	(Q)	DCO=0.9 4.
784.7 1	2190.9	7.4 5	D	DCO=0.68 24.
789.0	4380.7	<1.0		
792.3 2	4878.24+x	3.0 7		
800.7 1	6060.1	11.5 8	Q	DCO=1.2 4.
805.8 2	3158.1	1.8 6		
814.8 1	2190.9	7.0 9	(Q)	DCO=0.9 3.
830.9 3	5248.8	0.6 3		
847.2 1	5681.6	3.7 5	Q	DCO=1.1 4.
850.4 2	4409.0	1.7 4		
859.3 1	4417.9	7.3 3	Q	DCO=1.30 24.
865.8 2	2242.0	3.8 8		
875.6 1	4932.0	2.4 2		
	5259.4	8.7 4	(Q)	DCO=1.0 4.
883.0	4409.0	<1.0		
896.9 1	2302.6	5.6 9		
898.9 3	6340.8+x	0.9 6		
903.2 2	5283.9	1.4 6		
909.8 1	3262.0	16.7 9	Q	DCO=1.04 14.
916.4 3	9363.4	1.6 8		
922.9 3	5306.7	2.2 8		
928.0 3	4486.6	1.9 7		
942.8 $\frac{1}{2}$ 2	5874.8	1.7 $\frac{1}{2}$ 4		
	8447.0	6.7 $\frac{1}{2}$ 3	Q	DCO=0.90 14.
946.5 1	2352.4	45.9 7	Q	DCO=1.07 5.
955.1	3307.5	<1.0		
966.8 1	4383.8	11.3 7	Q	DCO=1.1 4.
967.0 1	3158.1	4.3 3	Q	DCO=1.8 4. DCO for $\Delta J=1$, dipole gate.
981.0	4383.8	<1.0		

Continued on next page (footnotes at end of table)

$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 2009Dh01 2009Dh01 (continued) $\gamma(^{139}\text{Pm})$ (continued)

$E\gamma$	E(level)	$I\gamma$	Mult. [†]	Comments
997.2 2	6724.9	1.0 4		
1009.3 1	5843.7	3.9 5	(D)	DCO=0.7 3.
1014.9 1	4922.9	4.2 5	(Q)	DCO=1.0 5.
1035.8 2	9482.8	1.5 6		
1050.5 3	4467.4	1.8 8		
1059.7 2	1714.4	2.9 5		
1064.2 3	6939.1	0.8 3		
1064.5 1	3416.9	12.6 9	Q	DCO=1.12 11.
1087.7 2	5505.6	2.8 4		
1112.3 2	2518.4	2.5 4		
1122.0 3	4383.8	3.6 10		
1199.0 2	6704.6	1.0 6		
1214.0	7918.6	<1.0		
1254.0	5162.0	<1.0		
1274.8 3	6109.2	1.1 5		
1297.7 1	1952.3	14.5 5	D	DCO=0.58 10.
1327.0 3	3679.4	0.8 3		
1608.0 3	5516.0	2.5 9		

[†] From DCO ratios. Several multiplicities are assigned in 2009Dh01 without DCO ratios and many others are based on DCO ratios with large uncertainties so that it is difficult to distinguish between $\Delta J=2$, quadrupole and $\Delta J=1$, dipole transitions.

[‡] Multiply placed; undivided intensity given.

[§] Multiply placed; intensity suitably divided.

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

¹¹⁶Cd(²⁷Al,4nγ): 1987Xu01 1987Xu01,1990XuZW

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

1987Xu01, 1990XuZW (thesis): ¹¹⁶Cd(²⁷Al,4nγ),E(²⁷Al)=110-142 MeV. Measured excitation functions, E_γ, I_γ, γγ-coin, γ(θ), and γ(t) using 4-n type BGO Compton-suppressed Ge(Li) detector at Stony Brook accelerator facility.

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

1973VaYZ, 1973HaWF: ¹⁴¹Pr(α,6nγ),Eα=104 MeV. Measured E_γ, γ(θ), and γγ-coin.

All data are from 1987Xu01 and 1990XuZW, except as noted. The gamma-ray energy uncertainties, relative I_γ values and γ(θ) 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 γγ-coincidence gates and corroborated by dipole transitions to the πh_{11/2}⊗vh_{11/2}² band.

¹³⁹Pm Levels

E(level) [†]	Jπ [‡]	T _{1/2} [§]	Comments
0.0	(5/2)+		Jπ: 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 ^{&} 14	15/2		
1951.3 ^{&} 14	17/2		
2106.4 ^a 15	19/2+		
2163.4 ^{&} 15	19/2		
2190.1 [@] 14	21/2-		
2301.6 ^{&} 14	21/2		
2351.9 [#] 14	23/2-		
2570.6 ^{&} 15	23/2		
2689.5 ^a 16	23/2+		
2798.4 ^{&} 16	25/2		
2964.2 ^b 16	25/2+		
3023.5 ^{&} 17			
3157.3 [@] 16	25/2-		
3261.4 ^c 16	27/2-		
3279.6 ^a 19	27/2+		
3416.8 [#] 17	27/2-		
3558.0 ^b 19	29/2+		
3590.0 ^c 19	29/2-		
3906.3 ^c 21	31/2-		
4155.0 ^a 21	31/2+		
4379.3 ^c 24	33/2-		
4383.2 [#] 20	31/2-		
4417.8 ^b 21	33/2+		
4833 ^c 3	35/2-		
5258.5 [#] 23	35/2-		
5505.8 ^b 23	(37/2+)		
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 E_γ data.

[‡] From γ(θ) 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}≤10 ns from γγ(t).

[#] (A): π3/2[541],α=-1/2.

[@] (B): π3/2[541],α=+1/2 (?).

[&] (C): ΔJ=1 band based on 15/2. Positive parity given in Table 4.4 of 1990XuZW.

^a (D): πg_{7/2}⊗vh_{11/2}²,α=-1/2 (?).

^b (E): πg_{7/2}⊗vh_{11/2}²,α=+1/2 (?).

^c (F): πh_{11/2}⊗vh_{11/2}² (?).

¹¹⁶Cd(²⁷Al,4n γ): 1987Xu01 1987Xu01,1990XuZW (continued)

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

Dipole transitions from members of the $\pi 3/2[541]$, $\alpha=-1/2$, band to members of the $(\pi h_{11/2})(\nu h_{11/2}^2)$ band mentioned by 1987Xu01 but not shown.

All the γ rays are seen in $\gamma\gamma$ -coin data of 1987Xu01, 1990XuZW.

$E\gamma^\dagger$	E(level)	I_γ	Mult. [‡]	α	Comments
104.1 2	3261.4	4.6 1	D		$A_2=-0.23$ 3; $A_4=+0.03$ 4.
^x 132.0 2		2.0 $\S$ 5			
138.1 2	2301.6	14.7 1	D+Q		$A_2=-0.283$ 14; $A_4=+0.074$ 19.
^x 148.0@					
^x 149.9 2		1.9 $\S$ 5			
188.5	188.5		E3	1.501	$E\gamma$: from ($\alpha,6n\gamma$), $I_\gamma=60$.
212.1 2	2163.4	21.2 2	D		$A_2=-0.294$ 13; $A_4=-0.017$ 19.
^x 224.4 2		6.8 $\S$ 5	D+Q		$A_2=-0.271$ 18; $A_4=+0.090$ 25.
225.1 5	3023.5	≤ 1			
^x 227.2 2		1.7 $\S$ 5			
227.6&	227.6?				$E\gamma$: unresolved doublet.
227.6 2	2798.4	10.8 $\S$ 5	D+Q		$A_2=-0.213$ 9; $A_4=+0.129$ 13.
^x 236.5 2		1.2 $\S$ 5			
236.9 2	1951.3	8.3 2	D+Q		$A_2=-0.31$ 3; $A_4=+0.10$ 4.
^x 260.8 5		≤ 1			
^x 262.0 2		2.9 $\S$ 4	D+Q		$A_2=-0.153$ 8; $A_4=+0.119$ 11.
268.7 2	2570.6	19.0 2	D+Q		$A_2=-0.393$ 16; $A_4=+0.056$ 22.
316.3 2	3906.3	10.3 $\S$ 5	D+Q		$A_2=-0.339$ 18; $A_4=+0.128$ 25.
328.6 2	3590.0	17.1 $\S$ 5	D+Q		$A_2=-0.358$ 13; $A_4=+0.077$ 18.
337.5 2	2689.5	6.3 2	D+Q		$A_2=+0.43$ 5; $A_4=+0.35$ 6.
^x 393.6@					
393.6 2	2964.2	5.6 2	D+Q		$A_2=-0.84$ 6; $A_4=+0.66$ 7.
^x 396.3 5		≤ 1			
453.0#	3023.5				
453.7 2	4833	3.5 $\S$ 4	D+Q		$A_2=-0.37$ 3; $A_4=+0.22$ 4.
465.9 2	654.4	100.0 6	Q		$A_2=+0.284$ 6; $A_4=-0.046$ 9.
^x 468.5 5		≤ 1			
473.0 2	4379.3	4.6 $\S$ 4	(D+Q)		$A_2=-0.075$ 26; $A_4=-0.32$ 4. Negative A_4 is inconsistency with $\Delta J=1$ transition.
497.1#	2798.4				
^x 533 1		≤ 1			Tentative placement from (37/2-) to (35/2-), only in Table 4.4 of 1990XuZW.
^x 537 1		≤ 1			
^x 551 1		≤ 1			
583.1 2	2689.5	9.1 2	Q		$A_2=+0.36$ 4; $A_4=-0.12$ 6.
590.1 2	3279.6	9.0 $\S$ 4	Q		$A_2=+0.12$ 3; $A_4=-0.42$ 4.
590.2 5	778.7?	≤ 1			
^x 591 1		≤ 1			
593.8 2	3558.0	10.3 2	Q		$A_2=+0.42$ 3; $A_4=-0.28$ 4.
597.0 5	1375.7	≤ 1			
612.4 2	2964.2	5.7 $\S$ 4	D+Q		$A_2=-0.809$ 34; $A_4=+0.63$ 4.
^x 618 1		≤ 1			
663.1 2	6722	4.5 1	(Q)		$A_2=+0.30$ 5; $A_4=-0.07$ 7.
^x 672.6 5		≤ 1			
^x 693.0 5		≤ 1			
701.0 2	2106.4	8.6 $\S$ 5	D+Q		$A_2=-0.112$ 13; $A_4=+0.026$ 19. $\Delta J=0$ transition.
721.3 2	1375.7	10.6 2	D+Q		$A_2=-0.92$ 4; $A_4=+0.46$ 5.
^x 732.2 2		4.0 2			$A_2=+0.05$ 6; $A_4=+0.20$ 9.
751.3 2	1405.5	57.2 4	(Q)		$A_2=+0.274$ 10; $A_4=-0.001$ 13.
^x 775.0 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	7503	6.0 2	Q		$A_2=+0.16$ 5; $A_4=-0.43$ 7.
784.5 2	2190.1	6.7 2	D+Q		$A_2=-0.73$ 5; $A_4=+0.18$ 6.
800.5 2	6059.0	6.3 1	(Q)		$A_2=+0.15$ 5; $A_4=+0.07$ 7.
^x 814.5 5		≤ 1			Tentative placement from (15/2+) to (11/2+), only in Table 4.4 of 1990XuZW.
814.5 2	2190.1	8.0 2	(Q)		$A_2=+0.29$ 5; $A_4=+0.16$ 6. Sign of A_4 is inconsistent with stretched quadrupole.
^x 847.3 2		2.6 1	D		$A_2=-0.08$ 9; $A_4=-0.01$ 13.

Continued on next page (footnotes at end of table)

$^{116}\text{Cd}(^{27}\text{Al},4n\gamma)$: 1987Xu01 1987Xu01,1990XuZW (continued) $\gamma(^{139}\text{Pm})$ (continued)

$E\gamma^\dagger$	E(level)	I_γ	Mult. ‡	Comments
859.8 2	4417.8	3.4 1	(Q)	$A_2=+0.64$ 10; $A_4=+0.13$ 14.
875.3 2	5258.5	8.6 § 4	(Q)	$A_2=+0.16$ 6; $A_4=-0.03$ 9.
875.4 5	4155.0	≤ 1		
896.0 2	2301.6	5.2 2	D+Q	$A_2=-0.47$ 6; $A_4=+0.17$ 8.
909.5 2	3261.4	6.3 § 3	(Q)	$A_2=+0.22$ 3; $A_4=0.00$ 4.
^x 938.5 2		3.5 § 5		
942.0 5	8445	≤ 1		
946.3 2	2351.9	31.7 3	(Q)	$A_2=+0.279$ 16; $A_4=+0.174$ 21. Sign of A_4 is inconsistent with stretched quadrupole.
^x 954.5 2		3.9 2		$A_2=+0.12$ 11; $A_4=+0.36$ 15. 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	4383.2	11.4 3	Q	$A_2=+0.374$ 25; $A_4=-0.15$ 4.
967.3 2	3157.3	5.1 § 3		
^x 1008.6 2		7.7 2		$A_2=+0.27$ 41; $A_4=-0.06$ 6.
1035.0 5	9480	≤ 1		
1060.0 2	1714.4	4.0 1	D+Q	$A_2=+0.49$ 12; $A_4=-0.54$ 16. $\Delta J=0$ transition.
1064.9 2	3416.8	13.2 3	(Q)	$A_2=+0.13$ 3; $A_4=+0.08$ 5.
1088.0 5	5505.8	≤ 1		
1112& 1	10592?	≤ 1		
1296.9 2	1951.3	12.8 3	D	$A_2=-0.33$ 6; $A_4=+0.06$ 9.

† 1990XuZW state the energy accuracy to 0.2 keV, except 1 keV when $E\gamma$ is given to the nearest keV. Evaluators assign 0.5 keV for $E\gamma$ values listed to the nearest tenth of a keV and with $I_\gamma \leq 1$.

‡ From the discussion of 1987Xu01 many of the transitions are apparently of a stretched quadrupole or dipole nature from $\gamma(0)$ 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.

& Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

Adopted Levels, Gammas

Q(β⁻)=-6982 17; S(n)=8954 16; S(p)=4729 30; Q(α)=1408 22 2012Wa38.

S(2n)=20500 40, S(2p)=7374 16, Q(εp)=2349 16 (2012Wa38).

Mass measurements: 2000Be42, 1997Be63, 1995Ve08.

¹³⁹Sm Levels

Cross Reference (XREF) Flags

- A ¹³⁹Eu ε Decay (17.9 s)
 B ¹³⁹Sm IT Decay (10.7 s)
 C ⁹⁹Ru(⁴⁸Ti,α2p2nγ)
 D ¹¹⁰Pd(³⁴S,5nγ)

E(level) [†]	Jπ [‡]	XREF	T _{1/2} [§]	Comments
0.0	1/2+	ABCD	2.57 min 10	%ε+%β ⁺ =100. μ=-0.53 2 (1992Le09,2014StZZ). RMS charge radius <r ² > ^{1/2} =4.9556 fm 34 (2013An02 evaluation). Jπ: spin from laser atomic spectroscopy (1992Le09); π=+ from E2 γ from 5/2+.
111.92 14	3/2+	ABCD		T _{1/2} : from 1982De06 (273.7γ,306.7γ). Other: 2.6 min 3 (1973VaYZ).
223.50 13	(3/2)+	AB D		μ: laser resonance ionization mass spectroscopy (1992Le09,1988Al41).
267.29 13	5/2+	ABCD		Jπ: M1(+E2) γ to 1/2+; stretched M1 γ from 5/2+.
457.38 23	11/2-	ABCD	10.7 s 6	Jπ: M1(+E2) γ to 1/2+ and syst of N=77 nuclei.
				Jπ: stretched E2 γ to 1/2+; π=+ from E3 γ from 11/2-.
				%IT=93.7 5; %ε+%β ⁺ =6.3 5 (1975Va14).
				μ=1.1 2 (1992Si22,2014StZZ).
				Jπ: E3 γ to 5/2+; π=- from allowed ε decay to (11/2)-.
				T _{1/2} : from IT decay.
				μ: nuclear orientation with γ detected (1992Si22).
531.4 4	5/2+	D		Jπ: stretched D γ to 3/2+; Q γ to 1/2+.
589.6 3	(9/2)-	A D		Jπ: 9/2-, 13/2- from DCO; 9/2- preferred based on available systematics.
686.7 4		A		
720.75 20	(7/2+)	A D		Jπ: 3/2,7/2 from stretched dipole to 5/2+; ≠3/2,7/2- from ε decay from (11/2)-.
786.8 5		A		
920.1 8		A		
1020.2 6		A		
1047.4& 7	15/2-	CD		
1065.5 8	(13/2-)	D		
1067.1 9		D		
1074.7 8	(9/2+)	D		
1137.1 7	(11/2+)	D		
1158.5 4		A		
1176.4 5		A		
1346.3 8	(9/2+)	D		
1380.3 3		A		
1454.5 9	(13/2+)	D		
1581.3 8	(15/2-)	D		
1779.0 9	(17/2-)	D		
1780.7 8	(15/2+)	D		
1870.4& 9	(19/2-)	CD		
1879.4 9	(13/2+)	D		
1968.5 10	(17/2+)	D		
2198.5 ^a 13	(19/2+)	D	<1 ns	T _{1/2} : quoted in 1996Re04 without giving the method used.
2249.6 9	(19/2-)	D		
2290.0 8	(17/2+)	D		
2550.0 10	(19/2+)	D		
2566.8 9	(19/2+)	D		
2582.7 ^a 17	(23/2+)	D		
2658.0 8	(21/2+)	D		
2671.0 9	(21/2-)	D		
2820.4& 10	(23/2-)	CD		
2867.9 ^c 11	(23/2+)	D		
2908.8 [#] 10	(21/2+)	D		
3100.2 10	(25/2+)	D		
3254.6 9	(23/2-)	CD		

