Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 149, 1 (2018)	1-Jan-2018

Q(β^-)=−13110 *24*; S(n)=13295.5 *6*; S(p)=5770.9 *6*; Q(α)=−6660.3 *9* 2017Wa10
Q(β^+)=6524.5 *6*, S(2n)=30289.3 *9*, S(2p)=10913.0 *6*, Q(εp)=143.2 *6* (2017Wa10).
First identification of ^{39}Ca nuclide by 1943Hu02.
Other reactions:
^{40}Ca(γ,nγ'): 1974Br15: ^{40}Ca resonances.
^{40}Ca(γ,nγ'): 1969Ul01.
^{40}Ca(e,en),(p,np): 2001Vo09.
^{40}Ca(e,e′n): 1994Ta12, 2005Sa37; see dataset.
^{40}Ca(π^+,p): 1987Bl07, 1987MiZW.
^{40}Ca(π^+,π^+n), (π^-,π^-n): 1980Bu07, 1979Li11.
^{40}Ca(p,np): 1990Vo13: deformation parameters.
^{40}Ca(p,np): 1984Ah04, 1983AhZY, 1983Ch07, 1982Wa17, 1966Ne03.
^{40}Ca(pol P,np): 1986PaZI.
Mass measurements: 2011Tu09, 2008Ge08.

^{39}Ca Levels

Cross Reference (XREF) Flags

A	^{40}Ti εp decay (52.4 ms)	F	^{39}K(p,n)	K	^{40}Ca(^{3}He,α),(pol ^{3}He,α)
B	^{1}H(^{38}K,γ) E=res	G	^{39}K(^{3}He,t)	L	^{40}Ca(^{3}He,$\alpha\gamma$),^{3}He(^{40}Ca,$\alpha\gamma$)
C	^{16}O(^{28}Si,αnγ)	H	^{40}Ca(γ,n)	M	^{40}Ca(^{28}Si,^{29}Si)
D	^{36}Ar(α,nγ)	I	^{40}Ca(p,d),(pol p,d)		
E	^{39}K(π^+,π^0)	J	^{40}Ca(d,t),(pol d,t)		

E(level)[†]	J$^\pi$	T$_{1/2}$[#]	XREF	Comments
0	3/2$^+$	860.3 ms *10*	A CDEFGHIJKLM	%ε+%β^+=100 μ=1.02168 *12* (1976Mi05,2014StZZ) Q=0.036 *7* (1999MaZI,2016St14) J$^\pi$: L(pol p,d)=L(pol d,t)=L(pol ^{3}He,α)=2 and L-1/2 transfer from analyzing power. T$_{1/2}$: weighted average of 860.7 ms *10* (2010Bl09), 860.4 ms *30* (1973Al11) and 859.4 ms *16* (1977Az01). Others: 0.76 s *20* (1994Ha07), 0.95 s *4* (1964Ba24), 0.89 s *5* (1960Wa04), 0.873 s *8* (1960Li05), 0.860 s *5* (1958Mi85), 0.876 s *12* (1958Cl41), 0.90 s *1* (1954Kl36), 1.00 s *3* (1953Su81), 1.00 s *5* (1953Br07), 1.06 s *3* (1943Hu02). μ: using NMR technique with a polarized proton beam; also 1976Mi21 and 1980HuZX. Compilation: 2014StZZ. Q: using β-NMR method (1999MaZI). Also Q=0.040 *6* (1999MaZK) by the same group. Compilation: 2016St14. Experimental nuclear charge radius <r^2>$^{1/2}$=3.460 fm *3* (2013An02, evaluation). Δ<r^2>(^{40}Ca,^{39}Ca)=−0.127 fm^2 *18*; Δ<r^2>(^{41}Ca,^{39}Ca)=−0.115 fm^2 *18* (1996Ve04).
2466.9 *5*	1/2$^+$	162 fs *17*	A De GHIJKLM	J$^\pi$: L(p,d)=L(d,t)=L(^{3}He,α)=0. T$_{1/2}$: from ^{3}He(^{40}Ca,$\alpha\gamma$) (1988Al05).
2796.1 *6*	7/2$^-$	62 ps *17*	CDe GHIJKL	J$^\pi$: L(pol p,d)=L(d,t)=L(^{3}He,α)=3 and L+1/2 transfer from analyzing power. T$_{1/2}$: other: >12 ps in (^{3}He,$\alpha\gamma$).
3025.1 *9*	3/2$^-$	21 fs *11*	A De HIJKL	J$^\pi$: L(pol p,d)=L(d,t)=L(^{3}He,α)=1 and L+1/2 transfer from analyzing power. T$_{1/2}$: from (^{3}He,$\alpha\gamma$). Other: <7.6 ps in (α,nγ).

