Nuclear Data Sheets for A = 70^{*}

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Abstract: Spectroscopic data for all nuclei with mass number A=70 have been evaluated, and the corresponding level schemes from radioactive decay and reaction studies are presented. Since the previous evaluation, the half-life of ⁷⁰Mn has been measured and excited states in ⁷⁰Fe observed for the first time. Excited states in ⁷⁰Ni have been more extensively studied while Coulomb excitation and collinear laser spectroscopy measurements in ⁷⁰Cu have allowed for firm J π assignments. Despite new measurements, there remain some discrepancies in half-lives of low lying states in ⁷⁰Zn. New measurements have extended the knowledge of high-spin band structures in ⁷⁰Ge and ⁷⁰As. This evaluation supersedes the prior A=70 evaluation of 2004Tu09.

Cutoff Date: All data received by July 1, 2016 have been evaluated.

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 Brookhaven Lab's website: www.nndc.bnl.gov. The direct feeding(s) to excited states in β^- and ϵ decays have generally been computed by the evaluator from I(γ +ce) intensity balances at each level; the associated log *ft* values are calculated using LOGFT code. Theoretical conversion coefficients are from BrIcc code: v2.2b (20-Jan-2009) (2008Ki07) with "Frozen Orbitals" approximation, and with implicit uncertainty of 1.4%.

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NUCLEAR DATA SHEETS

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Skeleton Scheme for A=70

Skeleton Scheme for A=70 (continued)

Ground-State and Isomeric-Level Properties				
Nuclide	Level	$J\pi$	$T_{1/2}$	Decay Modes
^{70}Cr	0.0	0+	>620 ns	$\% \beta^- = ?$; $\% \beta^- n = ?$; $\% \beta^- 2n = ?$
^{70}Mn	0.0		19.9 ms <i>17</i>	$\% \beta^- = 100$; $\% \beta^- n = 50$ <i>20</i>
^{70}Fe	0.0	0+	65 ms <i>6</i>	$\% \beta^- = 100$; $\% \beta^- n = ?$
^{70}Co	0.0	(6 $^-$, 7 $^-$)	112 ms <i>7</i>	$\% \beta^- = 100$; $\% \beta^- n = ?$
	0+x	(3+)	0.47 s <i>5</i>	$\% \beta^- = 100$
^{70}Ni	0.0	0+	6.0 s <i>3</i>	$\% \beta^- = 100$
^{70}Cu	0.0	6 $^-$	44.5 s <i>2</i>	$\% \beta^- = 100$
	101.1	3 $^-$	33 s <i>2</i>	$\% \beta^- = 52$ <i>9</i> ; $\% \text{IT} = 48$ <i>9</i>
	242.6	1+	6.6 s <i>2</i>	$\% \beta^- = 93.2$ <i>9</i> ; $\% \text{IT} = 6.8$ <i>9</i>
	0.0	0+	$\geq 3.8 \times 10^{18}$ y	
^{70}Zn	0.0	1+	21.14 min <i>5</i>	$\% \beta^- = 99.59$ <i>5</i> ; $\% \epsilon = 0.41$ <i>5</i>
^{70}Ge	0.0	0+	stable	
^{70}As	0.0	4+	52.6 min <i>3</i>	$\% \epsilon + \% \beta^+ = 100$
^{70}Se	0.0	0+	41.1 min <i>3</i>	$\% \epsilon + \% \beta^+ = 100$
^{70}Br	0.0	0+	79.1 ms <i>8</i>	$\% \epsilon + \% \beta^+ = 100$
	2292.3	9+	2.2 s <i>2</i>	$\% \epsilon + \% \beta^+ = 100$
^{70}Kr	0.0	0+	40 ms <i>6</i>	$\% \epsilon + \% \beta^+ = 100$; $\% \epsilon p \leq 1.3$
^{71}Co	0.0	(7/2 $^-$)	80 ms <i>3</i>	$\% \beta^- n < 3.60$; ...
^{72}Co	0+x	(6 $^-$, 7 $^-$)	51.5 ms <i>3</i>	$\% \beta^- 2n = ?$; ...
	0+y	(0+, 1+)	47.8 ms <i>5</i>	$\% \beta^- 2n = ?$; ...

Adopted Levels: Tentative

$Q(\beta^-)=13580$ CA; $S(n)=4330$ CA; $S(p)=22730$ CA; $Q(\alpha)=-17530$ CA 1997Mo25.

$S(2n)=6160$; $S(2p)=42340$ (calculated, 1997Mo25).