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Adopted Levels, Gammas (continued) ^{139}Sm Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF	T _{1/2} [§]	Comments
3284.3 19	(25/2)	D		
3315.1@ 13	(27/2)	D		
3327.0 ^d 9	(25/2-)	CD		
3331.3 19	(25/2)	D		
3348.9 ^c 15	(27/2+)	D		
3410.4 ^a 19	(27/2+)	D		
3445.4 ^d 10	(27/2-)	CD		
3518.2 [#] 13	(25/2+)	D		
3554.2 19	(29/2)	D		
3710.3 ^d 11	(29/2-)	CD	0.69 ps +42-21	
3736.2@ 14	(31/2)	D		
4014.3 21	(33/2)	D		
4047.5 ^d 12	(31/2-)	CD	0.59 ps +15-12	T _{1/2} : other: 0.42 ps 15 from DSAM in $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$.
4119.5 20	(29/2)	D		
4124.5 ^c 18	(31/2+)	D		
4164.3 [#] 15	(29/2+)	D		
4338.6 ^a 19	(31/2+)	D		
4362.3 19	(31/2+)	D		
4444.5@ 17	(35/2)	D		
4457.0 ^d 13	(33/2-)	CD	0.54 ps +10-7	T _{1/2} : other: 0.28 ps 10 from DSAM in $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$.
4582.5 18	(33/2)	D		
4695.9 17	35/2	D		
4844.2 [#] 15	(33/2+)	D		
4856.9 16	(33/2+)	D		
4881.4 20	(33/2)	D		
4929.7 ^d 14	(35/2-)	CD	0.34 ps +8-6	T _{1/2} : other: 0.17 ps 6 from DSAM in $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$.
5088.5@ 17	(39/2)	D		
5145.7 ^c 21	(35/2+)	D		
5163.6 ^e 21	(33/2)	D		
5279.9 ^b 19	(37/2)	D		
5322.5 20	(35/2)	D		
5407.4 ^e 21	(35/2)	D		
5411.8 18	(39/2)	D		
5443.2 ^d 14	(37/2-)	CD	0.62 ps +42-21	
5483.9 19	(39/2)	D		
5578.9 [#] 16	(37/2+)	D		
5713.8@ 19	(43/2)	D		
5726.4 ^e 23	(37/2)	D		
5934.6 ^d 15	(39/2)	CD	>0.7 ps	
5962.5 ^b 19	(41/2)	D		
6103.3 20		D		
6121.6 25	(39/2)	D		
6125.6 ^e 25	(39/2)	D		
6154.5 20		D		
6247.5 20		D		
6386.8 [#] 19	(41/2+)	D		
6489.6@ 21	(47/2)	D		
6494.6 ^d 16	(41/2)	D		
6601.7 21		D		
6616.2 ^e 25	(41/2)	D		
6900.1 ^b 22	(45/2)	D		
7177 3	(43/2)	D		
7193 ^e 3	(43/2)	D		
7234.5 23		D		
7272.5 [#] 22	(45/2+)	D		
7367.4 23	(51/2)	D		
7406.6@ 23	(51/2)	D		
8031.1 ^b 24	(49/2)	D		
8068.7 23		D		
8175.1 [#] 24	(49/2+)	D		
8286.7@ 25	(55/2)	D		
8524.6 25		D		
9083 [#] 3	(53/2+)	D		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

¹³⁹Sm Levels (continued)

E(level) [†]	Jπ [‡]	XREF
9395@ 3	(59/2)	D
10053# 3	(57/2+)	D
11114# 3	(61/2+)	D

[†] ΔEγ=0.5 keV assumed in least-squares fit when not given.

[‡] From DCO and γ(θ) in ¹¹⁰Pd(³⁴S,5nγ), except as noted. Stretched Q γ's were assumed to be E2.

[§] From Doppler-shift attenuation method in ⁹⁹Ru(⁴⁸Ti,α2p2nγ) (2008Pa36).

(A): v_{i13/2} highly-deformed (intruder) band. Q=3.9 7 from DSAM analysis of 807.9, 885.7, 902.6, 908.0, 969.9 and 1061.0 transitions in this band (1996Ro04) in ¹¹⁰Pd(³⁴S,5nγ). An 1122γ placed as the top transition in 1994Va15 is not confirmed by 1996Ro04, thus omitted here.

@ (B): Band based on 27/2.

& (C): Band based on 15/2-.

a (D): Band based on 19/2+.

b (E): Band based on 37/2.

c (F): Band based on 23/2+.

d (G): Band based on 25/2-. Possible magnetic-dipole rotational (shears) band with configuration=vh_{11/2}⁻¹⊗πh_{11/2}², as interpreted by 1996Br33 based on B(M1)/B(E2) values deduced from their lifetime measurements.

e (H): Band based on 33/2.

γ(¹³⁹Sm)

See ε decay for unplaced gammas.

E(level)	Eγ [†]	Iγ [†]	Mult. ^a	δ	α	I(γ+ce) [§]	Comments
111.92	111.9 [‡] 2	100 [§]	M1(+E2) [§]	<0.50 [§]	1.26 4		
223.50	111.6 [‡] 2	26 [§] 6	[M1, E2]		1.41 18		
	223.5 [‡] 2	100 [§] 11	(M1+E2) [§]	§	0.161 18		
267.29	43.8 [‡] 1	≈0.17 [§]	(E2) [§]		57.7 11	8.7 15	
	155.3 [‡] 2	100 [§]	M1 [#]		0.486		Mult.: M1(+E2) with δ<1.6 from αK(exp) in IT decay; stretched D from DCO in ¹¹⁰ Pd(³⁴ S,5nγ).
	267.3 [‡] 2	100 [§] 10	E2@		0.0808		Mult.: E1+M2 or E2 from αK(exp) in IT decay; stretched Q from DCO in ¹¹⁰ Pd(³⁴ S,5nγ).
457.38	190.1 [‡] 2	100 [§]	E3 [§]		1.516		B(E3)(W.u.)=0.00411 24.
531.4	263.9	22 6	[M1, E2]		0.099 15		
	420.3	100 18	D [#]				
	531.5	25 6	(E2) [@]		0.01092		
589.6	132.2 2	100	(M1) [#]		0.764		
686.7	419.5 5	100 50					
	463.4 5	75 35					
720.75	189.4 [‡] 4	97 22	(M1) [#]		0.280 5		
	453.4 [‡] 2	100	(M1) [#]		0.0276		
	497.2 3	58 12					γ not observed in ¹¹⁰ Pd(³⁴ S,5nγ).
786.8	197.2 4	100					
920.1	330.5 7	100					
1020.2	299.5 5	100					
1047.4	590.0	100	Q@				
1065.5	608.2	100	D+Q				
1067.1	477.5	100					
1074.7	807.5	100	Q@				
1137.1	416.5	100 10	(E2) [@]		0.0212		
	547.4	75 8	D [#]				
1158.5	437.7 4	100 42					
	701.2 4	70 14					
1176.4	719.0 4	100					
1346.3	271.8	100 16	[M1, E2]		0.091 15		
	1079.0	61 7	Q@				
1380.3	659.5 3	100 22					
	693.8 4	87 44					
1454.5	108.3	19 6	[E2]		1.755		
	379.7	100 12	(E2) [@]		0.0276		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Sm})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ^a	α	Comments
1581.3	515.8	100 11	D#		
	534	14 8			
1779.0	713.7	38 4	Q@		
	731.6	100 7	D+Q		
1780.7	643.7	100 11	Q@		
	713.5	2.3 8			
1870.4	822.9	100	Q@		
1879.4	742.1	100	D#		
1968.5	514.0	100	(E2)@		
2198.5	419.5	100	(E1) #		B(E1)(W.u.)>3.4×10 ⁻⁶ .
2249.6	470.9	48 17			
	668.5	100 15	Q@		
	1201.7	45 17			
2290.0	410.4	24.1 26	E2@	0.0221	
	509.3	100 10			
	708.4	1.9 6			
	1242.9	3.4 8	D#		
2550.0	260.1	100	[M1, E2]	0.103 16	
2566.8	786.2	100	Q@		
2582.7	384.2	100	E2@	0.0267	
2658.0	91.0	1.8 7	[M1, E2]	2.8 6	
	108.2	4.5 14	[M1, E2]	1.56 21	
	368.0	100 11	(E2)@	0.0303	
	689.5	61 7	Q@		
	787.5	6.7 20			
2671.0	800.5	100 14	D#		
	891.9	70 11	Q@		
2820.4	950.1	100	Q@		
2867.9	209.9	100	[M1, E2]	0.195 18	
2908.8	342.3	14 4			
	618.5	100 13	Q@		
3100.2	232.3	41 6	(M1) #	0.1605	
	441.9	100 11	(E2)@	0.0180	
3254.6	434.1	100 12			
	583.5	63 12	D#		
	1005.2	69 12	Q@		
	1384.2	85 10	Q@		
3284.3	701.6	100	D#		
3315.1	214.8	100	D#		
3327.0	72.2	90 18	M1	4.32	Mult.: from $\alpha(\text{exp})$ in $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$.
	227.2	25 8	(E1) #	0.0302	
	506.4	100 20	(M1) #	0.0208	
	656	10 6			
	669.1	30 9			
3331.3	748.6	100	D#		
3348.9	481.0	100	[E2]		
3410.4	827.7	100	Q@		
3445.4	118.6	100 17	M1	1.039	Mult.: stretched dipole from DCO in $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$; M1 from $\alpha(\text{exp})$ in $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$.
	344.5	14 4	(E1) #		
	625.4	15 4	Q@		
3518.2	609.5	100	Q@		
3554.2	222.8	20 7	(E2)@	0.1458	
	270.0	100 18	(E2)@	0.0783	
3710.3	265.0	100 11	(M1) #	0.1125	B(M1)(W.u.)=1.5 +5-10.
	383.5	4.4 17	[E2]	0.0269	B(E2)(W.u.)=90 +50-70.
3736.2	421.0	100	E2@	0.0206	
4014.3	460.1	100	(E2)@		
4047.5	337.3	100 12	(M1) #	0.0594	B(M1)(W.u.)=0.72 +19-22.
	601.9	29 5	E2&		B(E2)(W.u.)=61 +18-20.
4119.5	835.2	100	Q@		
4124.5	775.6	100	Q@		
4164.3	646.2	100	Q@		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Sm})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ^a	α	Comments
4338.6	784.3	40 8			
	928.1	100 18	Q@		
4362.3	808.3	52 12	D#		
	952.1	100 22	Q@		
4444.5	708.1	100	Q@		
4457.0	409.4	100 14	(M1) #	0.0359	B(M1)(W.u.)=0.43 +10-12.
	746.6	36 8	E2&		B(E2)(W.u.)=27 +8-9.
4582.5	846.3	100	D#		
4695.9	251.1	36 12			
	960.0	100 24	(Q)@		
4844.2	680.0	100 14	Q@		
	1108.0	20 6	D#		
4856.9	1120.7	100	D#		
4881.4	519.5	100 28	D#		
	542.5	96 28	D#		
4929.7	472.6	100 19	(M1) #	0.0248	B(M1)(W.u.)=0.35 +11-12.
	882.3	71 14	E2&		B(E2)(W.u.)=30 +9-10.
5088.5	392.4	9 9 24	(E2)@	0.0251	
	644.1	100 11	Q@		
5145.7	1021.2	100	Q@		
5163.6	1044	100			
5279.9	835.4	100	D		
5322.5	740	100	D#		
5407.4	243.8	100 22	D#		
	526.0	47 15	D#		
5411.8	967.4	100	Q@		
5443.2	513.5	100 21	(M1) #	0.0201	B(M1)(W.u.)=0.15 +8-6.
	986.2	68 17	[E2]		B(E2)(W.u.)=9 +5-4.
5483.9	1039.4	100	Q@		
5578.9	722.0	21 6	(Q)@		
	734.6	100 15	Q@		
5713.8	302.0	6 2 24	(E2)@	0.0551	
	625.3	100 12	Q@		
5726.4	319.0	100	D#		
5934.6	491.3	44 12			
	1005.0	100 30			
5962.5	550.7	53 12	D#		
	682.5	100 24	Q@		
6103.3	1014.8	100			
6121.6	395.1	100	D#		
6125.6	399.3	100	D#		
6154.5	1066	100			
6247.5	1159	100			
6386.8	807.9	100	Q@		
6489.6	775.8	100	Q@		
6494.6	560.0	80 27			
	1051.4	100 34			
6601.7	1189.9	100			
6616.2	490.7	100 20	D#		
	494.5	39 14	D#		
6900.1	937.6	100	Q@		
7177	560.5	100	D#		
7193	577.2	100	D#		
7234.5	987	100			
7272.5	885.7	100	Q@		
7367.4	877.8	100	Q@		
7406.6	917.0	100	Q@		
8031.1	1131	100			
8068.7	662.0	100 33			
	701.3	100 33			
8175.1	902.6	100	Q@		
8286.7	880.1	100			
8524.6	1118	100			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Sm})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\ddagger}$	Mult. ^a
9083	908.0	100	Q@
9395	1108.5	100	
10053	969.9	100	Q@
11114	1061.0	100	Q@

[†] From $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$, except as noted.

[‡] From ε decay.

[§] From IT decay.

[#] Stretched dipole from DCO in $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$; $\Delta\pi$ from the level scheme.

@ Stretched quadrupole from DCO in $^{110}\text{Pd}(^{34}\text{S},5n\gamma)$; assumed to be E2.

& D,E2 from comparison to RUL; $\neq$ D from level scheme.

^a For high-spin data, assignments are from DCO and $\gamma(\theta)$, except as noted. Mult=Q indicates stretched quadrupole (most likely E2) and mult=D or D+Q indicates $\Delta J=1$, dipole. For γ transitions up to 600 keV, stretched quadrupoles are assigned (E2) from RUL for E2 and M2, assuming that level half-lives are less than 10 ns.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(E) Band based on 37/2

(F) band based on 23/2+

(G) Band based on 25/2-.

(H) band based on 33/2

¹³⁹Sm IT Decay (10.7 s) 1986De35,1975Va14,1973VaYZ

Parent ¹³⁹Sm: E=457.40 22; J π =11/2-; T_{1/2}=10.7 s 6; %IT decay=93.7 5.

¹³⁹Sm-%IT decay: from I γ (190.1 γ +188.7 γ (¹³⁹Pm))=100 and I γ (188.7 γ)/I γ (190.1 γ)=0.068 5 (1975Va14).

1986De35: ¹³⁹Eu produced in ¹⁴⁴Sm(p,6n),E=50-90 MeV. Identification by means of T_{1/2}=22 s, production threshold energy, and constancy of I γ as a function of bombarding energies. Measured E γ , I γ and x rays, $\gamma\gamma$, isomer half-life, ce. The isomer half-life measured over a period of $\approx$ 200 s; two groups, one with T_{1/2} of 17.9 s 6 and one with a feeding T_{1/2} of 17.9 s 6 and α decay T_{1/2} of 10.7 s 6.

1975Va14 (also 1973VaYZ, 1971Va22): measured γ and ce spectra.

All data are from 1986De35, except as noted. Decay scheme based on γ -ray singles, $\gamma\gamma$ -coin, energy sums, and conversion electron coefficients and differs from that of 1973VaYZ and 1975Va14 in the order of the 112 γ and completeness.

¹³⁹Sm Levels

E(level)	J π [†]	T _{1/2} [†]	Comments
0.0	1/2+	2.57 min 10	% ϵ +% β^+ =100. T _{1/2} and decay modes from Adopted Levels.
111.93 15	3/2+		
223.49 13	(3/2)+		
267.28 13	5/2+		
457.40 22	11/2-	10.7 s 6	% ϵ +% β^+ =6.3 5; %IT=93.7 5. T _{1/2} : other: 9.5 s 10 (1973VaYZ).

[†] From the Adopted Levels.

γ (¹³⁹Sm)

α (K)exp: from concurrent measurement of ce(K) and γ .

K/L are from 1973VaYZ, except for K/L(190.1 γ).

I γ normalization: from I γ (190.1 γ)(1+ α)=100 (evaluators).

E γ	E(level)	I γ &	Mult. [†]	δ [†]	α	I(γ +ce) ^a	Comments
43.8 $\ddagger$ 1	267.28	$\approx$ 0.17	E2		57.7 11	5.0 7	I γ : estimated from spectrum of low-energy γ 's and K x ray's in coin with 190.1 γ and calculated I γ (K x ray)'s (evaluators). Mult.: M1,E2 from decay scheme. E2 from I(γ +ce) and estimated I γ (evaluators). I(γ +ce): from 223.5 γ -190.1 γ coin, corrected for α . Uncertainty estimated by evaluators.
111.6 2	223.49	2.2 5	[M1,E2]		1.41 18		
111.9 2	111.93	68 7	M1(+E2) [§]	<0.50 [#]	1.26 4		α (K)exp=1.02 11; K/L=7.5 30.
155.3 2	267.28	100	M1 [§]	#	0.486		α (K)exp=0.42 6; K/L=5.0 25. δ (E2/M1)<1.7 from α (K)exp, but stretched dipole in in-beam γ -ray suggests dominant dipole.
190.1 2	457.40	102 10	E3 [§]		1.516	100	α (K)exp=0.64 5; K/L=0.97 8 (1986De35); K/L=1.03 6 (1975Va14).
223.5 2	223.49	8.6 9	(M1+E2) [@]	@	0.161 18		α (K)exp=0.13 6.
267.3 2	267.28	100 10	E2		0.0808		α (K)exp=0.066 7.

