Adopted Levels, Gammas

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	30-Nov-2021

Q(β^-)=−7620 *5*; S(n)=10400 *5*; S(p)=6130 *60*; Q(α)=−4265 *8* 2021Wa16

Q(ε)=5611 *24*, Q(εp)=1325 *7*, S(2n)=24273 *5*, S(2p)=10246 *6* (2021Wa16).

^{89}Mo identified by 1980Pa02 in ^{92}Mo(^{3}He,^{6}He) reaction experiment together with several excited states, but isotope half-life was not measured. 1975Ha11, while disproving assignment of a 7.1-min half-life to ^{89}Mo by 1964Bu12, suggested upper limits of 2 min and 1 min for the two activities. 1981Ga05 and 1980Ga16 reported half-life measurements for the two activities, later confirmed by 1983OxZZ and 1985Be12.

The following levels (gammas) from (^{3}He,4nγ) (1979DeYZ,1979DeZV) only and not reported in any of the later (HI,xnγ) studies (1993We04,1993Ga19,1992WeZS) have been omitted: 496.9 (496.8); 626.4 (129.2,627.0); 1156.0 (659.5,1155.5); 1253.1 (627.0,755.8); 1440.1 (813.7). Also the following levels and gammas reported by 1992WeZS only in (HI,xnγ) are omitted due to lack of confirmation by 1993We04 and 1993Ga19: 2548 (277γ); 2911 (327γ); 3502 (352γ); 4365 (297γ); 806γ (from 5170); 975γ (from 3559); 1090γ (from 4650); 1126γ (from 4262).

Multi-particle shell model configurations of seniority=3,5,7 are given in detail by 1993We04 and 1993Ga19. Comparisons of experimental γ branching ratios with those calculated for these configurations are given by 1995Za11.

Measured mass excess of ^{89}Mo: 2008We10, JYFLTRAP.

Additional information 1.

^{89}Mo Levels

Cross Reference (XREF) Flags

A	^{89}Mo IT decay (190 ms)	D	^{58}Ni(^{36}Ar,4pnγ),^{60}Ni(^{32}S,2pnγ)
B	^{89}Tc ε decay (12.8 s)	E	^{90}Zr(^{3}He,4nγ)
C	^{89}Tc ε decay (12.9 s)	F	^{92}Mo(^{3}He,^{6}He)

E(level)†	Jπ‡	$T_{1/2}$#	XREF	Comments
0.0	(9/2$^+$)	2.11 min *10*	ABCDEF	%ε+%β^+=100 $T_{1/2}$: weighted average of 1.98 min *14* (1985Be12: $\gamma^{\pm}$ timing in coin with ^{89}Nb γ transitions), 2.15 min *20* (1981Ga05: beam chopper system) and 2.2 min *1* (1983OxZZ: γ timing). Other: a 7.1-min activity assigned to ^{89}Mo by 1964Bu12 was not confirmed by 1975Ha11 and gave upper limits of <2 min for decay of 9/2$^+$ isomer and <1 m for decay of 1/2$^-$ isomer. Configuration=$\nu g_{9/2}^{-1}$ + seniority=3 states (1993We04). Additional information 2.
118.8 *1*	(7/2$^+$)		ABCDEF	
387.5 *2*	(1/2$^-$)	190 ms *15*	A CDEF	%IT=100 Configuration=$\nu p_{1/2}^{-1}$ + seniority=3 states (1993We04). $T_{1/2}$: from 1980Ga16. %IT: from log *ft*>3.6 for the transition to the J^{π}=(1/2)$^-$ state in ^{89}Nb %ε+%β^+ is estimated to be <10. From log *ft*>5, based on systematics of values for similar transitions in this mass region %ε+%β^+<0.4.
1000.7 *1*	(11/2$^+$)		D	
1016.4 *1*	(13/2$^+$)		D	
1253 *15*			F	
1645.8 *1*	(11/2$^+$)		D	
1740 *15*			F	
2008.4 *1*	(13/2$^-$)		D	
2096.4 *1*	(17/2$^+$)		D	
2110 *15*			F	
2271.2 *1*	(17/2$^-$)	1.14 ns *8*	D	$T_{1/2}$: from RDDS for 175γ (1995Za11). Other: 1.11 ns *28* from γ(t) of 175γ and 263γ (1995Ka06).