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Adopted Levels, Gammas (continued)

^{39}Ca Levels (continued)

E(level)[†]	Jπ	$T_{1/2}$[#]	XREF	Comments
3639.6[‡] *8*	(9/2−)[‡]	17 ps *10*	CD G IJKL	Jπ: 3640γ(θ) and 843γ(θ) in 1970Ba08 in (^{3}He,αγ) is consistent with 3/2,5/2,9/2 with best fit for 9/2; 1980Oh06 in (p,d) interpret this state as 9/2− state populated by L=2, J=3/2 transfer from 3740, 3− state in ^{40}Ca.
3823.6 *15*	(1/2,3/2,5/2)	0.15 ps *6*	D IJKL	Jπ: 798.0γ to 3/2− and 3823.4γ to 3/2+. L(d,t)=(0) suggests (1/2+), but L(p,d)=(3) suggests (5/2−,7/2−).
3870.0 *9*		<3.5 ps	D k	Jπ: 3869.8γ to 3/2+.
3882 *2*	(3/2−,5/2,7/2+)	>1.7 ps	i L	E(level): from (^{3}He,αγ). Jπ: 3882γ to 3/2+, 1085γ to 7/2−. $T_{1/2}$: from (^{3}He,αγ).
3891.1[‡] *9*	(11/2−)[‡]	<26 ps	CD i	Jπ: 1094.5γ to 7/2− and 252γ to (9/2−).
3935.7 *7*	(3/2−)	<62 fs	D g ijkL	Jπ: L(p,d)=L(d,t)=L(^{3}He,α)=1 for a single state around 3950 could be for the 3936+3950 double; possible analog state of the 4083, 3/2− level in ^{39}K from 1974Ke09 in (α,nγ). $T_{1/2}$: from (^{3}He,αγ). Other: <3.5 ps in (α,nγ).
3951.8 *8*	(3/2−)	21 ps *17*	D g ijkL	Jπ: 3952γ to 3/2+, 1155.3γ to 7/2−; 1155γ(θ) and 3952γ(θ) in (^{3}He,αγ) is consistent with 1/2,3/2,5/2, but 3952γ is most likely a doublet with 3939γ from 3939 level observed in (^{3}He,αγ). L(p,d)=L(d,t)=L(^{3}He,α)=1 for a single state around 3950 could be for the doublet. $T_{1/2}$: other: 0.75 ps *+28−24* from (^{3}He,αγ).
4020.7 *17*	1/2+	0.42 ps *12*	G IJKL	E(level),$T_{1/2}$: from (^{3}He,αγ). Jπ: L(p,d)=L(d,t)=L(^{3}He,α)=0.
4332 *10*	(5/2,7/2)−		G IJK	E(level): weighted average of 4320 *15* in (d,t), 4320 *20* in (^{3}He,α) and 4340 *10* in (p,d). Jπ: L(p,d)=3. But L(d,t)=(2) is inconsistent.
4439 *10*	3/2+,5/2+		IJK	XREF: J(4460). E(level): weighted average of 4432 *10* in (p,d), 4430 *20* in (^{3}He,α), and 4460 *15* in (d,t). Jπ: L(p,d)=L(d,t)=L(^{3}He,α)=2.
4488 *10*	7/2−		I K	E(level): weighted average of 4487 *10* in (p,d), 4490 *20* in (^{3}He,α). Jπ: L(pol p,d)=3 and L+1/2 transfer from analyzing power.
4610 *20*			K	
4710 *20*			K	
4929 *10*	3/2+,5/2+		IJK	E(level): weighted average of 4926 *10* in (p,d), 4920 *20* in (^{3}He,α), and 4940 *15* in (d,t). Jπ: L(p,d)=2.
5070 *20*	3/2+,5/2+		G K	E(level): from (^{3}He,α). Jπ: L(^{3}He,α)=2.
5129 *10*	5/2+		FG IJK	E(level): weighted average of 5128 *10* in (p,d), 5130 *20* in (^{3}He,α), and 5130 *15* in (d,t). Jπ: L(pol p,d)=L(pol ^{3}He,α)=L(d,t)=2 and L+1/2 transfer from analyzing power.
5151[‡] *2*	(11/2−)[‡]		C	
5222 *10*	3/2+,5/2+		I	Jπ: L(p,d)=2.
5317 *10*	7/2−		f IJ	E(level): weighted average of 5316 *10* in (p,d) and 5320 *15* in (d,t). Jπ: L(pol p,d)=3 and L+1/2 transfer from analyzing power. But L(d,t)=2 is inconsistent.
5364 *10*			f I	
5400 *10*			fG I	
5402[‡] *2*	(13/2−)[‡]		C	
5486 *10*	5/2+		G IJK	E(level): weighted average of 5484 *10* in (p,d), 5490 *20* in