[†] From Adopted Gammas, based mostly on data in the present decay.

$\ddagger$ Seen only in coincidence spectra.

[§] From α (K)exp and K/L.

[#] From K/L.

[@] From α (K)exp and decay scheme.

& For absolute intensity per 100 decays, multiply by 0.37 4.

^a For absolute intensity per 100 decays, multiply by 0.937 5.

^{139}Sm IT Decay (10.7 s) 1986De35,1975Va14,1973VaYZ (continued)

Decay Scheme

Intensities: I(γ +ce) per 100
 parent decays
 %IT=93.7 5

¹³⁹Eu ε Decay (17.9 s) 1986Re11,1986De35

Parent ¹³⁹Eu: E=0.0; Jπ=(11/2)-; T_{1/2}=17.9 s 6; Q(g.s.)=6982 17; %ε+%β⁺ decay=100.

¹³⁹Eu-Q(ε): From 2012Wa38.

1986De35: ¹³⁹Eu produced in ¹⁴⁴Sm(p,6n),E=50-90 MeV. Identification by means of T_{1/2}=22 s, production threshold energy, and constancy of I_γ as a function of bombarding energies. Measured E_γ, I_γ and x rays, γγ, isomer half-life, ce. The isomer half-life measured over a period of ≈200 s; two groups, one with T_{1/2} of 17.9 s 6 and one with a feeding T_{1/2} of 17.9 s 6 and α decay T_{1/2} of 10.7 s 6.

1986Re11: ¹³⁹Eu produced in ¹¹²Sn(³²S,3p2n),E=170 MeV and ¹⁰⁶Cd(³⁵Cl,2p),E=191 MeV reactions. Identification by means of γ rays observed in ¹³⁹Sm IT decay. Measured half-life; He jet.

1975Va14: measured β spectra, βγ-coin, γ spectra, ce; deduced shape implications for unhindered 11/2- to 11/2- β transition.

All data are from 1986De35, except as noted.

¹³⁹Sm Levels

E(level) [†]	Jπ [‡]	T _{1/2} [‡]	Comments
0.0	1/2+	2.57 min 10	%ε+%β ⁺ =100. T _{1/2} and decay modes from Adopted Levels.
111.92 14	3/2+		
223.50 13	(3/2)+		
267.29 13	5/2+		
457.37 23	11/2-	10.7 s 6	%ε+%β ⁺ =6.3 5; %IT=93.7 5. T _{1/2} and decay modes from Adopted Levels.
(531.4 4)	5/2+		E(level): from Adopted Levels.
589.6 3	(9/2)-		
686.7 4			
720.75 20	(7/2+)		
786.8 5			
920.1 8			
1020.2 6			
1158.5 4			
1176.4 5			
1380.3 4			

[†] ΔE_γ=0.5 keV assumed in least-squares analysis when not given.

[‡] From the Adopted Levels.

β⁺,ε Data

The β feedings and log ft values are considered as apparent as the decay scheme seems poorly known.

Eε	E(level)	Iβ ⁺ [†]	Iε [†]	Log ft	I(ε+β ⁺) [†]	Comments
(5602 17)	1380.3	11 3	2.0 6	5.3	13 4	
(5806 17)	1176.4	16 3	2.7 4	5.2	19 3	
(5824 17)	1158.5	13 3	2.1 6	5.3	15 4	
(5962 17)	1020.2	3.2 16	0.48 23	6.0	3.7 18	
(6062 17)	920.1	11 4	1.5 6	5.5	12 5	
(6195 17)	786.8	6 3	0.8 3	5.8	7 3	
(6261 17)	720.75	18 5	5.2 16	7.2 ^{1u}	23 7	
(6295 [‡] 17)	686.7	<4.1	<1.2	>7.8 ^{1u}	<5.3	Iβ ⁺ ,Iε,I(ε+β ⁺): upper limit with 90% confidence level has been estimated by evaluators for I(ε+β ⁺)=-1 4 (from gamma-ray transition intensity balance).
(6392 [‡] 17)	589.6	<14	<1.7	≥5.5	<16	Iβ ⁺ ,Iε,I(ε+β ⁺): upper limit with 90% confidence level has been estimated by evaluators for I(ε+β ⁺)=-15 4 (from gamma-ray transition intensity balance).
(6525 17)	457.37					Measured Eβ=5622 50. I(ε+β ⁺): not known since it is time-dependent.

[†] Absolute intensity per 100 decays.

[‡] Existence of this branch is questionable.

^{139}Eu ϵ Decay (17.9 s) $^{1986}\text{Re11},^{1986}\text{De35}$ (continued) $\gamma(^{139}\text{Sm})$

I_γ normalization: From summed transition intensity balances=100 for levels above the 457-keV isomer. The normalization factor is treated as approximate as the decay scheme seems incomplete.

E_γ	E(level)	I_γ^d	Mult. [†]	$\delta^\dagger$	α^c	Comments
43.8 $\frac{+}{-}$ § 1	267.29	b	(E2)		57.7 11	I(γ +ce): 10.2 15 (1986De35).
111.6 $\frac{+}{-}$ ‡ 2	223.50	#b	[M1, E2]		1.41 18	I γ : 12 3 (1986De35).
111.9 $\frac{+}{-}$ ‡ 2	111.92	#b	M1 (+E2)	<0.50	1.26 4	I γ : 142 16 (1986De35).
132.2 2	589.6	90 20	(M1)		0.764	
155.3 $\frac{+}{-}$ ‡ 2	267.29	#b	M1		0.486	I γ : 204 22 (1986De35).
189.4 $\frac{+}{-}$ § 4	720.75	97 22	(M1)		0.280 5	Placement from $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$ (evaluators). I γ : from I γ (190 γ)/I γ (454)=0.97 22 in $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$ and I γ (453 γ)=100 (evaluators).
190.1 $\frac{+}{-}$ ‡ 2	457.37	@b	E3		1.516	I(γ +ce): 417 51 (from intensity balance).
197.2 $\frac{+}{-}$ § 4	786.8	40 15	[D, E2]		0.15 10	
223.5 $\frac{+}{-}$ ‡ 2	223.50	#b	(M1+E2)		0.161 18	I γ : 46 10 (1986De35).
(263.9&)	(531.4)	19 ^a 6	[M1, E2]		0.099 15	
267.3 $\frac{+}{-}$ ‡ 2	267.29	#b	E2		0.0808	I γ : 204 24 (1986De35).
299.5 $\frac{+}{-}$ § 5	1020.2	25 12				
330.5 $\frac{+}{-}$ § 7	920.1	80 30				
419.5 $\frac{+}{-}$ § 5	686.7	20 10				
(420.3&)	(531.4)	85 ^a 19	(M1)		0.0335	
437.7 $\frac{+}{-}$ § 4	1158.5	60 25				
453.4 2	720.75	100	(M1)		0.0276	
463.4 $\frac{+}{-}$ § 5	686.7	15 7				
^x 486.5 $\frac{+}{-}$ § 4						
497.2 3	720.75	58 12	[E2]		0.01302	Not observed in $^{110}\text{Pd}(^{34}\text{S}, 5n\gamma)$.
(531.5&)	(531.4)	21 ^a 7	E2		0.01092	
659.5 3	1380.3	46 10				
693.8 $\frac{+}{-}$ § 4	1380.3	40 20				
701.2 4	1158.5	42 8				
719.0 4	1176.4	130 20				
^x 741.2 $\frac{+}{-}$ § 3						

[†] From Adopted Gammas.

[‡] From ^{139}Sm IT decay.

§ Observed clearly only in the coincidence spectrum.

From adopted branching ratios, α , and $\Sigma I(\gamma+\text{ce})$ feeding level. Strong direct feeding of (11/2)⁻ level indicates levels below 457 are not directly fed (evaluators).

@ From I(γ +ce) and α .

& From Adopted Gammas.

^a From I γ (1+ α)(189 γ) and adopted branching ratios and α 's.

^b Value is not given due to their time-dependency arising from comparable half-lives of the ^{139}Eu parent (17.9 s) and 10.7-s isomer at 457 keV in ^{139}Sm populated in this decay. Apparent values from intensity balances are given under comments.

^c Theoretical values from BrIcc code. When $\delta(\text{E2/M1})$ is not given, listed value overlaps those for pure M1 and for pure E2.

^d For absolute intensity per 100 decays, multiply by ≈ 0.15 .

^x γ ray not placed in level scheme.

¹³⁹Eu ε Decay (17.9 s) 1986Re11,1986De35 (continued)

⁹⁹Ru(⁴⁸Ti,α2p2nγ) 2008Pa36

2008Pa36: E=240 MeV beam provided by ALPI accelerator at Legnaro. ¹¹⁴Sn(³²S,α2pn), E=160 MeV reaction also performed. Measured E_γ, I_γ, γγ-coinc using EUROBALL III array. Detected charged particles using ISIS array. Measured lifetimes using Doppler-Shift Attenuation method. Comparisons with Tilted-Axis Cranking (TAC) model. 2008Pa36 give B(M1) and B(E2) values. See Adopted dataset for these values deduced by the evaluators.

¹³⁹Sm Levels

E(level) [†]	Jπ [§]	T _{1/2} [‡]	Comments
0.0 [#]	1/2+		
112.0 [#] 10	3/2+		
267.6 [#] 15	5/2+		
457.8 [@] 18	11/2-	10.7 s 6	%ε+%β ⁺ =6.3 5; %IT=93.7 5. T _{1/2} and decay modes from Adopted Levels.
1047.5 [@] 20	15/2-		
1869.9 [@] 23	19/2-		
2819.5 [@] 24	23/2-		
3253.4 ^{&} 24	23/2-		
3325.6 ^{&} 25	25/2-		
3443.8 ^{&} 25	27/2-		
3708.5 ^{&} 25	29/2-	0.69 ps +42-21	
4045.5 ^{&} 25	31/2-	0.59 ps +15-12	
4455 ^{&} 3	33/2-	0.54 ps +10-7	
4927 ^{&} 3	35/2-	0.34 ps +8-6	
5440 ^{&} 3	37/2-	0.62 ps +42-21	
5931 ^{&} 3	(39/2-)	>0.7 ps	

[†] From least-squares fit to E_γ data, assuming an uncertainty of 0.3 keV when not stated.

[‡] From Doppler-shift attenuation method (2008Pa36).

[§] Proposed from band structure given in 2008Pa36. For low-lying levels, the assignments are from the Adopted Levels.

[#] (A): The g.s. band.

[@] (B): 11/2- band.

[&] (C): πh_{11/2}²⊗v h_{11/2}⁻¹. Possibly a magnetic-rotational band with prolate or triaxial deformation.

⁹⁹Ru(⁴⁸Ti,α2p2nγ) 2008Pa36 (continued)

γ(¹³⁹Sm)

E _γ	E(level)	I _γ	Mult.	α	Comments
72.0	3325.6				
112.0	112.0				
118.4	3443.8				
155.6	267.6				
190.2	457.8		E3		Mult.: from Adopted Gammas.
264.7 2	3708.5	24.5 2	[M1]	0.1129	
337.0 2	4045.5	17.9 17	[M1]	0.0595	
382.9 5	3708.5	0.9 5	[E2]	0.0270	
409.1 2	4455	11.6 11	[M1]	0.0359	
433.9	3253.4				
472.4 2	4927	7.0 9	[M1]	0.0249	
490.4 4	5931	1.1 4	[M1]	0.0226	
506.2	3325.6				
513.5 5	5440	3.1 7	[M1]	0.0201	
589.7	1047.5	100			
601.7 4	4045.5	3.0 5	[E2]		
746.3 7	4455	3.4 9	[E2]		
822.4	1869.9				
881.8 4	4927	4.1 8	[E2]		
949.8	2819.5				
985.7 6	5440	2.8 7	[E2]		
1003.2 6	5931	2.3 5	[E2]		
1383.3	3253.4				

¹¹⁰Pd(³⁴S,5nγ) 1996Ro04,1996Br33,1994Va15

Includes ¹¹⁴Cd(²⁹Si,4nγ) reaction from 1990Ba13; and ⁶²Ni(⁸¹Br,3npγ),E=350 MeV from 1996Br33.

1996Ro04 (also 1995Ro15): E(³⁴S)=150, 165 MeV. Measured E_γ, I_γ, γγ, γ(θ), γγ(θ)(DCO), DSAM for six top transitions in the highly-deformed (intruder) band using GASP array at Legnaro accelerator facility.

1996Br33: ⁶²Ni(⁸¹Br,3npγ),E=350 MeV. Measured level lifetimes by DSAM using GASP array of Compton-suppressed Ge detectors.

1994Va15: E(³⁴S)=159 MeV. Measured E_γ, I_γ, and γγ using TESSA3 array of 16 Compton-suppressed Ge detectors and a 50-element BGO multiplicity and total-energy filter at Stony Brook accelerator facility. This work was mainly concerned with the finding of the decoupled, strongly-deformed band (band 1 in 1996Ro04).

1990Ba13: ¹¹⁴Cd(²⁹Si,4nγ),E=128 MeV. Measured E_γ, I_γ, γγ, γ(θ) at Legnaro accelerator facility. A detailed level scheme is given in a brief paper, with no details of gamma-ray data.

Level scheme is from 1996Ro04. 1994Va15 report primarily the highly deformed (intruder) band with small differences of level scheme from 1996Ro04.

¹³⁹Sm Levels

E(level) [†]	Jπ [‡]	T _{1/2}	Comments
0.0	1/2+&		
111.8 7	3/2+&		
224.0 8	(3/2)+&		
267.6 7	5/2+		
457.9 10	11/2-&	10.7 s 6	%ε+%β ⁺ =6.3 5; %IT=93.7 5. T _{1/2} and decay modes from Adopted Levels.
531.7 7	5/2+		
590.3 12	9/2-§		
721.4 9	7/2+		
1048.0 ^b 11	15/2-		
1066.0 12	13/2-		
1067.8 13			
1075.1 10	9/2+		
1137.8 11	11/2+ [#]		
1346.7 10	9/2+		
1454.9 11	13/2+		
1581.9 12	15/2-		

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¹¹⁰Pd(³⁴S,5n γ) 1996Ro04,1996Br33,1994Va15 (continued)

¹³⁹Sm Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	T _{1/2}	Comments
1779.5 12	17/2-		
1781.3 12	15/2+		
1870.9 ^b 12	19/2-		
1880.0 13	13/2+		
1969.0 12	17/2+		
2199.0 ^c 16	19/2+	<1 ns	T _{1/2} : quoted in 1996Ro04 without giving the method used.
2250.1 12	19/2-		
2290.6 11	17/2+		
2550.5 13	19/2+		
2567.4 12	19/2+		
2583.2 ^c 19	23/2+		
2658.5 11	21/2+		
2671.5 13	21/2-		
2820.9 ^b 13	23/2-		
2868.4 ^d 14	23/2+		
2909.3 ^h 13	21/2+ [@]		
3100.8 13	25/2+		
3255.2 12	23/2-		
3284.8 20	25/2		
3315.6 ^f 15	27/2		
3327.5 ^e 12	25/2-		
3331.9 21	25/2		
3349.5 ^d 17	27/2+		
3410.9 ^c 20	27/2+		
3445.9 ^e 13	27/2-		
3518.7 ^h 16	25/2+		
3554.7 21	29/2		
3710.9 ^e 14	29/2-		
3736.7 ^f 17	31/2		
4014.8 23	(33/2)		
4048.0 ^e 15	31/2-	0.42 ps ^a 15	
4120.0 22	29/2		
4125.1 ^d 20	31/2+		
4164.9 ^h 17	29/2+		
4339.2 ^c 21	31/2+		
4362.8 21	31/2+		
4445.0 ^f 18	35/2		
4457.5 ^e 15	33/2-	0.28 ps ^a 10	
4583.0 19	33/2		
4696.5 18	35/2		
4844.8 ^h 17	33/2+		
4857.4 18	33/2+		
4882.0 22	33/2		
4930.2 ^e 16	35/2-	0.17 ps ^a 6	
5089.0 ^f 19	39/2		
5146.3 ^d 22	35/2+		
5164.1 ^g 23	33/2		
5280.5 ⁱ 20	37/2		
5323.0 22	35/2		
5407.9 ^g 23	35/2		
5412.4 20	39/2		
5443.7 ^e 17	37/2-		
5484.4 21	(39/2)		
5579.4 ^h 18	37/2+		
5714.3 ^f 20	43/2		
5726.9 ^g 25	37/2		
5935.1 ^e 17	(39/2)		
5963.0 ⁱ 21	41/2		
6103.8 22			
6122 3	39/2		
6126 ^g 3	39/2		
6155.0 22			
6248.0 22			

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¹¹⁰Pd(³⁴S,5n γ) 1996Ro04,1996Br33,1994Va15 (continued)

¹³⁹Sm Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	E(level) [†]	J $\pi^{\ddagger}$	E(level) [†]	J $\pi^{\ddagger}$
6387.3 ^h 21	41/2+	7194 ^g 3	43/2	8175.6 ^h 25	49/2+
6490.2 ^f 23	47/2	7235.0 24		8287 ^f 3	(55/2)
6495.1 ^e 18	(41/2)	7273.0 ^h 23	45/2+	8525 3	
6602.3 22		7367.9 24	51/2	9084 ^h 3	53/2+
6617 ^g 3	41/2	7407.2 ^f 24	51/2	9396 ^f 3	(59/2)
6900.6 ⁱ 23	45/2	8031.6 ⁱ 25	(49/2)	10054 ^h 3	57/2+
7177 3	43/2	8069.2 25		11115 ^h 3	61/2+

[†] From least-squares fit to E γ values, assuming $\Delta E\gamma=0.5$ keV uncertainty for each γ rays.