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Adopted Levels, Gammas (continued)

^{89}Mo Levels (continued)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	XREF	Comments
2415.8 *1*	(17/2$^+$)		D	
2454.5 *2*	(17/2$^-$)	5.8 ps *11*	D	
2583.7 *1*	(21/2$^+$)	9.49 ns *21*	D	μ=+8.3 *4* (1995We12,2020StZV) T$_{1/2}$: from γ(t) of 168γ, 487γ, 320γ, 1016γ, 1080γ, 1399γ (1995Ka06). Other: ≈21 ns (1993We04). μ: from g=+0.79 *4* (TDPAD method, 1995We12). Configuration=40% $\pi g_{9/2}^2(8^+)\otimes\nu g_{9/2}^{-1}$ + 21% $\pi g_{9/2}^2(6^+)\otimes\nu g_{9/2}^{-1}$ + 15% $\pi g_{9/2}^2(8^+)\otimes\nu g_{9/2}^{-3}(7/2^+)$ + 1% $\nu g_{9/2}^{-3}$ gives theoretical g=+0.79 (1995We12).
3134.0 *2*	(23/2$^+$)	<1.1 ps	D	
3151.1 *2*	(21/2$^-$)	1.8 ps *+6−10*	D	
3558.4 *2*	(25/2$^+$)	<1.0 ps	D	
3701.8 *2*	(23/2$^-$)		D	
3716.7 *2*	(25/2$^+$)	0.8 ps *6*	D	
4069.0 *2*	(25/2$^-$)	2.8 ps *+6−3*	D	
4260.6 *2*	(27/2$^+$)	0.28 ps *+7−14*	D	
4575.4 *2*	(27/2$^-$)	0.69 ps *+28−14*	D	
4649.1 *2*	(29/2$^+$)		D	
4980.7 *2*	(29/2$^+$)	<0.7 ps	D	
5170.9 *2*	(29/2$^-$)	<0.76 ps	D	
5251.0 *2*	(31/2$^+$)	2.3 ps *8*	D	
5340 *25*			F	
5420.0 *2*	(31/2$^-$)	<0.7 ps	D	
5480 *25*			F	
5643.0 *2*	(33/2$^+$)	0.55[@] ps *14*	D	
6436.4 *2*	(35/2$^-$)	2.6 ps *6*	D	
6470.6 *3*	(35/2$^+$)		D	
6755.9 *3*	(37/2$^+$)		D	
7590.1 *3*	(39/2$^-$)	1.39[@] ps *14*	D	

[†] From least-squares fit to Eγ data.
[‡] From 1995Za11, based on $\gamma(\theta)$ (1993We04,1993Ga19) and $\gamma\gamma(\theta)$(DCO) of 1993We04. J^π values of g.s., 119 and 388 states are based on systematics and probable shell-model configurations.
[#] From RDDS (1995Za11), unless otherwise stated.
[@] Effective T$_{1/2}$ not corrected for feeding.