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Adopted Levels, Gammas (continued)

^{39}Ca Levels (continued)

E(level)†	Jπ	XREF	Comments
			(^{3}He,α), and 5490 *15* in (d,t). Jπ: L(pol p,d)=2 and L+1/2 transfer from analyzing power.
5588 *10*	3/2+,5/2+	I	Jπ: L(p,d)=2.
5673 *10*	3/2+,5/2+	I	Jπ: L(p,d)=2.
5720 *10*	(5/2−,7/2−)	I	Jπ: L(p,d)=(3).
5786 *15*	1/2,3/2−	IJK	E(level): weighted average of 5790 *10* in (p,d), 5760 *20* in (^{3}He,α), and 5790 *15* in (d,t). Jπ: L(p,d)=L(d,t)=L(^{3}He,α)=1.
5851 *10*	1/2−,3/2−	I	Jπ: L(p,d)=1.
6008 *10*		E IJK	E(level): weighted average of 6009 *10* in (p,d), 6000 *20* in (^{3}He,α), and 6010 *15* in (d,t). Jπ: 1/2−,3/2− from L(d,t)=1; 3/2+,5/2+ from L(^{3}He,α)=2; (7/2−) from L(pol p,d)=(3) and L+1/2 from analyzing power. It is possible that there are three separate levels near this energy.
6094 *10*	(1/2+)	I	Jπ: L(p,d)=(0).
6157 *10*	5/2+	B f IJK	E(level): weighted average of 6158 *10* in (p,d), 6150 *20* in (^{3}He,α), 6160 *15* in (d,t) and 6157 *13* in ^{1}H(^{38}K,γ) E=res. Jπ: L(pol p,d)=L(pol ^{3}He,α)=L(d,t)=2 and L+1/2 transfer from analyzing power.
6286 *10*	3/2+,5/2+	B f I	E(level): from (p,d). Other: 6286 *13* from ^{1}H(^{38}K,γ) E=res. Jπ: L(p,d)=2. (5/2+) from expected L=0 resonances from 3+ g.s. in ^{38}K in ^{1}H(^{38}K,γ) E=res.
6405 *10*	5/2−,7/2−	I	Jπ: L(p,d)=3.
6432‡ *2*	(15/2+)‡	C	
6451 *2*	3/2+,5/2+	B IJ	E(level): weighted average of 6467 *10* in (p,d), 6450 *30* in (d,t) and 6450 *2* in ^{1}H(^{38}K,γ) E=res. Jπ: L(p,d)=L(d,t)=2. (5/2+) from expected L=0 resonances from 3+ g.s. in ^{38}K in ^{1}H(^{38}K,γ) E=res.
6514 *10*	3/2+,5/2+	I	Jπ: L(p,d)=2.
6580 *10*	5/2−,7/2−	I	Jπ: L(p,d)=3.
6629 *10*		I	
6722 *10*	5/2−,7/2−	I	Jπ: L(p,d)=3.
6794 *10*	3/2+,5/2+	I	Jπ: L(p,d)=2.
6834 *10*	3/2+,5/2+	IJ	E(level): weighted average of 6835 *10* in (p,d), 6820 *30* in (d,t). Jπ: L(d,t)=2.
6900‡ *2*	(15/2−)‡	C	
6906 *10*	1/2+	IJ	XREF: J(6920). Jπ: L(pol p,d)=0 and analyzing power. But L(d,t)=2 is inconsistent.
6954 *10*	5/2−,7/2−	I	Jπ: L(p,d)=3.
7025 *10*	(5/2−,7/2−)	I	Jπ: L(p,d)=(3).
7060 *10*		I	
7132 *10*	3/2+,5/2+	I	Jπ: L(p,d)=2.
7199 *10*	5/2+	f Ij	Jπ: L(pol p,d)=2 and L+1/2 transfer from analyzing power.
7248 *10*	3/2+,5/2+	f Ij	Jπ: L(p,d)=2.
7310 *10*	(5/2−,7/2−)	I	Jπ: L(p,d)=(3).
7380 *10*	5/2+	IJ	Jπ: L(pol p,d)=L(d,t)=2 and L+1/2 transfer from analyzing power.
7427 *10*	(3/2,5/2)+	F I	XREF: F(7450). Jπ: L(p,d)=(2); L(p,n)=0 from 3/2+ target.
7480 *10*	(5/2−,7/2−)	Ij	Jπ: L(p,d)=(3) but L(d,t)=1 for 7480 and/or 7532 gives 1/2−,3/2−.
7532 *10*	(5/2−,7/2−)	Ij	Jπ: L(p,d)=(3) but L(d,t)=1 for 7480 and/or 7532 gives 1/2−,3/2−.
7581 *10*	(5/2−,7/2−)	I	Jπ: L(p,d)=(3).
7635 *10*	(5/2−,7/2−)	I	Jπ: L(p,d)=(3).
7711 *10*	3/2+,5/2+	IJ	E(level): other: 7700 *30* from (d,t). Jπ: L(p,d)=L(d,t)=2.
7750‡ *2*	(19/2−)‡	C	
7773 *10*		I	