[‡] As proposed by 1996Ro04 from DCO and $\gamma(0)$, except as noted.

[§] 9/2-, 13/2- from DCO; 9/2- preferred based on available systematics.

J $\pi=7/2-$ (1994Va15) not compatible with DCO's of the upper transitions (particularly the 509.3 γ).

@ J $\pi=17/2+$ (1990Ba13,1994Va15) not compatible with 807.5 γ DCO and DCO values of γ transitions in the parallel sequence built on the 721 keV, 7/2+.

& From Adopted Levels.

^a From DSAM (1996Br33).

^b (A): Band based on 15/2-.

^c (B): Band based on 19/2+.

^d (C): Band based on 23/2+.

^e (D): Band based on 25/2-. Possible magnetic-dipole rotational (shears) band with configuration= $\nu h_{11/2}^{-1} \otimes \pi h_{11/2}^2$, as interpreted by 1996Br33 based on B(M1)/B(E2) values deduced from their lifetime measurements.

^f (E): Band based on 27/2.

^g (F): Band based on 33/2.

^h (G): $\nu i_{13/2}$ highly-deformed (intruder) band. Q=3.9 7 from DSAM analysis of 807.9, 885.7, 902.6, 908.0, 969.9 and 1061.0 transitions in this band (1996Ro04). An 1122 γ placed as the top transition in 1994Va15 is not confirmed by 1996Ro04, thus omitted here.

ⁱ (H): Band based on 37/2.

$\gamma(^{139}\text{Sm})$

All data are from 1996Ro04, except as noted.

The A_2 and A_4 coefficients are deduced by 1996Ro04 from $\gamma(0)$ data obtained at five angles from 90° to 150° in their previous experiment (reported in 1990Ba13) using ¹¹⁴Cd(²⁹Si,4n γ),E=128 MeV reaction.

The DCO values are from 1996Ro04. DCO(Q) are for gates on on stretched quadrupole transitions (or on a sum of consecutive stretched quadrupole transitions). DCO(D) are for gates on stretched dipole transitions (or on a sum of consecutive stretched dipole transitions). In two cases, DCO(D+Q) values are listed implying gate on a $\Delta J=1$, D+Q transition.

$\alpha(\text{exp})$ obtained from the analysis of a clean double-gated spectrum with gates set on the transitions belonging to the upper part of the band.

E γ	E(level)	I γ	Mult. [†]	α	Comments
43.6	267.6				
72.2	3327.5	6.0 12	M1 [‡]	4.32	$\alpha(\text{exp})=3.8$ 11 (1996Ro04).
91.0	2658.5	0.8 3			
108.2	2658.5	2.0 6	[§]		
108.3	1454.9	3.9 12	[§]		
112.0	111.8		D		$A_2=-0.20$ 3; $A_4=-0.07$ 5.
118.6	3445.9	12.3 20	M1 [‡]	1.039	$\alpha(\text{exp})=1.02$ 8 (1996Ro04). $A_2=-0.33$ 4; $A_4=+0.08$ 5. DCO(D)=1.08 17.
132.4	590.3	15.3 37	D		$A_2=-0.34$ 6; $A_4=-0.09$ 8. DCO(D)=0.97 15.
155.6	267.6		D		$A_2=-0.18$ 3; $A_4=-0.03$ 4. DCO(D)=0.94 15.
189.9	721.4	19.8 31	D [§]		DCO(Q)=0.53 10.
190.2	457.9		E3 [§]		
209.9	2868.4	29.6 35	D+Q		$A_2=-0.19$ 1; $A_4=-0.08$ 2. Negative sign of A_4 is inconsistent with $\Delta J=1$ transition. DCO(Q)=0.79 10.
214.8	3315.6	49 6	D		$A_2=-0.20$ 1; $A_4=-0.06$ 1. DCO(Q)=0.52 5.
222.8	3554.7	1.7 6	(E2)		DCO(D)=1.98 80.

Continued on next page (footnotes at end of table)

$^{110}\text{Pd}(^{34}\text{S},5\text{n}\gamma)$ 1996Ro04,1996Br33,1994Va15 (continued) $\gamma(^{139}\text{Sm})$ (continued)

E_γ	E(level)	I_γ	Mult. [†]	Comments
223.9	224.0			
227.2	3327.5	1.7 5	D	DCO(D)=1.02 20.
232.3	3100.8	20.1 25	D	$A_2=-0.22$ 2; $A_4=-0.02$ 3. DCO(D)=0.94 10.
243.8	5407.9	4.2 9	D	DCO(D)=1.21 25.
251.1	4696.5	0.9 3		
260.1	2550.5	9.0 11		DCO(D+Q)=1.13 20.
263.9	531.7	4.0 11		
265.0	3710.9	24.5 27	D	DCO(D)=1.03 9.
267.6	267.6		(E2)	DCO(Q)=1.09 10.
270.0	3554.7	8.7 15	(E2)	DCO(D)=2.01 25.
271.8	1346.7	8.7 10	D	$\Delta J=0$ transition. DCO(Q)=0.81 20.
302.0	5714.3	0.8 3	(E2)	DCO(Q)=0.85 25.
319.0	5726.9	6.4 13	D	DCO(D)=1.10 15.
337.3	4048.0	20.2 23	D	DCO(D)=0.97 7. B(M1)=1.8 6 (1996Br33).
342.3	2909.3	1.7 4		
344.5	3445.9	1.7 5	D	DCO(D)=0.80 27.
368.0	2658.5	45 5	(E2)	$A_2=+0.13$ 1; $A_4=-0.01$ 2. DCO(Q)=0.96 10.
379.7	1454.9	20.5 23	(E2)	$A_2=+0.15$ 5; $A_4=-0.21$ 7. DCO(Q)=1.01 7.
383.5	3710.9	1.1 4		
384.2	2583.2	34.8 36	(E2)	$A_2=+0.46$ 2; $A_4=-0.12$ 3. DCO(D)=2.05 18.
392.4	5089.0	2.5 6	(E2)	DCO(Q)=0.79 35.
395.1	6122	2.9 6	D	DCO(D)=0.82 25.
399.3	6126	4.9 11	D	DCO(D)=1.02 15.
409.4	4457.5	11.1 15	D	B(M1)=1.5 5 (1996Br33). DCO(D)=0.95 10.
410.4	2290.6	12.9 14	(E2)	DCO(Q)=0.93 10.
416.5	1137.8	43 4	(E2)	$A_2=+0.26$ 2; $A_4=+0.07$ 2. Positive sign of A_4 is inconsistent with $\Delta J=2$, Q transition. DCO(D)=1.86 20.
419.5	2199.0	42 4	D	DCO(Q)=0.52 5.
420.3	531.7	18.1 31	D	DCO(D)=1.19 25.
421.0	3736.7	45 5	(E2)	DCO(Q)=1.02 7.
434.1	3255.2	11.0 13		DCO(Q)=0.89 15.
441.9	3100.8	49 5	(E2)	DCO(Q)=1.08 10. $A_2=+0.12$ 2; $A_4=-0.05$ 3. A_2, A_4 : corrected for a 50% contribution from a 441.9 E2 γ in ^{140}Sm .
453.8	721.4	20.5 32	D+Q	$A_2=-0.72$ 3; $A_4=+0.51$ 4. DCO(Q)=0.57 10.
460.1	4014.8	6.3 18	(E2)	DCO(Q)=0.87 30.
470.9	2250.1	2.0 7		
472.6	4930.2	6.5 12	D	B(M1)=1.2 4 (1996Br33). DCO(D)=0.96 9.
477.5	1067.8	1.5 5		
481.0	3349.5	6.2 12		DCO(D+Q)=1.87.
490.7	6617	3.8 8	D	DCO(D)=1.01 20.
491.3	5935.1	1.5 4		
494.5	6617	1.5 5	D	DCO(D)=0.90 25.
506.4	3327.5	6.7 13	D	DCO(D)=1.09 13.
509.3	2290.6	54 5	D+Q	DCO(Q)=0.72 10.
513.5	5443.7	3.4 7	D	DCO(D)=1.05 11.
514.0	1969.0	27.9 29	(E2)	$A_2=+0.14$ 2; $A_4=-0.02$ 3. DCO(Q)=0.98 7.
515.8	1581.9	5.6 6	D	DCO(Q)=0.52 8.
519.5	4882.0	5.5 15	D	DCO(Q)=0.65 18.
526.0	5407.9	2.0 6	D	DCO(D)=0.90 20.
531.5	531.7	4.5 10	(E2)	DCO(D)=1.89 15.
534	1581.9	0.8 4		

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$^{110}\text{Pd}(^{34}\text{S},5\text{n}\gamma)$ 1996Ro04,1996Br33,1994Va15 (continued) $\gamma(^{139}\text{Sm})$ (continued)

E_{γ}	E(level)	I_{γ}	Mult. [†]	Comments
542.5	4882.0	5.3 15	D	DCO(Q)=0.53 15.
547.4	1137.8	32.2 32	D	$A_2=-0.15$ 1; $A_4=+0.05$ 2. DCO(D)=0.94 10.
550.7	5963.0	2.3 5	D	DCO(Q)=0.43 11.
560.0	6495.1	1.2 4		
560.5	7177	1.2 4	D	DCO(D)=1.17 25.
577.2	7194	2.7 9	D	DCO(D)=0.89 25.
583.5	3255.2	6.9 13	D	DCO(Q)=0.48 7.
590.0	1048.0	100.0	(E2)	$A_2=+0.31$ 1; $A_4=-0.08$ 2. DCO(Q)=1.01 5.
601.9	4048.0	5.9 9	(E2)	Mult.: D,E2 from comparison to RUL; $\Delta J\pi=2$, from level scheme. B(E2)=0.39 13 (1996Br33).
608.2	1066.0	27.0 32	D+Q	$A_2=-1.19$ 12; $A_4=+0.27$ 17. DCO(Q)=0.37 8.
609.5 [#]	3518.7	11.2 14	Q	DCO(Q)=0.94 10.
618.5 [#]	2909.3	11.6 15	Q	DCO(Q)=1.03 10.
625.3	5714.3	12.8 15	Q	DCO(Q)=0.96 8.
625.4	3445.9	1.8 5	Q	DCO(Q)=1.70 40.
643.7	1781.3	66 7	Q [§]	DCO(Q)=1.10 19.
644.1	5089.0	25.3 28	Q [§]	DCO(Q)=0.94 9.
646.2	4164.9	9.9 14	Q	DCO(Q)=1.02 10.
656	3327.5	0.7 4		
662.0	8069.2	1.5 5		
668.5	2250.1	4.2 6	Q	DCO(D)=2.04 25.
669.1	3327.5	2.0 6		
680.0	4844.8	7.4 10	Q	DCO(Q)=1.04 9.
682.5	5963.0	4.3 10	Q	DCO(Q)=1.03 12.
689.5	2658.5	27.5 29	Q	DCO(Q)=1.02 10.
701.3	8069.2	1.5 5		
701.6	3284.8	13.6 16	D	DCO(Q)=0.46 6.
708.1	4445.0	34 4	Q	DCO(Q)=0.99 7.
708.4	2290.6	1.0 3		
713.5	1781.3	1.5 5		
713.7	1779.5	16.6 17	Q	DCO(D)=1.82 25.
722.0	5579.4	1.5 4	(Q)	DCO(D)=1.50 75.
731.6	1779.5	44.0 31	D+Q	$A_2=-0.83$ 2; $A_4=+0.06$ 3. DCO(Q)=0.27 3.
734.6	5579.4	7.0 10	Q	DCO(Q)=0.97 10.
740	5323.0	1.0 3	D	DCO(D)=1.06 20.
742.1	1880.0	13.7 15	D	DCO(Q)=0.61 11.
746.6	4457.5	4.0 8	(E2)	Mult.: D,E2 from comparison to RUL; $\Delta J\pi=2$ from level scheme. B(E2)=0.23 8 (1996Br33).
748.6	3331.9	5.0 10	D	DCO(Q)=0.41 19.
775.6	4125.1	4.6 12	Q	DCO(Q)=1.14 15.
775.8	6490.2	8.8 13	Q	DCO(Q)=1.04 9.
784.3	4339.2	2.8 5		
786.2	2567.4	5.7 6	Q	DCO(Q)=1.08 25.
787.5	2658.5	3.0 9		
800.5	2671.5	9.8 13	D	DCO(Q)=0.54 9.
807.5	1075.1	34.9 36	Q	DCO(Q)=0.98 7.
807.9	6387.3	7.7 8	Q	DCO(Q)=1.02 11.
808.3	4362.8	3.1 7	D	DCO(D)=1.22 40.
822.9	1870.9	48.1 34	Q	$A_2=+0.26$ 2; $A_4=-0.17$ 3. DCO(Q)=0.98 6.
827.7	3410.9	13.7 16	Q	DCO(Q)=1.01 11.
835.2	4120.0	3.1 8	Q	DCO(D)=1.67 50.
835.4	5280.5	4.6 6	D	DCO(Q)=0.61 15.
846.3	4583.0	3.9 6	D	DCO(Q)=0.55 10.
877.8	7367.9	3.2 6	Q	DCO(Q)=0.84 20.
880.1	8287	0.8 3		
882.3	4930.2	4.6 9	(E2)	B(E2)=0.25 8 (1996Br33).
885.7	7273.0	3.1 6	Q	Mult.: D,E2 from comparison to RUL (evaluators); $\Delta J\pi=2$, from level scheme. DCO(Q)=0.91 15.

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$^{110}\text{Pd}(^{34}\text{S},5\text{n}\gamma)$ 1996Ro04,1996Br33,1994Va15 (continued) $\gamma(^{139}\text{Sm})$ (continued)

E_γ	E(level)	I_γ	Mult. [†]	Comments
891.9	2671.5	6.9 10	Q	DCO(D)=2.09 35.
902.6	8175.6	2.3 5	Q	DCO(Q)=1.04 18.
908.0	9084	1.9 5	Q	DCO(Q)=0.95 18.
917.0	7407.2	4.3 8	Q	DCO(Q)=0.96 10.
928.1	4339.2	7.0 12	Q	DCO(Q)=0.98 9.
937.6	6900.6	3.4 7	Q	DCO(Q)=1.05 15.
950.1	2820.9	23.7 24	Q	DCO(Q)=0.97 7.
952.1	4362.8	6.0 13	Q	DCO(Q)=1.35 40.
960.0	4696.5	2.5 6	(Q)	DCO(Q)=0.85 40.
967.4	5412.4	6.7 11	Q	DCO(Q)=0.98 12.
969.9	10054	1.6 5	Q	DCO(Q)=1.08 22.
986.2	5443.7	2.3 6		
987	7235.0	0.8 3		
1005.0	5935.1	3.4 10		
1005.2	3255.2	7.6 13	Q	DCO(Q)=2.15 25.
1014.8	6103.8	1.0 3		
1021.2	5146.3	1.3 4	Q	DCO(Q)=1.07 30.
1039.4	5484.4	1.2 4	Q	DCO(Q)=1.05 77.
1044	5164.1	0.9 3		
1051.4	6495.1	1.5 5		
1061.0	11115	1.5 4	Q	DCO(Q)=90 26.
1066	6155.0	1.0 3		
1079.0	1346.7	5.3 6	Q	DCO(Q)=0.96 15.
1108.0	4844.8	1.5 4	D	DCO(Q)=0.51 15.
1108.5	9396	0.8 4		
1118	8525	0.9 3		
1120.7	4857.4	2.0 5	D	DCO(Q)=0.55 18.
1131	8031.6	1.1 3		
1159	6248.0	1.4 4		
1189.9	6602.3	1.1 3		
1201.7	2250.1	1.9 7		
1242.9	2290.6	1.8 4	D	DCO(Q)=0.48 15.
1384.2	3255.2	9.4 11	Q	$A_2=+0.30$ 5; $A_4=-0.15$ 7. DCO(Q)=0.96 10.

[†] From DCO and $\gamma(\theta)$, except as noted. Mult=Q indicates stretched quadrupole (most likely E2) and mult=D or D+Q indicates $\Delta J=1$, dipole. For γ transitions up to 600 keV, stretched quadrupoles are assigned (E2) from RUL for E2 and M2, assuming that level half-lives are less than 10 ns.

[‡] From comparison of $\alpha(\text{exp})$ (1996Ro04) to theory.

[§] $A_2=+0.10$ 9, $A_4=0$ for 108.2+108.3 γ rays. $A_2=-0.05$ 3, $A_4=-0.09$ 4 for 190.2+189.9 γ 's. $A_2=+0.11$, $A_4=+0.06$ for 643.7+644.1 γ rays.

[#] 1994Va15 considered 609.5 γ as a linking transition. Present work indicates that it is a member of the highly deformed band and that 618.5 γ is the linking transition.

Adopted Levels, Gammas

Q(β⁻)=-7770 SY; S(n)=11720 30; S(p)=1189 18; Q(α)=2200 70 2012Wa38.

Estimated ΔQ(β⁻)=200 (2012Wa38).

S(2n)=21420 200 (syst), S(2p)=5903 19, Q(εp)=2250 30 (2012Wa38).

2000Be42, 1997Be63; Mass measurements.