γ(^{89}Mo)

E$_i$(level)	J$_i^\pi$	E$_\gamma$	I$_\gamma$[†]	E$_f$	J$_f^\pi$	Mult.[‡]	α[@]	Comments
118.8	(7/2$^+$)	118.8 *1*	100	0.0	(9/2$^+$)			E$_\gamma$: from (HI,xnγ).
387.5	(1/2$^-$)	268.6 *2*	100	118.8	(7/2$^+$)	(E3)	0.1494 *24*	B(E3)(W.u.)=0.117 *10* E$_\gamma$: average of values from (HI,xnγ) and ^{89}Mo IT decay. Mult.: α(K)exp=0.28 *6* (1991He04) in ^{89}Tc ε decay (12.9 s) gives δ(M4/E3)=0.39 *12*, but this admxiture of M4 gives unrealistically large B(M4)(W.u.). RUL=10 for B(M4)(W.u.) suggests negligible δ(M4/E3). Value of α(K)exp=0.28 *6* (1991He04) agrees better with M3. Multipolarity assignment here is essentially from systematics supporting 1/2$^-$ for the isomer and dominant E3 multipolarity to 7/2$^+$ level, and only marginally supported by large value of α(K)exp.

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Adopted Levels, Gammas (continued)

γ(^{89}Mo) (continued)