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Adopted Levels, Gammas (continued)

^{39}Ca Levels (continued)

E(level)†	J$^{\pi}$	XREF	Comments
7840 *10*		I	
7924 *10*	5/2^{+}	F I	XREF: F(7900). J$^{\pi}$: L(pol p,d)=2 and L+1/2 transfer from analyzing power.
7972 *10*	5/2^{+}	f IJ	E(level): other: 7970 *30* from (d,t). J$^{\pi}$: L(pol p,d)=L(d,t)=2 and L+1/2 transfer from analyzing power.
8021 *10*	3/2^{+},5/2^{+}	f I	J$^{\pi}$: L(p,d)=2.
8082 *10*	3/2^{+},5/2^{+}	I	J$^{\pi}$: L(p,d)=2.
8157 *10*	5/2^{+}	f I	J$^{\pi}$: L(pol p,d)=2 and L+1/2 transfer from analyzing power.
8219 *10*	3/2^{+},5/2^{+}	f IJ	XREF: J(8190). J$^{\pi}$: L(p,d)=2.
8280 *10*	3/2^{+},5/2^{+}	I	J$^{\pi}$: L(p,d)=2.
8336 *10*	5/2^{+}	IJ	XREF: J(8360). J$^{\pi}$: L(pol p,d)=L(d,t)=2 and L+1/2 transfer from analyzing power.
8396 *10*	3/2^{+},5/2^{+}	f I	J$^{\pi}$: L(p,d)=2.
8460 *10*	3/2^{+},5/2^{+}	f I	J$^{\pi}$: L(p,d)=2.
8509 *10*	3/2^{+},5/2^{+}	f IJ	E(level): other: 8500 *30*. J$^{\pi}$: L(p,d)=L(d,t)=2.
8582 *10*	3/2^{+},5/2^{+}	I	J$^{\pi}$: L(p,d)=2.
8650 *10*	3/2^{+},5/2^{+}	I	J$^{\pi}$: L(p,d)=2.
8692 *10*	5/2^{+}	IJ	E(level): other: 8700 *30* from (d,t). J$^{\pi}$: L(pol p,d)=L(d,t)=2 and L+1/2 transfer from analyzing power.
8748 *10*	3/2^{+},5/2^{+}	F I	J$^{\pi}$: L(p,d)=2.
8806 *10*	3/2^{+},5/2^{+}	IJ	XREF: J(8800). J$^{\pi}$: L(p,d)=2. But L(d,t)=1 is inconsistent.
8895 *10*		I	
8937 *10*	3/2^{+},5/2^{+}	f I	J$^{\pi}$: L(p,d)=2.
8988 *10*	3/2^{+},5/2^{+}	I	J$^{\pi}$: L(p,d)=2.
9039 *10*	3/2^{+},5/2^{+}	Ij	J$^{\pi}$: L(p,d)=2.
9104 *10*	3/2^{+},5/2^{+}	Ij	J$^{\pi}$: L(p,d)=2.
9158 *10*	3/2^{+},5/2^{+}	Ij	J$^{\pi}$: L(p,d)=2.
9213 *10*	3/2^{+},5/2^{+}	Ij	J$^{\pi}$: L(p,d)=2.
9271 *10*	(3/2^{+},5/2^{+})	IJ	XREF: J(9280). J$^{\pi}$: L(d,t)=(2).
9329 *10*		I	
9426 *10*		I	
9505 *10*	(3/2^{+},5/2^{+})	IJ	XREF: J(9500). J$^{\pi}$: L(d,t)=(2).
10100	(1/2 to 5/2)$^{+}$	F	J$^{\pi}$: L(p,n)=0 from 3/2^{+}.
10.9×10^{3} *3*		I	width≥500 keV.
17.8×10^{3} *5*		I	width≥500 keV.

† From a least-squares fit γ-ray energies for levels (up to 3952) connected with γ transitions with $\Delta E\gamma$; for levels (above 3952) only populated in transfer reactions, values are from (p,d), unless otherwise noted.
‡ From (^{28}Si,$\alpha n\gamma$). J^{π} assignments are from analogy of level energy and decay branching with mirror partner ^{39}K.
# From DSAM in (α,nγ), unless otherwise noted. Values are also available in (^{3}He,$\alpha\gamma$) using DSAM.

Adopted Levels, Gammas (continued)