2013Ta14: possible identification of ^{70}Cr by fragmentation of ^{82}Se beam at $E=139$ MeV/nucleon on Be and W targets.

^{70}Cr separated using A1900 fragment separator combined with S800 analysis beam line to form a two stage separator system. ^{70}Cr identified through magnetic rigidity, ΔE , total kinetic energy and time-of-flight using eight Si PIN diodes, plastic scintillators, Si detectors and parallel-plate avalanche counters. Measured production cross section= 0.0041 pb +73-31 using ^9Be target (e-mail on May 22, 2013 to XUNDL compilers from O. Tarasov, first author of 2013Ta14).

 ^{70}Cr Levels

E(level)	$J\pi$	$T_{1/2}$	Comments
0.0?	0+	>620 ns	<p>$\% \beta^-$=?; $\% \beta^-n$=?; $\% \beta^-2n$=?</p> <p>Only one event was found to be consistent with ^{70}Cr.</p> <p>$T_{1/2}$: lower limit estimated from time-of-flight of ≈ 620 ns as in 2009Ta24 (same lab as 2013Ta14).</p> <p>Actual half-life is expected to be much longer as suggested by the value of 14 ms from theoretical calculations (2003Mo09).</p> <p>E(level): assuming observed event corresponds to the ground state of ^{70}Cr.</p> <p>Theoretical calculations give $\% \beta^-n=35$, $\% \beta^-2n=2.5$ (2003Mo09).</p>

Adopted Levels

$Q(\beta^-)=17090$ SY; $S(n)=2750$ SY; $Q(\alpha)=-16030$ SY 2012Wa38.

$\Delta Q(\beta^-)=860$; $\Delta S(n)=920$; $\Delta Q(\alpha)=920$ (2012Wa38).

$S(2n)=7060$ syst 860; $Q(\beta^-n)=11770$ syst 810 (2012Wa38).

2009Ta05,2009Ta24: ^{70}Mn produced in fragmentation of ^{76}Ge beam at 132 MeV/nucleon on Be and W targets. Separated using A1900 fragment separator and S800 to form a two-stage separator system. Unambiguous identification of ^{70}Mn using multiple ΔE , magnetic rigidity, total energy and time-of-flight measurements. ΔE measured with a stack of eight Si PIN diodes and time of flight measured in four ways using plastic scintillators, Si detectors, and parallel-plate avalanche counters. Measured cross section= 20×10^{-12} mb +10-14 (read by the evaluators from figure 2 of 2009Ta05).

2015Be32: ^{70}Mn produced in in-flight fission of a ^{238}U beam at $E=345$ MeV/nucleon on a Be target and separated with the Big-RIPS separator combined with the ZeroDegree Spectrometer. Measured $E\gamma$, $I\gamma$, $\beta\gamma$, $\beta(t)$, $\beta\gamma(t)$ using the 5 silicon detectors of the WAS3ABI array which was surrounded by the EURICA spectrometer consisting of 12 HPGe EUROBALL cluster detectors and 18 small volume $\text{LaBr}_3(\text{Ce})$ scintillators.

 ^{70}Mn Levels

E(level)	$T_{1/2}$	Comments
0.0	19.9 ms 17	$\% \beta^- = 100$; $\% \beta^-n = 50$ 20 (2015Be32). $T_{1/2}$: from implant- $\beta(t)$ in 2015Be32; $\Delta T_{1/2}$ includes both statistical and systematic uncertainty. $\% \beta^-n$: deduced as free parameters in the fit to implant- $\beta(t)$ curves (2015Be32).

Adopted Levels, Gammas

$Q(\beta^-)=10610$ SY; $S(n)=5320$ SY; $S(p)=19060$ SY; $Q(\alpha)=-14200$ SY 2012Wa38.

$\Delta Q(\beta^-)=590$; $\Delta S(n)=640$; $\Delta S(p)=780$; $\Delta Q(\alpha)=710$ (2012Wa38).

$S(2n)=8630$ syst 620; $S(2p)=36010$ syst 860; $Q(\beta^-n)=5790$ syst 540 (2012Wa38).

First production and identification of ^{70}Fe : Be(^{238}U ,F), E=750 MeV/nucleon (1997Be70), Pb(^{238}U ,F), E=750 MeV/nucleon (1995CzZZ), identification by time-of-flight.