¹³⁹Eu Levels

Cross Reference (XREF) Flags

A ¹³⁹Gd ε Decay (5.8 s)

B ¹³⁹Gd ε Decay (4.8 s): ?

C ¹⁴⁰Tb εp Decay (2.0 s)

D ⁹²Mo(⁵⁰Cr,3pγ)

E ⁹²Mo(⁵⁰Cr,3pγ), ¹¹⁰Cd(³²S,p2nγ)

F ⁹²Mo(⁵⁴Fe,5p2nγ)

E(level)	Jπ [†]	XREF	T _{1/2} [‡]	Comments
0.0&	(11/2)-	ABCDEF	17.9 s 6	%ε+%β ⁺ =100. μ=6.1 8 (1992Si22,2014StZZ). RMS charge radius <r ² > ^{1/2} =4.9760 fm 93 (2013An02 evaluation). Jπ: allowed ε decay to 11/2-.
				T _{1/2} : from 1986De35. Others: 24 s 5 (1986Re11) and 22 s 3 (1973WeZK, Gd(p,pxn), E(p)=600 MeV. ISOLDE; β ⁺ (t), x(t)). See ¹³⁹ Eu ε decay for details.
				μ: nuclear orientation with γ detected (1992Si22).
				1987Al25 measured hyperfine structure.
116.16 15	(13/2-)	A D F		
121.61 18	(9/2-)	B F		
148.3 3	(7/2+)	B F	10 μs 2	%IT=100.
				T _{1/2} : from (recoils)γ(t) (2011Cu01).
206.66 25		A		
281.0 4		A		
319.46 22		AB		
322.85& 6	(15/2-)	A CDE	36.0 ps 21	
346.5 4	(11/2+)	F		
406.7 4		A		
426.68 8	(13/2-)	A CD		
468.5 4		B		
507.8 4		B		
530.30 ^b 7	(13/2-)	CD		
553.0 4		B		
588.1 11		A		
664.1 4		B		
675.1 4		B		
690.6 4		B		
808.7 4		B		
835.4 4	(15/2+)	F		
865.42 ^c 10	(15/2-)	D		
876.93& 11	(19/2-)	CDE	2.77 ps 35	
969.33 ^b 9	(17/2-)	D		
1025.4 5		B		
1039.88 ^d 13	(17/2-)	D		
1417.7 8	(19/2+)	F		
1438.03 ^c 11	(19/2-)	D		
1589.37& 16	(23/2-)	DE	1.52 ps 35	
1623.45 ^b 12	(21/2-)	D		
1811.99 ^d 24	(21/2-)	D		
1890.80 [#] 18	(19/2+)	D		
2011.6 9	(23/2+)	F		
2212.63 ^c 15	(23/2-)	D		
2228.0 [§] 3	(21/2+)	D		
2345.12 [#] 17	(23/2+)	D		
2406.25& 17	(27/2-)	DE		
2431.53 ^b 15	(25/2-)	D		
2482.3 10	(27/2+)	F		
2611.7 ^d 4	(25/2-)	D		
2693.91 ^a 19	(27/2-)	D		
2699.84 [§] 20	(25/2+)	D		
2878.19 [#] 19	(27/2+)	D		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

¹³⁹Eu Levels (continued)

E(level)	Jπ [†]	XREF	E(level)	Jπ [†]	XREF	E(level)	Jπ [†]	XREF
3097.31 ^a 19	(31/2-)	DE	3969.85 [§] 22	(33/2+)	D	5211.5 [@] 3	(37/2-)	D
3137.5 11	(31/2+)	F	4117.5 4	(33/2-)	D	5701.5 [§] 4	(41/2+)	D
3142.1 ^c 4	(27/2-)	D	4282.07 [@] 22	(33/2-)	D	5937.3 ^a 3	(43/2-)	D
3266.85 [§] 19	(29/2+)	D	4352.09 [#] 24	(35/2+)	D	6149.5 [#] 4	(43/2+)	D
3338.43 ^b 25	(29/2-)	D	4722.4 4	(37/2-)	D	6222.5 [@] 5	(41/2-)	D
3358.47 [@] 19	(29/2-)	D	4765.22 ^a 24	(39/2-)	D	6715.6 [§] 5	(45/2+)	D
3561.49 [#] 21	(31/2+)	D	4787.3 [§] 3	(37/2+)	D	7190.3 [#] 4	(47/2+)	D
3809.72 ^a 21	(35/2-)	D	5210.0 [#] 3	(39/2+)	D	7265.5 ^a 10	(47/2-)	D

[†] Except for the g.s., from DCO ratios in ⁹²Mo(⁵⁰Cr,3pγ) and systematics of other odd-proton, even-neutron nuclides in this mass region (parentheses added by evaluators). See comments for the individual bands for additional details.

[‡] From recoil-distance Doppler shift (RDDS) (1988Bi03) in ⁹²Mo(⁵⁰Cr,3p), ¹¹⁰Cd(³²S,Xγ), except as noted.

[§] (A): ΔJ=2 band based on 21/2+, α=+1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. Average DCO ratio of 0.41 4 for γ rays feeding the yrast band are consistent with a pure dipole character implying a band starting at 21/2.

[#] (B): ΔJ=2 band based on 19/2+, α=-1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. DCO ratios of the three γ's feeding out of this band suggest either ΔJ=2 or ΔJ=0. The energy spacings and comparable Iγ values of this band and the ΔJ=2 band with J=21/2+ bandhead suggests the two bands are signature partners with a relatively small signature splitting. If this is true, this band most likely feeds out with a ΔJ=0 γ and, therefore, has a bandhead J=19/2 since ΔJ=2 would imply a very large signature splitting. π=+ is most likely for these two bands since stretched ΔJ=2 γ's were not observed in the decay out of the band based on 21/2+.

[@] (C): ΔJ=2 band based on 29/2-. Feeds out mainly into the yrast band through the 952γ. A weak 927γ from the first member of this band to 25/2- rules out ΔJ=2 for the 952γ and requires π=- for this band if the 952γ is ΔJ=1. From the DCO ratio for 952γ+956γ and the expected stretched E2 character of the 956γ, the 952γ is not stretched E2 in character and, most likely, is not pure dipole. This implies a mixed ΔJ=1 transition and Jπ=29/2-. If the 952γ were of a strongly mixed ΔJ=0 character, a bandhead Jπ=27/2- would be implied, placing the band too far above the yrast band to explain its considerable intensity.

[&] (D): Yrast band based on g.s. This band was established by 1985Lu06 and 1988Bi03 up to 31/2-. 1995Va22 extend the γ cascade to (47/2)-, with the interpretation that the yrast band undergoes backbend at 691-keV transition. DCO ratios of in-band γ rays through the 35/2- state are consistent with stretched quadrupole transitions. A separate band is defined by 1995Va22 above the 31/2- state.

^a (E): ΔJ=2 band based on 27/2-. This band is an extension of the yrast band based on g.s.

^b (F): ΔJ=2 band based on 13/2-. DCO ratios of in-band γ rays are consistent with stretched Q transitions. DCO ratios of γ rays feeding the yrast band suggest (M1+E2) admixture, implying a band starting at Jπ=13/2-.

^c (G): ΔJ=2 band based on 15/2-. This band decays by several transitions into the yrast band and a ΔJ=2 band based on 13/2-. The 865γ (to g.s.) DCO ratio suggests stretched Q and 335γ and 469γ to ΔJ=2 band based on 13/2- are consistent with ΔJ=1. This decay structure implies a band starting at Jπ=15/2-.

^d (H): ΔJ=2 band based on 17/2-. This band depopulates through the 613γ whose DCO ratio is consistent with stretched Q into a 13/2- state.

γ(¹³⁹Eu)

E(level)	Eγ [†]	Iγ [†]	Mult. ^{‡d}	α	Comments
116.16	116.1 2	100	(M1+E2)	1.31 11	Eγ is Weighted av. (external) from ¹³⁹ Gd β ⁺ decay (5.8 s) and ⁹² Mo(⁵⁰ Cr,3pγ). Eγ=117.2 1 in ⁹² Mo(⁵⁴ Fe,5p2nγ) (2011Cu01) seems discrepant, too high by ≈1 keV.
121.61	(4.6)				Eγ: existence of this transition implied by γγ-coin data in ⁹² Mo(⁵⁴ Fe,5p2nγ) (2011Cu01).
	121.6 [§] 2	100 11	(E2)	1.199 19	Mult.: from conversion coefficient measurement in ⁹² Mo(⁵⁴ Fe,5p2nγ) (2011Cu01).
148.3	26.7 [§] 2	100	(E1)	1.85 5	Mult.: from conversion coefficient measurement in ⁹² Mo(⁵⁴ Fe,5p2nγ) (2011Cu01).
206.66	90.5 [#] 2				
281.0	74.3 [#] 3				
319.46	197.8 ^{§e} 2				
	203.4 ^{#e} 3				
322.85	322.85 [@] 8	100	(E2)	0.0465	B(E2)(W.u.)=100 6.
346.5	198.2 ^c 2	100 ^c			
406.7	200.0 [#] 3				
426.68	103.9 ^{&} 1	11 6	(M1+E2)	1.88 23	
	310.42 24	21 6	(M1+E2)	0.066 14	
	426.7 1	100 11	D+Q		

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Eu})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult. ^{‡d}	α	Comments
468.5	149.0 $\S$ 3				
507.8	386.2 $\S$ 3				
530.30	207.5 1	11.1 19	(M1+E2)	0.214 24	
	530.3 1	100 13	D+Q		
553.0	431.4 $\S$ 3				
588.1	471.9 $\S$				
664.1	542.5 $\S$ 3				
675.1	553.5 $\S$ 3				
690.6	371.1 $\S$ 3				
808.7	489.2 $\S$ 3				
835.4	488.9 $\S$ 2	100 c			
865.42	335.1 1	88 7	D+Q		
	439.0 2	56 7	D+Q		
	542.8 2	100 7	D+Q		
	865 1	50 13	Q		
876.93	554.1 a 1	100	(E2)	0.01022	B(E2)(W.u.)=91 12.
969.33	439.1 1	50.0 13	(E2)		
	646.3 1	100 3	D+Q		
1025.4	903.8 $\S$ 4				
1039.88	613.2 1	100	Q		
1417.7	582.3 c 7	100 c			
1438.03	468.6 1	47 3	D+Q		
	572.7 1	100 6	(E2)		
1589.37	712.44 a 22	100	(E2)		B(E2)(W.u.)=47 11.
1623.45	654.1 1	100.0 23	Q		
	746.9 3	19.3 23	D+Q		
1811.99	772.1 2	100	Q		
1890.80	1013.8 2	100	(D)		
2011.6	593.9 c 3	100 c			
2212.63	774.6 1	100	Q		
2228.0	1350.8 5	100	D		
2345.12	454.3 1	18.0 12	(E2)	0.01732	
	755.8 1	100.0 12	D		
2406.25	816.88 b 9	100	Q		
2431.53	808.1 1	100.0 26	Q		
	842.1 2	38.0 26			
2482.3	470.7 c 4	100 c			
2611.7	799.7 3	100	(Q)		
2693.91	287.6 1	13.1 17	D+Q		
	1104.4 2	100 5	Q		
2699.84	471.8 f 2	17.5 f 18			
	1110.5 2	100 6	D		
2878.19	471.8 f 2	11.3 f 13	D		
	533.1 1	100.0 13	(E2)	0.01131	
3097.31	403.3 1	8.0 7	(E2)	0.0242	
	691.14 b 9	100.0 13	Q		
3137.5	655.2 c 4	100 c			
3142.1	929.5 3	100	Q		
3266.85	567.0 1	97 4	(E2)		
	860.6 1	100 7	D		
3338.43	906.9 2	100	Q		
3358.47	927.1 4	13.4 14			
	952.2 1	100.0 21	D+Q		
3561.49	683.3 1	100	Q		
3809.72	712.4 1	100	Q		
3969.85	703.0 1	100	Q		
4117.5	779.1 3	100			
4282.07	923.6 1	100			
4352.09	790.6 1	100	Q		
4722.4	912.7 3	100	D+Q		
4765.22	955.5 1	100	(Q)		
4787.3	817.4 2	100			
5210.0	857.9 1	100			

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Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Eu})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$
5211.5	929.4 2	100
5701.5	914.2 2	100
5937.3	1172.1 2	100
6149.5	939.5 2	100
6222.5	1011.0 3	100
6715.6	1014.1 3	100
7190.3	1040.8 2	100
7265.5	1328.2 9	100

[†] From $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$, except as noted.

[‡] From DCO in $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$ (parentheses added by evaluators), except as noted.

[§] From ^{139}Gd β^+ decay (4.8 s).

[#] From ^{139}Gd β^+ decay (5.8 s).

[@] Weighted av. (external) from ^{139}Gd β^+ decay (5.8 s), $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$, and $^{92}\text{Mo}(^{50}\text{Cr},3p),^{110}\text{Cd}(^{32}\text{S},X\gamma)$.

[&] Weighted av. (internal) from ^{139}Gd β^+ decay (5.8 s) and $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$.

^a Weighted av. (external) from $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$ and $^{92}\text{Mo}(^{50}\text{Cr},3p),^{110}\text{Cd}(^{32}\text{S},X\gamma)$.

^b Weighted av. (internal) from $^{92}\text{Mo}(^{50}\text{Cr},3p\gamma)$ and $^{92}\text{Mo}(^{50}\text{Cr},3p),^{110}\text{Cd}(^{32}\text{S},X\gamma)$.

^c From $^{92}\text{Mo}(^{54}\text{Fe},5p2n\gamma)$.

^d Assigned by the evaluators based on the DCO values in 1995Va22 for $\Delta J=2$ and $\Delta J=1$ transitions. Below 600 keV, RUL for E2 and M2 transitions is used to assign (E2) for stretched quadrupoles and below 300 keV, (M1+E2) for $\Delta J=1$ transitions, with the assumption that level half-lives are less than ≈ 10 ns. 1995Va22 assigned E2 for stretched quadrupoles, M1+E2 for $\Delta J=1$, mixed transitions, and E1 for $\Delta J=1$, dipole transitions. For γ rays where no DCO values were available, 1995Va22 assigned multipolarities as implied by their $J\pi$ values.

^e Placement of transition in the level scheme is uncertain.

^f Multiply placed; intensity suitably divided.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

¹³⁹Gd ε Decay (5.8 s) 1999Xi04

Parent ¹³⁹Gd: E=0.0; Jπ=(9/2-); T_{1/2}=5.8 s 9; Q(g.s.)=7770 syst; %ε+%β⁺ decay=100.
¹³⁹Gd-J,T_{1/2}: From ¹³⁹Gd Adopted Levels.
¹³⁹Gd-Q(ε): 7770 200 (syst,2012Wa38).
Measured γγ(t), (x ray)γ(t); He-jet; Ge(HP) detectors.

¹³⁹Eu Levels

E(level)	Jπ [†]	T _{1/2} [†]
0.0	(11/2-)	17.9 s 6
115.94 19	(13/2-)	
206.4 3		
280.7 4		
319.3 4		
322.2 3	(15/2-)	
406.4 4		
426.0 3	(13/2-)	
587.8 4		

[†] From the Adopted Levels.

γ(¹³⁹Eu)

Eγ	E(level)	Mult. [†]	α
74.3 3	280.7		
90.5 2	206.4		
104.1 3	426.0	(M1+E2)	1.87 23
115.8 2	115.94	M1+E2	1.32 11
200.0 3	406.4		
203.4 3	319.3		
309.7 3	426.0	(M1+E2)	0.067 14
322.5 3	322.2	(E2)	0.0466
471.9 3	587.8		

[†] From the Adopted Gammas.

Decay Scheme

¹³⁹Gd ε Decay (4.8 s): ? 1999Xi04

Parent ¹³⁹Gd: E=0+x; Jπ=?; T_{1/2}=4.8 s 9; Q(g.s.)=7770 syst; %ε+%β⁺ decay=100.
¹³⁹Gd-E: Uncertain isomer.
¹³⁹Gd-Q(ε): 7770 200 (syst,2012Wa38).
The existence of this isomer is treated as uncertain by the evaluators.
Measured γγ(t), (x ray)γ(t); He-jet; Ge(HP) detectors.

¹³⁹Eu Levels

E(level)	Jπ [†]	T _{1/2} [†]	E(level)	E(level)
0.0	(11/2)-	17.9 s 6	468.4 5	675.1 4
121.60 20			507.8 4	690.5 5
148.3 3	(7/2+)	10 μs 2	553.0 4	808.6 5
319.4 3			664.1 4	1025.4 5

[†] From the Adopted Levels.

γ(¹³⁹Eu)

Eγ	E(level)	Eγ	E(level)	Eγ	E(level)
26.7 2	148.3	371.1 3	690.5	542.5 3	664.1
121.6 2	121.60	386.2 3	507.8	553.5 3	675.1
149.0 3	468.4	431.4 3	553.0	903.8 4	1025.4
197.8 2	319.4	489.2 3	808.6		

Decay Scheme

^{140}Tb ϵp Decay (2.0 s) 2006Xu03

Parent ^{140}Tb : $E=0.0$; $J\pi=7+$; $T_{1/2}=2.0$ s 5; $Q(\text{g.s.})=7630$ 800; $\% \epsilon\text{p}$ decay=0.26 13.

$^{140}\text{Tb}-T_{1/2}$: From 2006Xu03.

$^{140}\text{Tb}-J$: From 2006Xu03 based on comparison of calculated proton branches with measured values. 7- is also possible, but possible configuration= $\nu 9/2[514] \otimes \pi 5/2[532]$ is assigned to this state.