$\gamma(^{39}Ca)$

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.	δ	Comments
2466.9	1/2+	2467.2 *5*	100	0	3/2+			E_γ: weighted average of 2467.3 *5* from ^{40}Ti εp decay (52.4 ms) and 2467.0 *10* from (α,nγ).
2796.1	7/2−	2795.9 *7*	100	0	3/2+	M2+E3	−0.13 *7*	B(M2)(W.u.)=0.25 *+10−6*; B(E3)(W.u.)=2.7 *+59−23* E_γ: from (α,nγ). Mult.,δ: Q+O from $\gamma(\theta)$ in (^{3}He,$\alpha\gamma$); polarity from parity change determined from L-transfers.
3025.1	3/2−	3023.6 *10*	100	0	3/2+	E1+M2	−0.07 *2*	B(E1)(W.u.)=0.0010 *+12−4*; B(M2)(W.u.)=2.5 *+61−17* E_γ: from (α,nγ). Mult.,δ: D+Q from $\gamma(\theta)$ in (^{3}He,$\alpha\gamma$); polarity from parity change determined from L-transfers.
3639.6	(9/2−)	844.0 *10*	100 *13*	2796.1	7/2−	(M1+E2)	−0.24 *4*	B(M1)(W.u.)=0.0015 *10*; B(E2)(W.u.)=0.4 *3* Mult.,δ: D+Q from $\gamma(\theta)$ in (^{3}He,$\alpha\gamma$).
		3639.3 *10*	34 *9*	0	3/2+	(E3)		B(E3)(W.u.)=23 *17* I_γ: weighted average of 35 *9* from (^{28}Si,αnγ), 33 *13* from (α,nγ), and 33 *13* from (^{3}He,$\alpha\gamma$),(^{40}Ca,$\alpha\gamma$). Mult.: O from $\gamma(\theta)$ in (^{3}He,$\alpha\gamma$).
3823.6	(1/2,3/2,5/2)	798.0‡ *15*		3025.1	3/2−			E_γ: reported only in (α,nγ).
		3823.4 *15*	100	0	3/2+			
3870.0		3869.8 *9*	100	0	3/2+			
3882	(3/2−,5/2,7/2+)	1086‡		2796.1	7/2−			E_γ: from (^{3}He,$\alpha\gamma$) only.
		3882		0	3/2+			E_γ: from (^{3}He,$\alpha\gamma$) only.
3891.1	(11/2−)	252	51 *6*	3639.6	(9/2−)			I_γ: from (^{28}Si,αnγ).
		1094.5 *10*	100 *12*	2796.1	7/2−	[E2]		B(E2)(W.u.)>1.2 I_γ: from (^{28}Si,αnγ).
3935.7	(3/2−)	3935.5 *7*	100	0	3/2+			E_γ: from (α,nγ) (1974Ke09). 1973BoXR in (^{3}He,$\alpha\gamma$) report 3939γ and 3952γ to g.s., while 1970Ba08 in that dataset only report a 3950γ and 1974Ke09 in (α,nγ) only report a 3935.5γ. It could be that the single γ peak in 1974Ke09 and 1970Ba08 is for the doublet in 1973BoXR.