2003So21: ^{70}Fe produced in fragmentation of a ^{76}Ge beam at E=61.8 MeV/nucleon on a ^{58}Ni target. Isotopes separated with the LISE3 spectrometer and identified through ΔE and time-of-flight measurements. Measured $T_{1/2}$ from time correlation between implantation and β events in a DSSD detector.

2011Da08: ^{70}Fe produced in fragmentation of a ^{86}Kr beam at E=57.8 MeV/nucleon on a natural Ta target. Isotopes separated with the LISE2000 spectrometer and identified through ΔE and time-of-flight measurements. Measured $T_{1/2}$ from time correlation between implantation and β events in a DSSD detector.

2013Ma87: ^{70}Fe produced in fragmentation of a ^{86}Kr beam at E=140 MeV/nucleon on a ^9Be target. Isotopes separated with the A1900 spectrometer and identified through ΔE and time-of-flight measurements. Measured $T_{1/2}$ from time correlation between implantation and β events in a DSSD detector.

 ^{70}Fe Levels

Cross Reference (XREF) Flags

A ^{70}Mn β^- Decay (19.9 ms)
B $^1\text{H}(^{71}\text{Co},2p\gamma)$

E(level) [†]	$J\pi^{\ddagger}$	XREF	$T_{1/2}$	Comments
0 . 0	0+	AB	65 ms 6	$\% \beta^-=100$; $\% \beta^-n=?$ $T_{1/2}$: weighted average of 61 ms 5 (2013Ma87), 71 ms 10 (2011Da08) and 94 ms 17 (2003So21), all from implant- $\beta(t)$. Theoretical calculations give $\% \beta^-n=11$ (2003Mo09).
480 13	(2+)	AB		
1346 16	(4+)	AB		

[†] From $E\gamma$.

[‡] From systematics along the Fe and Cr isotopic chains (2015Sa43).

 $\gamma(^{70}\text{Fe})$

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Comments
480	480 13	100	$E\gamma$: other: 483 in ^{70}Mn β^- decay.
1346	866 10	100	$E\gamma$: other: 855 in ^{70}Mn β^- decay.

[†] From $^{71}\text{Co}(p,2p\gamma)$.

^{70}Mn β^- Decay (19.9 ms) 2015Be32

Parent ^{70}Mn : $E=0.0$; $J\pi=?$; $T_{1/2}=19.9$ ms 17; $Q(\text{g.s.})=1.71\times 10^4$ syst; $\%\beta^-$ decay=100.

2015Be32: ^{70}Mn activity from in-flight fission of a ^{238}U beam at $E=345$ MeV/nucleon on a Be target. Fragments separated with the Big-RIPS separator combined with the ZeroDegree Spectrometer. Measured $E\gamma$, $I\gamma$, $\beta\gamma$, $\beta(t)$, $\beta\gamma(t)$ using the 5 silicon detectors of the WAS3ABI array which was surrounded by the EURICA spectrometer consisting of 12 HPGe EUROBALL cluster detectors and 18 small volume LaBr₃(Ce) scintillators.

The decay scheme given here is considered highly incomplete, as such, the normalization, beta-feedings and log ft values should be taken as approximate.

 ^{70}Fe Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$
0.0	0+
483	(2+)
1338	(4+)

† From $E\gamma$.

‡ From the Adopted Levels.

 β^- radiations

$E\beta^-$	$E(\text{level})$	$I\beta^-^\dagger^\ddagger$	$\text{Log } ft$	Comments
(15760)	1338	≈ 18.5	≈ 5.3	$I\beta^-$: 37 5 (2015Be32).
(17100)	0.0	< 39	> 5.2	$I\beta^-$: < 68 10 (2015Be32).

† Values given in 2015Be32 sum to 100, which is in conflict with a $\%\beta^-n$ branch of 50 20. Evaluators have adjusted values from 2015Be32 such that they sum to 50. Values from 2015Be32 are given in the comments.

‡ Absolute intensity per 100 decays.

 $\gamma(^{70}\text{Fe})$

$I\gamma$ normalization: 2015Be32 provide only $\%I\beta^-$ values, from which the evaluators have deduced $I\gamma$ values and a normalization factor which reproduces the $\%I\beta^-$ values (correcting for a 50% beta-delayed neutron branch).

$E\gamma$	$E(\text{level})$	$I\gamma^\dagger^\ddagger$
483	483	31 5
855	1338	37 5

† Deduced by evaluators from $\%I\beta^-=37.5$ to 1338-keV level and -6.8 to 483-keV level.

‡ For absolute intensity per 100 decays, multiply by ≈ 0.50 .