$^{140}\text{Tb}-\% \epsilon\text{p}$ decay: $\% \epsilon\text{p}=0.26$ 13 from Adopted Levels of ^{140}Tb .

2006Xu03 (also 2003Xu04): ^{140}Tb produced from fusion evaporation reaction: $^{106}\text{Cd}(^{40}\text{Ca}, \alpha\text{pn})$ at $E=232$ MeV. Measured $\text{p}\gamma$ -coin, lifetimes. Isotopic half-life extracted from decay curve.

^{139}Eu Levels

E(level)	$J\pi^\dagger$
0.0	(11/2-)
323.0 10	(15/2-)
427.0 10	(13/2-)
531.0 10	(13/2-)
877.0 15	(19/2-)

† From Adopted Levels.

Delayed protons

E(^{139}Eu)	I(p) †‡	Comments
323.0 10	30 4	I(p): Normalized to 30 by 2006Xu03.
427.0 10	12 3	
531.0 10	8.5 20	
877.0 15	<1	

† Relative values, normalized to 30 for proton branch to 323 level (2006Xu03). Proton branch to the ground state could not be measured in this work as the data were obtained as $\text{p}\gamma$ -coincidences.

‡ Absolute intensity per 100 decays.

$\gamma(^{139}\text{Eu})$

E_γ	E(level)
323	323.0
427	427.0
531	531.0
554	877.0

Decay Scheme

⁹²Mo(⁵⁰Cr,3pγ) 1995Va22

1995Va22: E=220 MeV. Measured Eγ, Iγ, γγ, γγ(θ)(DCO) using TESSA3 array of 16 Compton-suppressed HPGe detectors with a 50-element BGO multiplicity filter. Deduced high-spin levels, Jπ, bands, alignments. Total routhian surface calculations.

¹³⁹Eu Levels

E(level)	Jπ [†]	E(level)	Jπ [†]	E(level)	Jπ [†]
0.0 [@]	11/2-	2344.96 [§] 16	23/2+	4281.92 [#] 21	(33/2-)
116.19 8	13/2-	2406.10 [@] 16	27/2-	4351.93 [§] 23	35/2+
322.83 [@] 7	15/2-	2431.44 ^a 14	25/2-	4722.2 4	37/2-
426.69 7	13/2-	2611.7 ^c 4	25/2-	4765.03 ^{&} 22	(39/2-)
530.29 ^a 8	13/2-	2693.74 ^{&} 17	27/2-	4787.1 [‡] 3	(37/2+)
865.41 ^b 10	15/2-	2699.69 [‡] 18	25/2+	5209.84 [§] 25	(39/2+)
876.85 [@] 12	19/2-	2878.03 [§] 18	27/2+	5211.3 [#] 3	(37/2-)
969.31 ^a 9	17/2-	3097.12 ^{&} 17	31/2-	5701.3 [‡] 4	(41/2+)
1039.89 ^c 12	17/2-	3142.1 ^b 4	27/2-	5937.1 ^{&} 3	(43/2-)
1438.01 ^b 11	19/2-	3266.70 [‡] 17	29/2+	6149.3 [§] 4	(43/2+)
1589.19 [@] 14	23/2-	3338.35 ^a 25	29/2-	6222.3 [#] 5	(41/2-)
1623.39 ^a 12	21/2-	3358.32 [#] 18	29/2-	6715.4 [‡] 5	(45/2+)
1811.99 ^c 24	21/2-	3561.33 [§] 20	31/2+	7190.1 [§] 4	(47/2+)
1890.66 [§] 17	19/2+	3809.52 ^{&} 20	35/2-	7265.3 ^{&} 10	(47/2-)
2212.61 ^b 15	23/2-	3969.70 [‡] 20	33/2+		
2227.86 [‡] 25	21/2+	4117.5 4	(33/2-)		

[†] As proposed by 1995Va22 from DCO ratios and systematics of odd-proton, even-neutron nuclides in this mass region. See the footnotes on the individual bands for additional details. The assignments in Adopted Levels differ only in their being placed under parentheses due to lack of strong arguments even for the g.s.

[‡] (A): ΔJ=2 band based on 21/2+, α=+1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. Average DCO ratio of 0.41 4 for γ rays feeding the yrast band are consistent with a pure dipole character implying a band starting at 21/2.

[§] (B): ΔJ=2 band based on 19/2+, α=-1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. DCO ratios of the three γ's feeding out of this band suggest either ΔJ=2 or ΔJ=0. The energy spacings and comparable Iγ values of this band and the ΔJ=2 band with J=21/2+ bandhead suggests the two bands are signature partners with a relatively small signature splitting. If this is true, this band most likely feeds out with a ΔJ=0 γ and, therefore, has a bandhead J=19/2 since ΔJ=2 would imply a very large signature splitting. π=+ is most likely for these two bands since stretched ΔJ=2 γ's were not observed in the decay out of the band based on 21/2+.

[#] (C): ΔJ=2 band based on 29/2-. Feeds out mainly into the yrast band through the 952γ. A weak 927γ from the first member of this band to 25/2- rules out ΔJ=2 for the 952γ and requires π=- for this band if the 952γ is ΔJ=1. From the DCO ratio for 952γ+956γ and the expected stretched E2 character of the 956γ, the 952γ is not stretched E2 in character and, most likely, is not pure dipole. This implies a mixed ΔJ=1 transition and Jπ=29/2-. If the 952γ were of a strongly mixed ΔJ=0 character, a bandhead Jπ=27/2- would be implied, placing the band too far above the yrast band to explain its considerable intensity.

[@] (D): Yrast band based on g.s. This band was established by 1985Lu06 and 1988Bi03 up to 31/2-. 1995Va22 extend the γ cascade to (47/2)-, with the interpretation that the yrast band undergoes backbend at 691-keV transition. DCO ratios of in-band γ rays through the 35/2- state are consistent with stretched quadrupole transitions. A separate band is defined by 1995Va22 above the 31/2- state.

[&] (E): ΔJ=2 band based on 27/2-. This band is an extension of the yrast band based on g.s.

^a (F): ΔJ=2 band based on 13/2-. DCO ratios of in-band γ rays are consistent with stretched Q transitions. DCO ratios of γ rays feeding the yrast band suggest (M1+E2) admixture, implying a band starting at Jπ=13/2-.

^b (G): ΔJ=2 band based on 15/2-. This band decays by several transitions into the yrast band and a ΔJ=2 band based on 13/2-. The 865γ (to g.s.) DCO ratio suggests stretched Q and 335γ and 469γ to ΔJ=2 band based on 13/2- are consistent with ΔJ=1. This decay structure implies a band starting at Jπ=15/2-.

^c (H): ΔJ=2 band based on 17/2-. This band depopulates through the 613γ whose DCO ratio is consistent with stretched Q into a 13/2- state.

γ(¹³⁹Eu)

DCO ratios are for 37° and 90° geometry. For gates on stretched quadrupole transitions, expected DCO is 1.0 for stretched quadrupole and 0.4 for stretched dipole.

Eγ	E(level)	Iγ	Mult. [‡]	α [†]	Comments
103.9 1	426.69	0.2 1	(M1+E2)	1.88 23	DCO=0.27 13.
116.2 1	116.19	0.7 1	(M1+E2)	1.31 11	DCO<1.
207.5 1	530.29	0.6 1	(M1+E2)	0.214 24	DCO=0.43 12.
287.6 1	2693.74	0.8 1	D+Q		DCO=0.70 20.
310.5 1	426.69	0.4 1	(M1+E2)	0.066 14	DCO=0.80 14.

Continued on next page (footnotes at end of table)

$^{92}\text{Mo}(^{50}\text{Cr},3\text{p}\gamma)$ 1995Va22 (continued) $\gamma(^{139}\text{Eu})$ (continued)

$E\gamma$	E(level)	$I\gamma$	Mult. [‡]	$\alpha^{\dagger}$	Comments
322.8 1	322.83	100.0 7	(E2)	0.0465	DCO=1.00 1.
335.1 1	865.41	1.4 1	D+Q		DCO=0.26 6.
403.3 1	3097.12	1.2 1	(E2)		DCO=1.20 20.
426.7 1	426.69	1.9 2	D+Q		DCO=0.38 22.
439.0 2	865.41	0.9 1	D+Q		DCO=1.6 8.
439.1 1	969.31	3.9 1	(E2)		DCO=1.30 34.
454.3 1	2344.96	1.6 1	(E2)		DCO=1.05 22.
468.6 1	1438.01	1.6 1	D+Q		DCO=0.27 7.
471.8§ 2	2699.69	1.0§ 1			
	2878.03	0.9§ 1	D		DCO=1.41 43.
					Mult.: $\Delta J=0$ transition. DCO value is probably for the doublet.
530.3 1	530.29	5.4 7	D+Q		DCO=0.25 5.
533.1 1	2878.03	8.0 1	(E2)		DCO=0.99 10.
542.8 2	865.41	1.6 1			
554.0 1	876.85	69.6 5	(E2)		DCO=1.06 1.
567.0 1	3266.70	3.1 1	(E2)		DCO=0.94 11.
572.7 1	1438.01	3.4 2	(E2)		DCO=1.07 17.
613.2 1	1039.89	4.3 2	Q		DCO=0.80 19.
646.3 1	969.31	7.8 2	D+Q		DCO=0.33 2.
654.1 1	1623.39	8.8 2	Q		DCO=1.04 7.
683.3 1	3561.33	7.6 2	Q		DCO=0.99 9.
691.1 1	3097.12	15.1 2	Q		DCO=0.97 6.
703.0 1	3969.70	7.7 2	Q		DCO=0.93 8.
712.3 1	1589.19	60.0 5	Q		DCO=0.95 1.
					DCO for 712.3+712.4.
712.4 1	3809.52	9.3 3	Q		DCO=0.95 1.
					DCO for 712.4+712.3.
746.9 3	1623.39	1.7 2	D+Q		DCO=0.38 8.
755.8 1	2344.96	8.9 1	D		DCO=0.98 8.
					Mult.: $\Delta J=0$ transition.
772.1 2	1811.99	3.3 2	Q		DCO=1.16 33.
774.6 1	2212.61	5.6 3	Q		DCO=0.85 15.
779.1 3	4117.5	1.6 2			
790.6 1	4351.93	5.7 2	Q		DCO=1.05 15.
799.7 3	2611.7	1.9 2	(Q)		DCO=0.71 19.
808.1 1	2431.44	7.9 2	Q		DCO=0.90 11.
816.9 1	2406.10	38.9 4	Q		DCO=0.88 2.
817.4 2	4787.1	3.2 3			
842.1 2	2431.44	3.0 2			
857.9 1	5209.84	4.2 2			
860.6 1	3266.70	3.2 2	D		DCO=0.40 5.
865 1	865.41	0.8 2	Q		DCO=1.06 24.
906.9 2	3338.35	5.1 2	Q		DCO=0.85 19.
912.7 3	4722.2	1.8 2	D+Q		DCO=0.23 6.
914.2 2	5701.3	2.8 2			
923.6 1	4281.92	7.0 2			
927.1 4	3358.32	1.9 2			
929.4 2	5211.3	3.5 2			
929.5 3	3142.1	2.3 2	Q		DCO=1.24 44.
939.5 2	6149.3	2.9 1			
952.2 1	3358.32	14.2 3	D+Q		DCO=0.70 5.
					DCO for 952.2+955.5.
955.5 1	4765.03	5.5 2	(Q)		DCO=0.70 5.
					DCO for 955.5+952.2 doublet.
1011.0 3	6222.3	2.1 2			
1013.8 2	1890.66	3.9 3	(D)		DCO=0.73 10.
1014.1 3	6715.4	2.3 2			
1040.8 2	7190.1	2.1 1			
1104.4 2	2693.74	6.1 3	Q		DCO=1.00 15.
1110.5 2	2699.69	5.7 3	D		DCO=0.38 7.
1172.1 2	5937.1	2.6 1			
1328.2 9	7265.3	0.7 1			
1350.8 5	2227.86	2.0 2	D		DCO=0.45 13.

Footnotes continued on next page

⁹²Mo(⁵⁰Cr,3pγ) 1995Va22 (continued)

γ(¹³⁹Eu) (continued)

† From BrIcc code. For M1+E2, value overlaps that for pure M1 and for pure E2.

‡ Assigned by the evaluators according to the expected DCO values for ΔJ=2 and ΔJ=1 transitions. Below 600 keV, RUL for E2 and M2 transitions is used to assign (E2) for stretched quadrupoles and below 300 keV, (M1+E2) for ΔJ=1 transitions, with the assumption that level half-lives are less than =10 ns. 1995Va22 assigned E2 for stretched quadrupoles, M1+E2 for ΔJ=1, mixed transitions, and E1 for ΔJ=1, dipole transitions. For γ rays where no DCO values were available, 1995Va22 assigned multipolarities as implied by their Jπ values.

§ Multiply placed; intensity suitably divided.

⁹²Mo(⁵⁰Cr,3pγ), ¹¹⁰Cd(³²S,p2nγ) 1988Bi03, 1985Lu06

1985Lu06: E(³²S)=126–170 MeV. Measured excitation functions (activation) for ¹⁰⁸Pd, ¹⁰⁹Ag, and ^{110,112}Cd targets.

¹¹⁰Cd(³²S,p2nγ) E=130, 143 MeV: measured Eγ, Iγ, γ(θ), and level lifetimes by recoil-distance Doppler shift (RDDS) method; Ge, NaI multiplicity filter.

1988Bi03: ⁹²Mo(⁵⁰Cr,3pγ) E=230 MeV. Measured Eγ, Iγ, γγ-coincidences; escape-suppressed Ge detectors. RDM.

Decay scheme is based on that suggested by 1985Lu06 and was confirmed and extended by 1988Bi03.

¹³⁹Eu Levels

E(level)	Jπ [†]	T _{1/2} [‡]	Comments
0.0	11/2-		
322.95 11	15/2-	36.0 ps 21	T _{1/2} : 36 ps 2 if side feeding and cascade feeding times are comparable, 37 ps 2 if side feeding time is <100 fs, with recommended value of 36.0 ps 21 (1988Bi03). Other: 36.8 ps 11 (1985Lu06).
877.13 15	19/2-	2.77 ps 35	T _{1/2} : 2.56 ps 28 if side feeding and cascade feeding times are comparable; 2.84 ps 35 if side feeding time is <100 fs, with recommended value of 2.77 ps 35 (1988Bi03). Other: 2.3 ps 5 (1985Lu06)
1589.88 22	23/2-	1.52 ps 35	T _{1/2} : 2.84 ps 21 with no corrections for feeding; 1.18 ps 21 or 1.87 21 if it is assumed that the 1590 and preceding levels have the same deformation, with recommended value of 1.52 ps 35 (1988Bi03). Other: 1.6 ps 4 (1985Lu06).
2406.7 3	27/2-		
3098.0 4	(31/2-)		
3569.1?§ 5	#		
4079.6?§ 6	#		
4835.0?§ 7	#		
5609.9?§ 8	#		

† As suggested by 1985Lu06 (based on γ(θ), multipolarity, and similarity to yrast band in ¹³⁸Sm), except as noted.

‡ From recoil-distance Doppler shift (RDDS) method (1988Bi03), where side feedings have been discussed in detail. Previously measured values from 1985Lu06 using the same method are given under comments. The two measurements are in general agreement, but 1985Lu06 did not discuss corrections for the side feedings.

§ Tentatively added to the yrast band by 1988Bi03. However, 1988Bi03 note that the transitions could arise from a separate band feeding the 3098 level.

(35/2-), (39/2-), (43/2-), and (47/2-) with assumed assignment of levels to yrast band, but the 471.1, 755.4 and 774.9 γ rays are placed from different levels, not members of the yrast structure in 1995Va22. The 510.5γ is not confirmed in 1995Va22. None of these levels is given in the Adopted dataset.

γ(¹³⁹Eu)

Coincidences are from 1988Bi03.

Eγ [†]	E(level)	Iγ [†]	Mult. [‡]	α
322.95 11	322.95	100 2	E2	0.0464
471.1§ 3	3569.1?	11 3		
510.5§ 3	4079.6?	9 2		
554.18 10	877.13	100 7	E2	0.01024
691.3 2	3098.0	22 4		
712.75 15	1589.88	91 6	E2	
755.4§ 4	4835.0?	15 3		
774.9§ 4	5609.9?	15 3		
816.8 2	2406.7	43 6		

Footnotes continued on next page

⁹²Mo(⁵⁰Cr,3pγ),¹¹⁰Cd(³²S,p2nγ) 1988Bi03,1985Lu06 (continued)

γ(¹³⁹Eu) (continued)

† From 1988Bi03.

‡ From γ(0) of 1985Lu06 and comparison to RUL.

§ Placement of transition in the level scheme is uncertain.

⁹²Mo(⁵⁴Fe,5p2nγ) 2011Cu01

2011Cu01: Measured Eγ, Iγ, (recoil)γ coin, isomer half-life using JUROGAM array of 40 HPGe detectors for prompt γ rays and GREAT planar and clover Ge detectors for delayed γ rays. Recoil-decay tagging method. Recoil products were transported to the focal plane of the gas-filled recoil-ion transport unit (RITU) and implanted into a 500-μm thick Al foil. Multiwire Proportional Counter (MWPC) used to detect recoils.