3951.8	(3/2−)	1155.3 *10*	43 *14*	2796.1	7/2−			E_γ: from (α,nγ), also observed in (^{3}He,$\alpha\gamma$). I_γ: from (^{3}He,$\alpha\gamma$).
		3952	100 *14*	0	3/2+			E_γ,I_γ: from (^{3}He,$\alpha\gamma$) only, not reported in (α,nγ). 1973BoXR in (^{3}He,$\alpha\gamma$) report two γ rays around 3950: 3939γ and 3952γ to g.s., while 1970Ba08 in that dataset only report a 3950γ deexciting a 3950 level and 1974Ke09 in (α,nγ) only report a 3935.5γ deexciting the 3936 level. But it is unlikely that while 1970Ba08 observed 3950γ and 1155γ from the 3950 level,

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Adopted Levels, Gammas (continued)

$\gamma(^{39}Ca)$ (continued)

E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult.	Comments
							1974Ke09 only observed the weaker one, 1155γ. So it could be that the single γ peak at 3950 in 1974Ke09 and at 3935.5 in 1970Ba08 is for the doublet in 1973BoXR.
							Mult.,δ: 1970Ba08 report δ(Q/D)=−0.10 *7* or +6.7 *+22−61* for J(3951)=3/2.
4020.7	$1/2^+$	995.6	25 *13*	3025.1	$3/2^-$	[E1]	B(E1)(W.u.)=0.00028 *+32−18*
							E_γ,I_γ: reported in (^{3}He,αγ) only. Energy is from level-energy difference.
		1553.8	100 *13*	2466.9	$1/2^+$	[M1]	B(M1)(W.u.)=0.011 *+7−4*
							E_γ,I_γ: reported in (^{3}He,αγ) only. Energy is from level-energy difference.
5151	$(11/2^-)$	1260 *1*	100	3891.1	$(11/2^-)$		E_γ: from (^{28}Si,αnγ).
5402	$(13/2^-)$	1511 *1*	100	3891.1	$(11/2^-)$		E_γ: from (^{28}Si,αnγ).
6432	$(15/2^+)$	1030 *1*	100	5402	$(13/2^-)$		E_γ: from (^{28}Si,αnγ).
6900	$(15/2^-)$	1749 *1*	73 *6*	5151	$(11/2^-)$		E_γ,I_γ: from (^{28}Si,αnγ).
		3008 *2*	100 *9*	3891.1	$(11/2^-)$		E_γ,I_γ: from (^{28}Si,αnγ).
7750	$(19/2^-)$	850 *1*	100	6900	$(15/2^-)$		E_γ: from (^{28}Si,αnγ).

† From (α,nγ), unless otherwise noted.

‡ Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level