Decay Scheme

${}^1\text{H}({}^{71}\text{Co}, 2\text{p}\gamma) \quad 2015\text{Sa43}$

2015Sa43: ${}^{71}\text{Co}$ at E=260 MeV/nucleon from fragmentation of a ${}^{238}\text{U}$ beam at E=345 MeV/nucleon on a ${}^9\text{Be}$ target. The secondary ${}^{71}\text{Co}$ beam selected by Bp- ΔE -Bp method using the BigRIPS and ZeroDegree Spectrometers. Secondary beam impinged on the MINOS device integrating a liquid hydrogen target and a time projection chamber (TPC) as a vertex tracker. Measured $\text{E}\gamma$, $\text{I}\gamma$, $\gamma\gamma$, proton- γ coincidence using the DALI2 array consisting of 186 NaI scintillator detectors coupled with proton tracking using the TPC.

 ${}^{70}\text{Fe}$ Levels

<u>$\text{E}(\text{level})^\dagger$</u>	<u>$\text{J}\pi^\ddagger$</u>
0 . 0	0+
480 13	(2+)
1346 16	(4+)

† From $\text{E}\gamma$.

‡ From relative intensities of measured γ rays and from systematics along the Fe and Cr isotopic chains (2015Sa43).

 $\gamma({}^{70}\text{Fe})$

<u>$\text{E}\gamma$</u>	<u>$\text{E}(\text{level})$</u>
480 13	480
866 10	1346

Adopted Levels

Q(β⁻)=12290 300; S(n)=4820 350; S(p)=15150 SY; Q(α)=-1.26×10⁴ 3 2012Wa38.
ΔS(p)=500 (2012Wa38).
S(2n)=11140 300; S(2p)=33200 syst 590; Q(β⁻)=4990 300 (2012Wa38).
2015Pr10: ⁷⁰Co produced in fragmentation of a ⁷⁶Ge beam at E=130 MeV/nucleon on a ⁹Be target separated with the A1900 fragment separator and identified through ΔE-TOF measurements. Measured E_γ, I_γ, β_γ, β(t), β_γ(t) using 16 detectors of the segmented Ge array (SeGA) for γ's and a planar Ge double-sided strip detector for β's. Measured T_{1/2} from time correlation between implantation events and β events in the planar Ge, including decay curves gated by γ rays.
2011Da08: ⁷⁰Co produced in fragmentation of a ⁸⁶Kr beam at E=57.8 MeV/nucleon on a natural Ta target. Isotopes separated with the LISE2000 spectrometer and identified through ΔE and time-of-flight measurements. Measured T_{1/2} from time correlation between implantation and β events in a DSSD detector.
2005NiZZ: ⁷⁰Co produced in fragmentation of a ⁸⁶Kr beam at E=63 MeV/nucleon on a ⁹Be target. Reaction products separated with the RIPS spectrometer and identified using trajectory, ΔE, and TOF measurements using 4 position sensitive PPACs, a single-sided strip detector and two scintillators. Measured T_{1/2} using implant-β(t).
2003So21: ⁷⁰Co produced in fragmentation of a ⁷⁶Ge beam at E=61.8 MeV/nucleon on a ⁵⁸Ni target. Isotopes separated with the LISE3 spectrometer and identified through ΔE and time-of-flight measurements. Measured T_{1/2} from time correlation between implantation and β events in a DSSD detector.
2003Sa40: ⁷⁰Co produced in fragmentation of a ⁸⁶Kr beam at E=58 MeV/nucleon on a natural Ta target. Isotopes separated with the LISE2000 spectrometer and identified through ΔE, total E and time-of-flight measurements. Measured T_{1/2} from time correlation between implantation and β events in a DSSD detector.
2000Mu10: ⁷⁰Co produced in proton-induced fission of ²³⁸U with E=30 MeV. Isotopes separated using the LIGLIS-LISOL ion-guide laser-ion source and mass separator. Measured T_{1/2} using γ(t).
1998Am04: ⁷⁰Co produced by fragmentation of a ⁸⁶Kr beam with E=500 MeV/nucleon on a Be target. Isotopes separated with the FRS and identified by Bp-ΔE-time-of-flight measurements. Measured T_{1/2} from time correlation between implantation and β events in a Si detector.
1985Gu14: ⁷⁰Co first produced in the fragmentation of a ⁸⁶Kr beam with E=33 MeV/nucleon and identified through time-of-flight and ΔE-E measurements.