E_i(level)	J_i^π	E_γ	I_γ [†]	E_f	J_f^π	Mult.[‡]	δ	α[@]	Comments
1000.7	(11/2$^+$)	1000.7 *1*	100	0.0	(9/2$^+$)				
1016.4	(13/2$^+$)	1016.3 *1*	100	0.0	(9/2$^+$)	(Q)			
1645.8	(11/2$^+$)	629.5 *2*	18 *7*	1016.4	(13/2$^+$)				
		1527.2 *2*	100 *10*	118.8	(7/2$^+$)				
		1645.9 *2*	44 *8*	0.0	(9/2$^+$)				
2008.4	(13/2$^-$)	362.6 *1*	34 *5*	1645.8	(11/2$^+$)	D			
		991.8 *1*	100 *7*	1016.4	(13/2$^+$)	(D)			δ(Q/D)=0.00 *+7−13* from γ(θ), −0.4 from DCO (1993Ka24).
		1007.9 *2*	45 *5*	1000.7	(11/2$^+$)	D			
2096.4	(17/2$^+$)	1080.0 *1*	100	1016.4	(13/2$^+$)	Q			
2271.2	(17/2$^-$)	174.8 *1*	100 *2*	2096.4	(17/2$^+$)	(E1)		0.0250	B(E1)(W.u.)=3.4×10^{-5} *3*
		262.8 *1*	59 *2*	2008.4	(13/2$^-$)	(E2)		0.0380	B(E2)(W.u.)=6.0 *5*
2415.8	(17/2$^+$)	319.5 *1*	42.9 *14*	2096.4	(17/2$^+$)				
		1399.3 *1*	100.0 *14*	1016.4	(13/2$^+$)	Q			
2454.5	(17/2$^-$)	183.5 *1*	100	2271.2	(17/2$^-$)	[M1]		0.0481	B(M1)(W.u.)=0.59 *12*
2583.7	(21/2$^+$)	168.0 *1*	79 *2*	2415.8	(17/2$^+$)	(E2)		0.185	B(E2)(W.u.)=7.7 *3*
		487.3 *1*	100 *2*	2096.4	(17/2$^+$)	(E2)			B(E2)(W.u.)=0.0474 *16*
3134.0	(23/2$^+$)	550.3 *1*	100	2583.7	(21/2$^+$)	[M1][#]			B(M1)(W.u.)>0.12
3151.1	(21/2$^-$)	696.8 *1*	4 *1*	2454.5	(17/2$^-$)	[E2]			B(E2)(W.u.)=3.1 *13*
		879.8 *1*	100 *1*	2271.2	(17/2$^-$)	(E2)			B(E2)(W.u.)=24 *9* δ(O/Q)=0.00 *+10−6* from γ(θ), +0.05 *8* from DCO (1993Ka24).
3558.4	(25/2$^+$)	424.4 *1*	100	3134.0	(23/2$^+$)	[M1][#]			B(M1)(W.u.)>0.29
3701.8	(23/2$^-$)	550.7 *1*	100	3151.1	(21/2$^-$)	D			
3716.7	(25/2$^+$)	582.6 *1*	100	3134.0	(23/2$^+$)	M1+E2	−3.4 *17*		B(M1)(W.u.)=0.007 *+83−5*; B(E2)(W.u.)>200 δ(Q/D)=−2.4 *7* from γ(θ), −3.7 *+17−13* from DCO (1993Ka24).
4069.0	(25/2$^-$)	367.2 *1*	30 *3*	3701.8	(23/2$^-$)	[M1][#]			B(M1)(W.u.)=0.037 *9*
		917.8 *1*	100 *3*	3151.1	(21/2$^-$)	(E2)			B(E2)(W.u.)=10.1 *23*
4260.6	(27/2$^+$)	543.9 *1*	41 *4*	3716.7	(25/2$^+$)	[M1]			B(M1)(W.u.)=0.14 *4*
		702.3 *1*	100 *4*	3558.4	(25/2$^+$)	[M1][#]			B(M1)(W.u.)=0.16 *5*
4575.4	(27/2$^-$)	506.5 *1*	100	4069.0	(25/2$^-$)	[M1][#]			B(M1)(W.u.)=0.25 *10*
4649.1	(29/2$^+$)	388.4 *1*	100	4260.6	(27/2$^+$)	D			
4980.7	(29/2$^+$)	331.6 *1*	73 *8*	4649.1	(29/2$^+$)	[M1]		0.0105	B(M1)(W.u.)>0.23
		720.1 *1*	97 *11*	4260.6	(27/2$^+$)	[M1]			B(M1)(W.u.)>0.030
		1264.0 *1*	100 *11*	3716.7	(25/2$^+$)	(E2)			B(E2)(W.u.)>3.9
5170.9	(29/2$^-$)	595.5 *1*	100 *5*	4575.4	(27/2$^-$)	[M1][#]			B(M1)(W.u.)>0.11
		1101.9 *1*	27 *5*	4069.0	(25/2$^-$)	[E2]			B(E2)(W.u.)>4.1
5251.0	(31/2$^+$)	270.3 *1*	100 *4*	4980.7	(29/2$^+$)	[M1][#]		0.0176	B(M1)(W.u.)=0.25 *9*
		601.9 *1*	39 *4*	4649.1	(29/2$^+$)	[M1]			B(M1)(W.u.)=0.009 *4*
		990.4 *2*	57 *4*	4260.6	(27/2$^+$)	[E2]			B(E2)(W.u.)=3.2 *12*
5420.0	(31/2$^-$)	249.0 *1*	100 *5*	5170.9	(29/2$^-$)	[M1][#]		0.0217	B(M1)(W.u.)>1.3
		844.9 *2*	54 *5*	4575.4	(27/2$^-$)	(E2)			B(E2)(W.u.)>27
5643.0	(33/2$^+$)	392.0 *1*	100	5251.0	(31/2$^+$)	[M1][#]			B(M1)(W.u.)=0.66 *17*
6436.4	(35/2$^-$)	1016.4 *1*	100	5420.0	(31/2$^-$)	[E2]			B(E2)(W.u.)=8.5 *20*
6470.6	(35/2$^+$)	827.6 *1*	100	5643.0	(33/2$^+$)				
6755.9	(37/2$^+$)	285.3 *1*	100	6470.6	(35/2$^+$)				
7590.1	(39/2$^-$)	1153.7 *1*	100	6436.4	(35/2$^-$)	(E2)			B(E2)(W.u.)=8.4 *9*

[†] Photon branching ratios from 1995Za11.

[‡] From (HI,xnγ). See details about ΔJ=0,1,2 assignments in this dataset.