¹³⁹Eu Levels

E(level) [†]	Jπ [‡]	T _{1/2}	Comments
0.0	(11/2-)		
117.20 10	(13/2-)		
121.80 10	(9/2-)		
148.20 § 23	(7/2+)	10 μs 2	T _{1/2} : from time difference of the recoils and delayed γ rays (2011Cu01).
346.4 § 3	(11/2+)		
835.3 § 4	(15/2+)		
1417.6 § 8	(19/2+)		
2011.5 § 9	(23/2+)		
2482.2 § 10	(27/2+)		
3137.4 § 11	(31/2+)		

† From Eγ data.

‡ As proposed by 2011Cu01 based on multiplicities determined from experimental conversion coefficient and band structure.

§ (A): Band based on (7/2+). The ordering of the transitions is based on intensities, since no γγ coin data are available due to limited statistics. Gain in alignment at E₀=0.27 MeV, most likely configuration is πg_{7/2} orbital.

γ(¹³⁹Eu)

Intensity of x rays in the delayed spectrum

E(x ray)	Intensity	Designation
40.9 2	87 11	K _α x-ray
47.2 2	20 4	K _β x-ray

Eγ	E(level)	Iγ	Mult. §	α	Comments
(4.6)	121.80				Eγ: possible transition which could explain observation of 117γ in the delayed spectrum.
26.4 2	148.20	34 [†] 6	(E1)	1.91 5	α(exp)=5.5 14. B(E1)(W.u.)=4.1×10 ⁻⁶ 8. Hindered E1 transition is probably due to difference in nuclear shape between the isomeric πg _{7/2} state and πh _{11/2} ground state.
117.2 1	117.20	21 [†] 3	M1	1.173	Mult.: from literature (1995Va22), but note that it is M1/E2 in 1995Va22. Observation of this γ in the delayed spectrum suggests a connecting transition between the 148-keV isomer and 117-keV level. There is no evidence of a 30-keV transition in recoil-decay tagged γ spectrum. There could be a link through a 5-keV transition from the 122-keV level to 117-keV level.
121.8 1	121.80	100 [†] 11	(E2)	1.192	α(K)exp=0.66 14. Mult.: α(K)exp gives E2(+M1) with δ(E2/M1)>0.85, 2011Cu01 assign E2 without any further arguments. Evaluators treat this assignment as tentative.
198.2 2	346.4	86 [‡] 13			
470.7 4	2482.2	39 [‡] 9			
488.9 2	835.3	100 [‡] 10			

Continued on next page (footnotes at end of table)

 $^{92}\text{Mo}(^{54}\text{Fe}, 5\text{p}2\text{n}\gamma)$ 2011Cu01 (continued)

 $\gamma(^{139}\text{Eu})$ (continued)

E_γ		E(level)		I_γ
582.3	7	1417.6		$86^{\ddagger}$ 15
593.9	3	2011.5		$66^{\ddagger}$ 13
655.2	4	3137.4		$17^{\ddagger}$ 6

† Delayed intensity normalized to 100 for 121.8 γ .

‡ Prompt intensity normalized to 100 for 488.9 γ .

§ Assigned from ce data with the consideration of 117.2-keV transition treated as pure M1, as known from 1995Va22.

Adopted Levels, Gammas

Q(β⁻)=-9500 SY; S(n)=10050 SY; S(p)=3170 SY; Q(α)=2800 SY 2012Wa38.
 Estimated uncertainties (2012Wa38): ΔQ(β⁻)=360, ΔS(n)=280, ΔS(p)=200, ΔQ(α)=250.
 Q(εp)=6580 200, S(2n)=22560 360, S(2p)=4180 200 (all from syst, 2012Wa38).
 1983Ni05: ¹³⁹Gd identified in ⁵⁰Cr(⁹²Mo,n2p) reaction at E=385 MeV. OASIS. Measured protons; semi telescope.
 Identification based on Q(ε)-S(p)=6.5 MeV, σ=70 mb, and agreement between measured T_{1/2} and theoretical T_{1/2}=6.4 s from β decay gross theory (1973Ta30) and supported by cross bombardment of ⁵⁴Fe by ⁹²Mo which produced protons in the same energy range but much lower yield.
 1988WiZN: measured beta-delayed E(p), (x ray)p coin, γp coin, T_{1/2}.
 1999Xi04: ¹⁰⁶Cd(³⁶Ar,X). Measured γγ(t), (x ray)γ(t); He-jet; half-lives, isomers, HPGe detectors. 1999Xi04 claim to have discovered two activities with nearly the same half-lives but with different spins, one a low-spin and the other a high-spin of 9/2-. However, the excitation functions obtained by 1999Xi04 for the two γ rays (115.8 and 121.6) from these two respective activities are nearly the same. Two separate decay schemes are presented but with no γ-ray intensities. In the opinion of the evaluators, sufficient details are absent to justify the existence of the two isomers.
 2001BeZY (a report at Int. Conf. St. Marlo (France) in 1988): ¹³⁹Gd identified in ¹⁰⁶Cd(³⁶Ar,2pn) and ¹⁰⁶Cd(³⁵Cl,pn) using SARA system and He-jet transport. The following γ rays were listed as emitted by the decay of ¹³⁹Gd: 27.0, 65.0, 87.5, 116.3, 122.0, 236 and 379. Only the 27.0, 116.3 and 122.0 are present in 1999Xi04, a 26.7 and 121.6 from 4.8-s activity, and 115.8 from 5.8-s activity. The 65.0γ in 2001BeZY could be from ¹³⁸Gd decay.
 2003Xu04: ¹³⁹Gd produced in ¹⁰⁶Cd(⁴⁰Ca,α2pn),E=232 MeV reaction at Lanzhou-China accelerator facility. The β-delayed proton decay observed through the detection of 347- and 545-keV γ rays in ¹³⁸Sm.
 All data are from ⁹²Mo(⁵⁰Cr,n2pγ), except for the ground and isomeric properties. The decay scheme of ¹³⁹Tb ε decay is unknown.

¹³⁹Gd Levels

Cross Reference (XREF) Flags

A ⁹²Mo(⁵⁰Cr,n2pγ)
 B ¹³⁹Tb ε Decay (1.6 s)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
0.0 [#]	(9/2-)	AB	5.8 s 9	%ε+%β ⁺ =100; %εp>0 (1983Ni05). T _{1/2} : from decay curve for γ rays (1999Xi04), probably the 115.8γ. Full details of this measurement are not available. Others: 4.9 s 10 (from proton decay,1983Ni05), 5.8 s 4 (2001BeZY, from decay curve for γ rays reported in a 1988 conference), 5 s 1 (from proton decay,1988WiZN) %εp: delayed protons observed in 1983Ni05, 1988WiZN and 2003Xu04. Jπ: from systematics of N=75 isotones. %ε+%β ⁺ =100; %εp>0 (1983Ni05). E(level): x=250 150 (syst,2012Au07). T _{1/2} : from decay curve for γ rays (1999Xi04), probably the 121.6γ. Full details of this measurement are not available. 1999Xi04 propose this isomer to be a low-spin without giving any Jπ assignment. With (9/2-) for the g.s., this isomer could only have 1/2 or 3/2 to explain the long half-life. 2012Au07 propose 1/2+ from systematics. In view of overlapping half-lives of the two activities and in the absence of detailed data for decay, the evaluators consider the existence of this isomer as uncertain.
0+x?			4.8 s 9	
211.95 [@] 24	(11/2-)	A		
427.0 ^{&} 7	(7/2-)	A		
530.06 [#] 24	(13/2-)	A		
753.0 ^{&} 8	(11/2-)	A		
755.2 [@] 3	(15/2-)	A		
1171.2 [#] 3	(17/2-)	A		
1255.0 ^{&} 12	(15/2-)	A		
1415.7 [@] 4	(19/2-)	A		
1626.0 ^a 12	(13/2+)	A		
1871.0 ^a 13	(17/2+)	A		
1882.0 ^{&} 14	(19/2-)	A		
1910.9 [#] 4	(21/2-)	A		
2174.7 [@] 4	(23/2-)	A		
2174.7 ^y d		A		
2238.0 ^s a 15	(21/2+)	A		
2318.7 ^y d 10		A		
2490.3 ^b 8		A		
2576.7 [#] 4	(25/2-)	A		
2590.0 ^{&} 18	(23/2-)	A		

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Adopted Levels, Gammas (continued)

139Gd Levels (continued)

E(level) [†]	Jπ [‡]	XREF	E(level) [†]	Jπ [‡]	XREF	E(level) [†]	Jπ [‡]	XREF
2607.7+y ^d 15		A	3390.7 ^c 15		A	4600.0 ^{§a} 25	(37/2+)	A
2691.3 ^b 13		A	3558.3 ^b 22		A	4768.3 [@] 11	(39/2-)	A
2697.0 ^{§a} 18	(25/2+)	A	3627.7 [#] 6	(33/2-)	A	4788.2 ^c 21		A
2766.8 [@] 5	(27/2-)	A	3683.8 ^c 17		A	5247.3 [#] 14	(41/2-)	A
2919.3 ^b 17		A	3705.7+y ^d 23		A	5401 ^{§a} 3	(41/2+)	A
2944.7+y ^d 18		A	3777.0 ^{&} 23	(31/2-)	A	5700.3 ^{?@} 14	(43/2-)	A
3031.4 [#] 5	(29/2-)	A	3880.0 ^a 23	(33/2+)	A	6280 ^{§a} 3	(45/2+)	A
3093.7 ^c 11		A	3960.0 [@] 8	(35/2-)	A	7231 ^{§a} 3	(49/2+)	A
3235.3 ^b 19		A	4011.6 ^c 17		A	8251 ^{§a} 4	(53/2+)	A
3245.0 ^a 20	(29/2+)	A	4108.7+y ^d 25		A	9340 ^a 4	(57/2+)	A
3257.0 ^{&} 20	(27/2-)	A	4370.6 [#] 9	(37/2-)	A	10498 ^{?a} 4	(61/2+)	A
3288.2 [@] 5	(31/2-)	A	4374.2 ^c 18		A			
3312.7+y ^d 20		A	4417.0 ^{&} 25	(35/2-)	A			

[†] From least-squares fit to E_γ data; ΔE_γ=1 keV assumed when not given.

[‡] From (9/2-) for the g.s.; multipolarities determined from DCO ratios, δ values and RUL; systematics of the lighter N=75 isotones, and γ deexcitation patterns. Ascending order of spins with excitation energy is assumed from yrast type population of states in this reaction.

[§] Lifetime measured in 1992Pa04 (see F(τ) curve in figure 2 of 1992Pa04).

[#] (A): v9/2[514] α=-1/2. At low spins, this band is from v_{h11/2} 9/2[514] orbital. At ħω=0.3 MeV and Jπ=23/2-, this band is crossed by a pair of h_{11/2} protons, thus evolves into a 3-qp configuration=v9/2[514]⊗ πh_{11/2}². This band was first proposed in 1989Ma03, later confirmed in 1990Ma53, 1991Pa04 and 1997Ro13.

[@] (B): v9/2[514], α=+1/2. See comment for the α=-1/2 partner.

[&] (C): v1/2[530] band. Band from v_{h9/2} orbital (1997Ro13).

^a (D): v1/2[660], Highly deformed band. Q(intrinsic)=7.0 (1992Pa04) from lifetime measurements of seven transitions in the band. Band from v_{i13/2} orbital (1997Ro13, 1990Ma53).

^b (E): ΔJ=(1) band. Band from 1990Ma53 only.

^c (F): ΔJ=1 band. Band from 1990Ma53 only.

^d (G): ΔJ=(1) band. Band from 1990Ma53 only.

γ(139Gd)

In 139Tb ε decay dataset, no levels are known, only two unplaced gamma rays of 109.0 and 119.7 keV are reported.

E(level)	E _γ	I _γ	Mult. [†]	δ [‡]	α [§]	Comments
211.95	212.0 3	100	D			
427.0	215	11.1 15				
	427	100 19	D			
530.06	318.2 3	100 10	D			
	530.0 3	46 5	Q			
753.0	326	100 8	(Q)			Mult.: D+Q also possible from DCO ratio.
	753	20 8	D			
755.2	225.3 3	86 9	M1+E2	-0.27 4	0.203 4	
	543.2 3	100	Q			
1171.2	416.2 3	100 11	M1+E2	-0.48 4	0.0372 7	
	641.0 3	83 9	Q			
1255.0	502	100	Q			
1415.7	244.3 3	38 5	M1+E2	-0.26 7	0.163 3	
	660.4 3	100 11	Q			
1626.0	873	100				
1871.0	245	6.1 12	Q			
	616	100 4	D			
1882.0	627	100	Q			
1910.9	495.1 3	71 9	M1+E2	-0.34 6	0.0247 6	
	740.0 3	100 12	Q			
2174.7	264.0 3	27 3	D			
	758.9 3	100 10	Q			
2174.7+y	y					
2238.0	356	12.2 24				
	367	100 4	E2		0.0329	
2318.7+y	144					
2490.3	579					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{139}\text{Gd})$ (continued)

E(level)	E_γ	I_γ	Mult. [†]	$\delta^\ddagger$	$\alpha^\S$
2490.3	1075				
2576.7	402.1 3	100 10	M1+E2	-0.17 4	0.0437
	665.6 3	51 5	(Q)		
2590.0	708	100	Q		
2607.7+y	289				
2691.3	201				
2697.0	459	100	E2		0.01754
2766.8	190.0 3	100 10	M1+E2	-0.17 6	0.328
	592.2 3	34 4	Q		
2919.3	228				
2944.7+y	337				
3031.4	264.8 3	100 11			
	455 1	<17	Q		
3093.7	919 [#]				
3235.3	316				
3245.0	548	100	Q		
3257.0	667	100	Q		
3288.2	256.9 3	100 11	M1+E2	-0.27 4	0.1416 23
	521.2 3	38 5	Q		
3312.7+y	368				
3390.7	297				
3558.3	323				
3627.7	339.3 3	100 12	M1+E2	-0.20 7	0.0679 13
	596.4 3	<40			
3683.8	293				
	590 [#]				
3705.7+y	393				
3777.0	520	100	Q		
3880.0	635	100	Q		
3960.0	332 1	100	M1+E2	-0.34 8	0.0701 18
	672				
4011.6	328				
	621				
4108.7+y	403				
4370.6	411				
	743				
4374.2	363				
	690				
4417.0	640	100			
4600.0	720				
4768.3	398				
	808				
4788.2	414				
5247.3	479				
	877 [#]				
5401	801				
5700.3?	453 [#]				
	932 [#]				
6280	879				
7231	951				
8251	1020				
9340	1089				
10498?	1158 [#]				

[†] Mult=Q indicates stretched quadrupole (most likely E2), mult=D indicates stretched dipole (most likely M1 or M1+E2, except E1 for 616 γ from 17/2+ level) from DCO ratios. Mult=M1+E2 is from measured DCO ratio, significantly large δ value and implied RUL. Mult=E2 is from DCO ratio and RUL; level lifetimes are not listed but are implied as short (in ps region) from transition quadrupole moment deduced from these measurements in 1992Pa04.

[‡] Read by the evaluators from figure 1 of 1991Pa04.

[§] Theoretical values from BrIcc v2.3b (16-Dec-2014) 2008Ki07, "Frozen Orbitals" approximation.

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

Adopted Levels, Gammas (continued)(A) $\nu 9/2[514]$ $\alpha=-1/2$.(B) $\nu 9/2[514]$, $\alpha=+1/2$.(C) $\nu 1/2[530]$ band.(D) $\nu 1/2[660]$, Highly deformed band.

Adopted Levels, Gammas (continued)

 (E) $\Delta J=(1)$ band.

 (F) $\Delta J=1$ band.

 (G) $\Delta J=(1)$
band.

¹³⁹Tb ε Decay (1.6 s) 1999Xi04

Parent ¹³⁹Tb: E=0.0; Jπ=?; T_{1/2}=1.6 s 2; Q(g.s.)=9500 syst; %ε+%β⁺ decay>0.
¹³⁹Tb-J,T_{1/2}: From Adopted Levels for ¹³⁹Tb.
¹³⁹Tb-Q(ε): 9500 360 (syst,2012Wa38).
Measured γγ(t), (x ray)γ(t); He-jet; HPGe detectors.
Assignment from observation in Gd-Kα gated spectrum and comparison of the excitation functions with that of 328.4γ (¹⁴⁰Tb).

¹³⁹Gd Levels

E(level)	Comments
0.0	Ground state is expected to be populated.

γ(¹³⁹Gd)

Eγ

x109.0
x119.7

x γ ray not placed in level scheme.

92Mo(50Cr,n2pγ) 1989Ma03,1990Ma53,1997Ro13

E=210–230 MeV.

1989Ma03: E=200–230 MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, excitation functions, $\gamma\gamma(\theta)$ using five BGO-shielded Ge detectors and a multiplicity filter of 14 BGO detectors. Main experiment at 210 MeV beam energy. Deduced average directional correlation (DCO) ratios. A negative-parity band established from 9/2– to 35/2– and ascribed to $\nu h_{11/2}$ 9/2[514] configuration, crossed at higher spins by a pair of $h_{11/2}$ protons.

1990Ma53 (same group as 1989Ma03): E=220 MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\gamma\gamma(\theta)$ (DCO) using TESSA3 array of 16 Ge detectors and 50 BGO inner ball detectors. An $i_{13/2}$ intruder highly-deformed band and several other sequences were found in this study, but no data details were provided.

1991Pa04 (same group as 1990Ma53 and same experimental arrangement used): measured $\gamma(\theta)$ and deduced mixing ratios for nine transitions in the 9/2[514] band.