⁷⁰Co Levels

See ⁷⁰Fe β⁻ decay and Ni(⁸⁶Kr,Xγ) for unplaced gamma-ray transitions.

Cross Reference (XREF) Flags

A ⁷⁰Fe β⁻ Decay
B Ni(⁸⁶Kr,Xγ)

E(level)	Jπ	XREF	T _{1/2}	Comments
0.0	(6-, 7-)		112 ms 7	%β ⁻ =100; %β ⁻ n=? T _{1/2} : weighted average of 100 ms 10 (2015Pr10), 108 ms 7 (2011Da08), 121 ms 8 (2003So21), 110 ms 9 (2003Sa40), 120 ms 30 (2000Mu10), 150 ms 20 (1998Am04). Others: 135 ms +11-9 (2005NiZZ, preliminary result), 92 ms 25 (1999Le67,1999So20 both same group as 2003So21). Jπ: from systematics of neighboring Co nuclides (2000Mu10,2003GrZZ) and direct β ⁻ feeding of Jπ=(5,6,7) and (6+) levels in ⁷⁰ Ni. Suggested configuration of πf _{7/2} ⁻¹ vg _{9/2} ⁺³ . %β ⁻ n: theoretical calculations give %β ⁻ n=2.0 (2003Mo09). %β ⁻ =100.
0+x	(3+)		0.47 s 5	T _{1/2} : weighted average of 0.47 s 5 (2015Pr10) and 0.50 s 18 (2000Mu10). Also observed as delayed state by 2003Sa40. Jπ: from systematics of neighboring Co nuclides (2000Mu10). Suggested configuration of πf _{7/2} ⁻¹ vp _{1/2} ⁻¹ vg _{9/2} ⁺⁴ .
0+y		B		
437.3+y		B	54 ns 10	T _{1/2} : from implant-γ(t) in Ni(⁸⁶ Kr,Xγ). Jπ: proposed as (4-) in Ni(⁸⁶ Kr,Xγ). However, observation of a single 274γ following ⁷⁰ Fe β ⁻ decay (Jπ=0+) suggests a low-spin assignment. E(level): based on nearly equal transition intensities of a 273γ and a 164γ, it is assumed that these transitions are emitted in cascade.

^{70}Fe β^- Decay 2013Ma87

Parent ^{70}Fe : $E=0.0$; $J\pi=0+$; $T_{1/2}=65$ ms 6; $Q(\text{g.s.})=10610$ syst; $\%\beta^-$ decay=100.

2013Ma87: ^{70}Fe activity produced in fragmentation of a ^{86}Kr beam at $E=140$ MeV/nucleon on a ^9Be target. Isotopes separated with the A1900 spectrometer and identified through ΔE and time-of-flight measurements. Measured $E\gamma$, $I\gamma$, $\beta\gamma$ coincidences using the SeGA array consisting of 12 segmented HPGe detectors and a DSSD.

A single 274γ is observed in the β -gated spectrum correlated with a ^{70}Fe implant. This could correspond to the β^- or β^-n decay of ^{70}Fe . Since a 273.2 5 transition is observed to depopulate the 54-ns isomer in ^{70}Co , 2013Ma87 tentatively place the 274γ as belonging to the β^- decay. However, this then creates a discrepancy with the proposed $J\pi=(4-)$ assignment to the 54-ns isomer, as population from the $0+$ ground state of ^{70}Fe is highly unlikely.

 $\gamma(^{70}\text{Co})$ $E\gamma$ $^{*}274^{\dagger} 1$

† Observed in β -gated spectrum correlated with an implanted ^{70}Fe .

x γ ray not placed in level scheme.

 $\text{Ni}(^{86}\text{Kr}, X\gamma)$ 2010Da06

2010Da06: $E(^{86}\text{Kr})=60.5$ MeV/nucleon on a natural Ni target. Reaction products separated with the LISE spectrometer and identified by ΔE , total energy, and time-of-flight measurements. Measured $E\gamma$, $I\gamma$, $\gamma(t)$ using four HPGe detectors. Additional details are provided in the thesis of 1999DaZQ.

1999DaZQ construct a level scheme where the 156γ and 273γ depopulate the 54-ns isomeric level, populating levels at 281 keV and 164 keV, respectively. The 164-keV level then decays by the 164γ to the ground state, whereas the 281-keV level is assumed to correspond to the $(3+)$, 0.50-s isomeric level. Since the proposed decay scheme disagrees with the results of ^{70}Fe β^- decay and is constructed based on assumptions of the γ -ray multipolarities, the evaluators do not adopt it here.