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Adopted Levels, Gammas (continued)

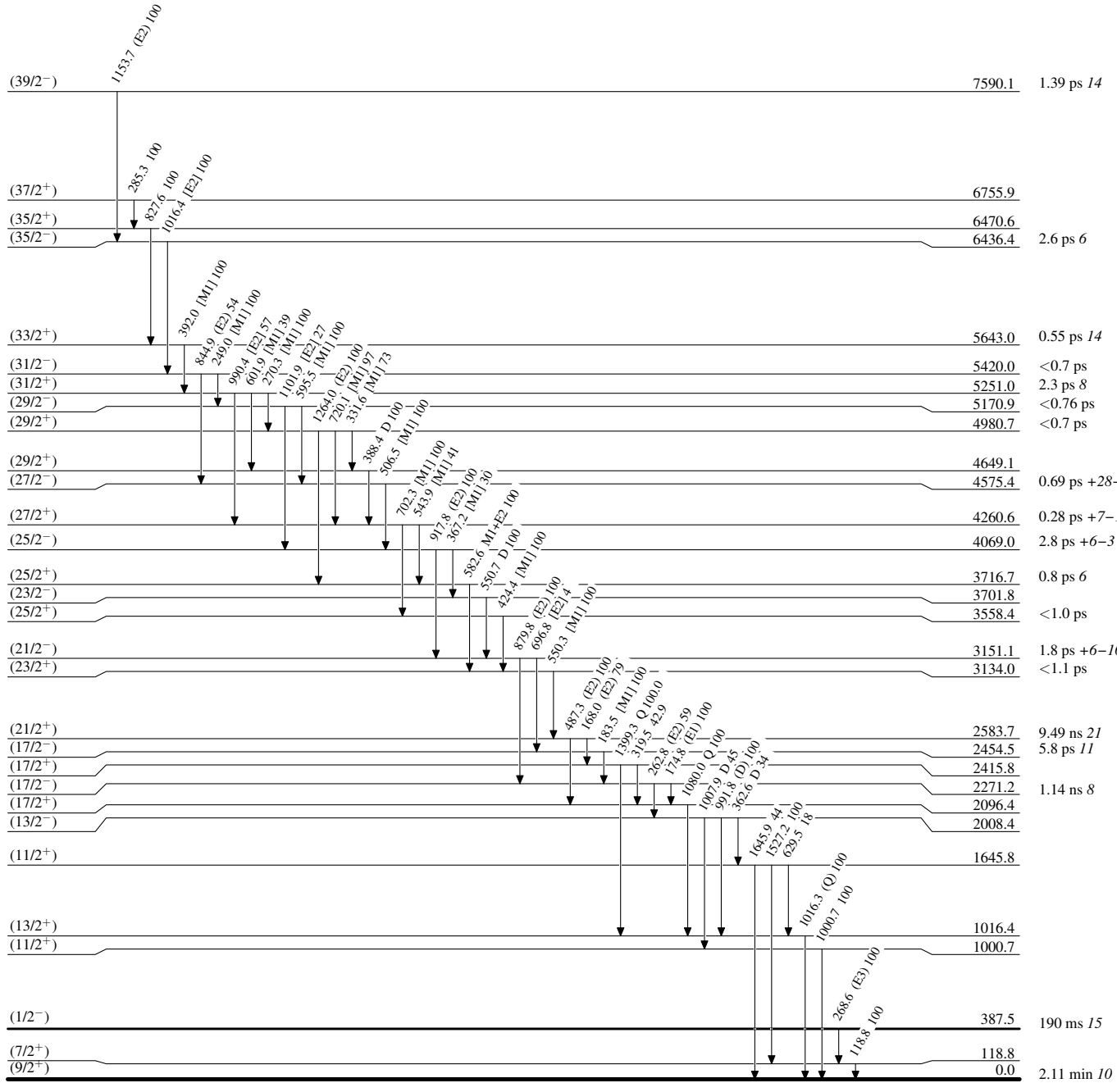
$\gamma(^{89}Mo)$ (continued)

[#] Mult=dipole from $\gamma(\theta)$ and/or $\gamma\gamma(\theta)$(DCO).
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with "Frozen Orbitals" approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{89}_{42}Mo_{47}$