1992Pa04 (same group as 1990Ma53 and same experimental arrangement used): measured Doppler-shift attenuations for γ rays in the highly-deformed (decoupled) band; deduced intrinsic quadrupole moment for the band and quadrupole deformation from lifetime measurements for seven transitions in the band.

1997Ro13 (also 1995Ro15): E=220 MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\gamma\gamma(\theta)$ (DCO) using GASP array of 40 Ge detectors and 80 BGO inner-ball detectors. Details of data on highly-deformed band and negative parity based on the ground state.

Main level scheme is from 1990Ma53, except that the 1/2[660] band linkage to lower section of the level scheme is from 1997Ro13.

139Gd Levels

E(level) [†]	Jπ [§]	E(level) [†]	Jπ [§]	E(level) [†]	Jπ [§]
0.0 [@]	9/2–	2590.0 ^a 18	23/2(–)	3777.0 ^a 23	31/2(–)
211.95 ^{&} 24	11/2–	2607.7+y ^e 15		3880.0 ^b 23	33/2+
427.0 ^a 7	(7/2–)	2691.3 ^c 13		3960.0 ^{&} 8	35/2–
530.06 [@] 24	13/2–	2697.0 ^{#b} 18	25/2+	4011.6 ^d 17	
753.0 ^a 8	11/2(–)	2766.8 ^{&} 5	27/2–	4108.7+y ^e 25	
755.2 ^{&} 3	15/2–	2919.3 ^c 17		4370.6 [@] 9	37/2–
1171.2 [@] 3	17/2–	2944.7+y ^e 18		4374.2 ^d 18	
1255.0 ^a 12	15/2(–)	3031.4 [@] 5	29/2–	4417.0 ^a 25	(35/2–)
1415.7 ^{&} 4	19/2–	3093.7 ^d 11		4600.0 ^{#b} 25	(37/2+)
1626.0 ^b 12	13/2+	3235.3 ^c 19		4768.3 ^{&} 11	39/2–
1871.0 ^b 13	17/2+	3245.0 ^b 20	29/2+	4788.2 ^d 21	
1882.0 ^a 14	19/2(–)	3257.0 ^a 20	27/2(–)	5247.3 [@] 14	41/2–
1910.9 [@] 4	21/2–	3288.2 ^{&} 5	31/2–	5401 ^{#b} 3	(41/2+)
2174.7 ^{&} 4	23/2–	3312.7+y ^e 20		5700.3 ^{?&} 14	(43/2–)
2174.7+y ^{‡e}		3390.7 ^d 15		6280 ^{#b} 3	(45/2+)
2238.0 ^{#b} 15	21/2+	3558.3 ^c 22		7231 ^{#b} 3	(49/2+)
2318.7+y ^e 10		3627.7 [@] 6	33/2–	8251 ^{#b} 4	(53/2+)
2490.3 ^c 8		3683.8 ^d 17		9340 ^b 4	(57/2+)
2576.7 [@] 4	25/2–	3705.7+y ^e 23		10498 ^{?b} 4	(61/2+)

[†] From least-squares fit to $E\gamma$ data, $\Delta E(\gamma)=1$ keV assumed when not given.

[‡] This level decays to 2174.7 level, but connecting $E\gamma$ is not known.

[§] As proposed in 1989Ma03, 1990Ma53 and 1997Ro13 based on DCO ratios, band structures, systematics of N=75 isotones and decay patterns. The assignments are the same in Adopted Levels, except that all are given in parentheses there due to lack of strong supporting arguments.

[#] Lifetime measured in 1992Pa04 (see $F(\tau)$ curve in figure 2 of 1992Pa04).

[@] (A): $\nu 9/2[514]$ $\alpha=-1/2$. At low spins, this band is from $\nu h_{11/2}$ 9/2[514] orbital. At $\hbar\omega=0.3$ MeV and $J\pi=23/2-$, this band is crossed by a pair of $h_{11/2}$ protons, thus evolves into a 3–qp configuration= $\nu 9/2[514] \otimes \pi h_{11/2}^2$. This band was first proposed in 1989Ma03, later confirmed in 1990Ma53, 1991Pa04 and 1997Ro13.

[&] (B): $\nu 9/2[514]$, $\alpha=+1/2$. See comment for the $\alpha=-1/2$ partner.

^a (C): $\nu 1/2[530]$ band. Band from $\nu h_{9/2}$ orbital (1997Ro13).

^b (D): $\nu 1/2[660]$, Highly deformed band. $Q(\text{intrinsic})=7.0$ (1992Pa04) from lifetime measurements of seven transitions in the band. Band from $\nu i_{13/2}$ orbital (1997Ro13, 1990Ma53).

^c (E): $\Delta J=(1)$ band. Band from 1990Ma53 only.

^d (F): $\Delta J=1$ band. Band from 1990Ma53 only.

^e (G): $\Delta J=(1)$ band. Band from 1990Ma53 only.

⁹²Mo(⁵⁰Cr,n2pγ) 1989Ma03,1990Ma53,1997Ro13 (continued)

γ(¹³⁹Gd)

DCO values correspond to gates on ΔJ=2, quadrupole transitions. Expected values are: ≈1 for ΔJ=2, Q and ≈0.5 for ΔJ=1, dipole transitions (1997Ro13); ≥1.0 for ΔJ=2, Q and ≤0.7 for ΔJ=1, transitions (1989Ma03).

Eγ [†]	E(level)	Iγ [‡]	Mult.§	δ [#]	Comments
y	2174.7+y				
144	2318.7+y				
190.0 3	2766.8	79 8	M1+E2	-0.17 6	DCO=0.7 1 (1989Ma03).
201	2691.3				
212.0 3	211.95	190 19	D		DCO=0.3 1 (1989Ma03).
215@	427.0	3.0& 4			
225.3 3	755.2	86 9	M1+E2	-0.27 4	DCO=0.4 1 (1989Ma03).
228	2919.3				
244.3 3	1415.7	33 4	M1+E2	-0.26 7	DCO=0.5 1 (1989Ma03).
245@	1871.0	5 ^a 1	Q		DCO=0.97 5 (1997Ro13).
256.9 3	3288.2	48 5	M1+E2	-0.27 4	DCO=0.7 1 (1989Ma03).
264.0 3	2174.7	19 2	D		DCO=0.7 1 (1989Ma03).
264.8 3	3031.4	58 6			
289	2607.7+y				
293	3683.8				
297	3390.7				
316	3235.3				
318.2 3	530.06	81 8	D		DCO=0.3 1 (1989Ma03).
323	3558.3				
326	753.0	57& 6	(Q)		DCO=1.21 25 (1997Ro13). Mult.: D+Q also possible from DCO ratio.
328	4011.6				
332 1	3960.0	<10	M1+E2	-0.34 8	
337	2944.7+y				
339.3 3	3627.7	25 3	M1+E2	-0.20 7	DCO=0.5 1 (1989Ma03).
356@	2238.0	10 ^a 2			
363	4374.2				
367 ^b	2238.0	82 ^a 3	E2		DCO=1.05 6 (1997Ro13).
368	3312.7+y				
393	3705.7+y				
398	4768.3				
402.1 3	2576.7	41 4	M1+E2	-0.17 4	DCO=0.3 1 (1989Ma03).
403	4108.7+y				
411	4370.6				
414	4788.2				
416.2 3	1171.2	46 5	M1+E2	-0.48 4	DCO=0.4 1 (1989Ma03).
427@	427.0	27& 5	D		DCO=0.51 7 (1997Ro13).
453 ^d	5700.3?				
455 1	3031.4	<10	Q		DCO=1.5 3 (1989Ma03).
459 ^b	2697.0	100 ^a	E2		DCO=1.03 6 (1997Ro13).
479	5247.3				
495.1 3	1910.9	25 3	M1+E2	-0.34 6	DCO=0.4 1 (1989Ma03).
502	1255.0	57& 12	Q		DCO=0.92 10 (1997Ro13).
520@	3777.0	6.8& 23	Q		DCO=1.03 10 (1997Ro13).
521.2 3	3288.2	18 2	Q		DCO=1.5 3 (1989Ma03).
530.0 3	530.06	37 4	Q		DCO=1.1 2 (1989Ma03).
543.2 3	755.2	100	Q		DCO=1.1 2 (1989Ma03).
548	3245.0	90 ^a 2	Q		DCO=1.05 10 (1997Ro13).
579	2490.3				
590 ^d	3683.8				
592.2 3	2766.8	27 3	Q		DCO=1.3 3 (1989Ma03).
596.4 3	3627.7	<10			
616	1871.0	82 ^a 3	D		DCO=0.50 5 (1997Ro13).
621	4011.6				
627@	1882.0	27& 3	Q		DCO=1.08 10 (1997Ro13).
635	3880.0	55 ^a 5	Q		DCO=0.90 10 (1997Ro13).
640@	4417.0	4.5& 23			
641.0 3	1171.2	38 4	Q		DCO=1.0 2 (1989Ma03).
660.4 3	1415.7	87 9	Q		DCO=1.0 1 (1989Ma03).
665.6 3	2576.7	21 2	(Q)		DCO>1.0 (1989Ma03).
667@	3257.0	9& 3	Q		DCO=1.02 20 (1997Ro13).

Continued on next page (footnotes at end of table)

$^{92}\text{Mo}(^{50}\text{Cr}, n2p\gamma)$ 1989Ma03, 1990Ma53, 1997Ro13 (continued) $\gamma(^{139}\text{Gd})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Mult. [§]	Comments
672	3960.0			
690	4374.2			
708@	2590.0	23& 3	Q	DCO=1.08 10 (1997Ro13).
720 ^b	4600.0			
740.0 ^c 3	1910.9	35 4	Q	DCO=1.0 2 (1989Ma03).
743	4370.6			
753@	753.0	11& 5	D	DCO=0.57 10 (1997Ro13).
758.9 ^c 3	2174.7	71 7	Q	DCO=1.0 2 (1989Ma03).
801 ^b	5401			
808	4768.3			
873@	1626.0	5 ^a 2		
877 ^d	5247.3			
879 ^b	6280			
919 ^d	3093.7			
932 ^d	5700.3?			
951 ^b	7231			
1020 ^b	8251			
1075	2490.3			
1089	9340			
1158 ^d	10498?			

[†] Values given with uncertainties are from 1989Ma03. Values with no uncertainties are from 1990Ma53, unless otherwise noted.

[‡] From 1989Ma03, normalized to $I\gamma(543\gamma)=100$ with typical uncertainty quoted as <10%, except as noted. The evaluators assign 10% uncertainty. Values listed are relative intensities, but for 1/2[660] band, values are relative within the band.

[§] Mult=Q indicates stretched quadrupole (most likely E2), mult=D indicates stretched dipole (most likely M1 or M1+E2, except E1 for 616 γ from 17/2+ level) from DCO ratios. Mult=M1+E2 is from measured DCO ratio, significantly large δ value and implied RUL. Mult=E2 is from DCO ratio and RUL; level lifetimes are not listed but are implied as short (in ps region) from transition quadrupole moment deduced from these measurements in 1992Pa04.

Read by the evaluators from figure 1 of 1991Pa04.

@ From 1997Ro13.

& From 1997Ro13. Values in 1997Ro13 are normalized to 100 for $I\gamma(212\gamma+530\gamma)$; these have been renormalized by the evaluators to $I\gamma(212\gamma+530\gamma)=227$ 19 to match the intensity scale in 1989Ma03, from which other $I\gamma$ values are taken.

^a From 1997Ro13, relative intensity within the band, normalized to 100 for the 459 transition.

^b Doppler-shift attenuation measurement for this γ transition in the highly-deformed band (1992Pa04).

^c Doublet with a transition in ^{140}Gd .

^d Placement of transition in the level scheme is uncertain.

Adopted Levels

$Q(\beta^-) = -10490$ SY; $S(n) = 12530$ SY; $S(p) = -240$ SY; $Q(\alpha) = 3590$ SY 2012Wa38.

Estimated uncertainties (2012Wa38): $\Delta Q(\beta^-) = 590$, $\Delta S(n) = 420$, $\Delta S(p) = 360$, $\Delta Q(\alpha) = 360$.

$Q(\epsilon p) = 6300$ 300, $S(2n) = 23310$ 590, $S(2p) = 2590$ 360 (syst, 2012Wa38).

1999Xi04: ^{139}Tb identified in $^{106}\text{Cd}(^{36}\text{Ar}, X)$ at 220 MeV; measured $\gamma\gamma(t)$, (x ray) $\gamma(t)$; He-jet; HPGe detectors.

2000So11: $^{90}\text{Zr}(^{197}\text{Au}, X)$ $E = 30$ MeV/nucleon; measured fragments charge and mass distribution and isotopic production $\sigma = 200$ μb for the production of ^{139}Tb .

No information is available about the decay scheme of ^{139}Dy ϵ decay.

 ^{139}Tb Levels

Cross Reference (XREF) Flags

A ^{139}Dy ϵ Decay (0.6 s)

E(level)	XREF	$T_{1/2}$	Comments
0.0	A	1.6 s 2	$\% \epsilon + \% \beta^+ > 0$; $\% \epsilon p = ?$; $\% p = ?$ $J\pi$: 3/2+ predicted by 1997Mo25; 11/2- from syst (2012Au07). Lack of correlation between decay gammas observed and those observed in ^{139}Gd from $^{92}\text{Mo}(^{50}\text{Cr}, n2p\gamma)$ supports a low spin of 3/2+. $T_{1/2}$: from decay curves for 109 γ and 120 γ in ^{139}Gd (1999Xi04).

 ^{139}Dy ϵ Decay (0.6 s) 1999Xu05

Parent ^{139}Dy : $E = 0.0$; $J\pi = (7/2+)$; $T_{1/2} = 0.6$ s 2; $Q(g.s.) = 10490$ syst; $\% \epsilon + \% \beta^+$ decay = 100.

^{139}Dy -J, $T_{1/2}$: From Adopted Levels of ^{139}Dy .

^{139}Dy - $Q(\epsilon)$: 10490 590 (syst, 2012Wa38).

^{139}Dy - $\% \epsilon + \% \beta^+$ decay: $\% \epsilon + \% \beta^+ = 100$, $\% \epsilon p = 11$ (2005Xu04).

1999Xu05: measured p - γ_1 (x ray)- γ_2 (x ray)-t; He-jet; totally depleted silicon surface barrier detectors, HPGe detectors.

 ^{139}Tb Levels

E(level)

0.0

Adopted Levels

S(n)=10780 SY; S(p)=1260 SY; Q(α)=4230 SY 2012Wa38.
 Estimated uncertainties (2012Wa38): ΔS(n)=640, ΔS(p)=590, ΔQ(α)=640.
 Q(εp)=10730 540, S(2p)=1010 590 (both from syst, 2012Wa38). S(2n)=24280 (theory, 1997Mo25).
 1999Xu05 (also 2005Xu04): ¹³⁹Dy produced and identified in ¹⁰⁶Cd(³⁶Ar,X) reaction at E=176 MeV. Measured p-γ₁(x ray)-γ₂(x ray)-t; He-jet; totally depleted silicon surface barrier detectors, HPGe detectors.
 2000So11: ⁹⁰Zr(¹⁹⁷Au,X) E=30 MeV/nucleon; measured fragments charge and mass distribution and isotopic production
 σ=70 μb for the production of ¹³⁹Dy.

¹³⁹Dy Levels

Cross Reference (XREF) Flags

A ¹⁴⁰Ho p Decay (6 ms)

E(level)	Jπ	XREF	T _{1/2}	Comments
0.0	(7/2+)	A	0.6 s 2	%ε+%β ⁺ =100; %εp=11 (2005Xu04). Jπ: from comparison of experimental delayed proton spectrum to statistical model calculations (1999Xu05,2005Xu04). T _{1/2} : from the decay curve of p-221γ in ¹³⁸ Gd (1999Xu05,2005Xu04). β _y =0.3 (from comparison of Jπ to Nilsson diagrams, 1999Xu04). Measured partial reaction cross sections via β ⁺ p decay=160 nb (1999Xu05) with a quoted uncertainty of a factor of 2. Observed 221γ and 384γ, assigned to the decay of first 2+ and 4+ states, respectively in ¹³⁸ Gd (1999Xu05).

¹⁴⁰Ho p Decay (6 ms) 1999Ry04

Parent ¹⁴⁰Ho: E=0; Jπ=(6-,0-,8+); T_{1/2}=6 ms 3; Q(g.s.)=1094 10; %p decay=100.
¹⁴⁰Ho-J,T_{1/2}: From ¹⁴⁰Ho Adopted Levels in the ENSDF database, Feb 2006 update; where Jπ value is from 2001Fe05 based on coupling between a π7/2[523] orbital and ν5/2[402], ν7/2[404], ν9/2[514] orbitals. 2012Au07 proposed 8+ from syst.
¹⁴⁰Ho-Q(g.s.): From 2012Wa38, based on E(p)(lab)=1086 10 (1999Ry04).
¹⁴⁰Ho-%p decay: assumed %p=100.
 1999Ry04: ¹⁴⁰Ho produced and identified in ⁹²Mo(⁵⁴Fe,X) reaction at E=315 MeV, recoil-mass separator (RMS), position-sensitive avalanche counter PSAC for mass and charge identification, implants into double-sided silicon detectors (DSSD) at HRIBF facility. Measured E(p), I(p), half-life, (implant)(proton) coin. Coupled-channel calculations with deformed optical potential.

¹³⁹Dy Levels

E(level)	Jπ	Comments
0.0	(7/2+)	Jπ: from Adopted Levels.

Protons

E(p)	E(¹³⁹ Dy)
1086 10	0.0

NUCLEAR DATA SHEETS

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