

Adopted Levels, Gammas

| Type | Author | History 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).

⁸⁹Mo identified by 1980Pa02 in ⁹²Mo(³He,⁶He) 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 ⁸⁹Mo 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 (³He,4n γ) (1979DeYZ,1979DeZV) only and not reported in any of the later (HI,xn γ) 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,xn γ) are omitted due to lack of confirmation by 1993We04 and 1993Ga19: 2548 (277 γ); 2911 (327 γ); 3502 (352 γ); 4365 (297 γ); 806 γ (from 5170); 975 γ (from 3559); 1090 γ (from 4650); 1126 γ (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 ⁸⁹Mo: 2008We10, JYFLTRAP.

Additional information 1.

⁸⁹Mo Levels

Cross Reference (XREF) Flags

| | | | |
|----------|--|----------|---|
| A | ⁸⁹ Mo IT decay (190 ms) | D | ⁵⁸ Ni(³⁶ Ar,4pn γ), ⁶⁰ Ni(³² S,2pn γ) |
| B | ⁸⁹ Tc ϵ decay (12.8 s) | E | ⁹⁰ Zr(³ He,4n γ) |
| C | ⁸⁹ Tc ϵ decay (12.9 s) | F | ⁹² Mo(³ He, ⁶ He) |

| E(level) [†] | J π [‡] | 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: γ^\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 175 γ (1995Za11). Other: 1.11 ns 28 from $\gamma(t)$ of 175 γ and 263 γ (1995Ka06). |

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

⁸⁹Mo Levels (continued)

| E(level) [†] | J ^π [‡] | 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% πg _{9/2} ² 8+⊗vg _{9/2} ⁻¹ + 21% πg _{9/2} ² 6+⊗vg _{9/2} ⁻¹ + 15% πg _{9/2} ² 8+⊗vg _{9/2} ⁻³ 7/2+ + 1% vg _{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 E_γ data.

[‡] From 1995Za11, based on γ(θ) (1993We04,1993Ga19) and γγ(θ)(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(⁸⁹Mo)

| E _i (level) | J _i ^π | E _γ | I _γ [†] | E _f | J _f ^π | Mult. [‡] | α [@] | Comments |
|------------------------|-----------------------------|----------------|-----------------------------|----------------|-----------------------------|--------------------|----------------|---|
| 118.8 | (7/2 ⁺) | 118.8 1 | 100 | 0.0 | (9/2 ⁺) | | | E _γ : 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 _γ : 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 admixture 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 |

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

γ(⁸⁹Mo) (continued)

| <u>E_i(level)</u> | <u>J_i^π</u> | <u>E_γ</u> | <u>I_γ[†]</u> | <u>E_f</u> | <u>J_f^π</u> | <u>Mult.[‡]</u> | <u>δ</u> | <u>α[@]</u> | <u>Comments</u> |
|-----------------------------|----------------------------------|----------------------|----------------------------------|----------------------|----------------------------------|--------------------------|----------|----------------------|--|
| | | | | | | | | | 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. |
| 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 ⁺) | | | | |

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Adopted Levels, Gammas (continued) $\gamma(^{89}\text{Mo})$ (continued)

| $E_i(\text{level})$ | J_i^π | E_γ | I_γ^\dagger | E_f | J_f^π | Mult. [‡] | Comments |
|---------------------|----------------------|------------|--------------------|--------|----------------------|--------------------|-------------------|
| 6755.9 | (37/2 ⁺) | 285.3 I | 100 | 6470.6 | (35/2 ⁺) | | |
| 7590.1 | (39/2 ⁻) | 1153.7 I | 100 | 6436.4 | (35/2 ⁻) | (E2) | B(E2)(W.u.)=8.4 9 |

[†] Photon branching ratios from [1995Za11](#).

[‡] From (HI,xn γ). See details about $\Delta J=0,1,2$ assignments in this dataset.

Mult=dipole from $\gamma(\theta)$ and/or $\gamma\gamma(\theta)$ (DCO).

@ Total theoretical internal conversion coefficients, calculated using the BrIcc code ([2008Ki07](#)) with Frozen orbital approximation based on γ -ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