 ^{70}Co Levels

$E(\text{level})$	$J\pi$	$T_{1/2}$	Comments
0+x			
437.3+x	(4-)	54 ns 10	$\%\text{IT}=100$. $T_{1/2}$: from implant- $\gamma(t)$ (2010Da06, 1999DaZQ). $E(\text{level})$: based on the nearly equal transition intensities of the 273γ and 164γ , 1999DaZQ assume these are emitted in cascade. $J\pi$: as proposed by 2010Da06, 1999DaZQ. $J\pi$ assignment is not adopted, as there is a discrepancy with the results of ^{70}Fe β^- decay.

 $\gamma(^{70}\text{Co})$

$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ‡
$^{*}155.8$ § 5	38 10	(E1+M2)
$^{*}164.1$ § 5	100 17	(M1)
$^{*}273.2$ § 5	95 20	(E2)

† From 1999DaZQ.

‡ As proposed in 2010Da06, 1999DaZQ based on a comparison with Weisskopf estimates; not adopted by the evaluators.

§ Gammas assigned to the decay of the 54-ns isomeric level (1999DaZQ, 2010Da06).

x γ ray not placed in level scheme.

Adopted Levels, Gammas

$Q(\beta^-)=3762.5\ 24$; $S(n)=7307\ 4$; $S(p)=16330\ 190$; $Q(\alpha)=-11571\ 5\ 2012\text{Wa}38$.
 $S(2n)=11893\ 4$; $S(2p)=29970\ 370\ (2012\text{Wa}38)$.

 ^{70}Ni LevelsCross Reference (XREF) Flags

A ^{70}Co β^- Decay (112 ms)
 B ^{70}Co β^- Decay (0.47 s)
 C ^{71}Co β^-n Decay
 D ^{72}Co β^-2n Decay

E Coulomb Excitation
 F $\text{Ni}(^{86}\text{Kr}, X\gamma), ^9\text{Be}(^{76}\text{Ge}, X\gamma)$
 G $^9\text{Be}(^{72}\text{Ni}, ^{70}\text{Ni}\gamma), (^{73}\text{Cu}, ^{70}\text{Ni}\gamma)$
 H $^{208}\text{Pb}(^{70}\text{Zn}, X\gamma)$

E(level) [†]	J π	XREF	T _{1/2}	Comments
0.0 [‡]	0+	ABCDEFGH	6.0 s 3	% β^- =100. T _{1/2} : from $\gamma(t)$ in 2001Fr21,1998Fr15.
1259.55 [‡] 5	2+	ABCDEFGH	1.04 ps 17	B(E2) $\uparrow$ =0.086 14. J π : Coulomb excitation from 0+ ground state. B(E2) $\uparrow$: from Coulomb excitation; relative to B(E2)=0.268 8 for the first 2+ state of ^{76}Ge . T _{1/2} : deduced by evaluators from B(E2) and adopted γ -ray properties.
1567.1 8	(0+)	B	<70 ns	T _{1/2} : from $\beta\gamma(t)$ in ^{70}Co β^- decay (0.47 s). J π : from non-observation in multinucleon transfer reactions and absence of 1567 γ in β -delayed, γ -ray spectrum.
1867.44 14	(2+)	B G		J π : direct β feeding from (3+) parent and 1868 γ to 0+.
2229.44 [‡] 6	4+	A D FGH		J π : E2 970 γ to 2+.
2507.4 10		G		
2516.36 21		G		
2677.82 [‡] 7	6+	A FGH	1.049 ns 26	XREF: G(?). T _{1/2} : from $\gamma\gamma(t)$ in $\text{Ni}(^{86}\text{Kr}, X\gamma), ^9\text{Be}(^{76}\text{Ge}, X\gamma)$. J π : E2 449 γ to 4+.
2860.93 [‡] 7	8+	F H	0.232 μ s 1	%IT=100. T _{1/2} : from $\gamma(t)$ in $\text{Ni}(^{86}\text{Kr}, X\gamma), ^9\text{Be}(^{76}\text{Ge}, X\gamma)$. J π : E2 183 γ to 6+.
2912.05 11	(5, 6+)	A H		configuration=($\nu g_{9/2}$) ⁺² (1998Gr14). J π : β -feeding from (6-, 7-) parent, 683 γ to 4+.
3209.6 20		G		
3510.9 8		B		
3592.2 3		A H		
3758.1 3		H		
4871.5 4		H		
5354.4 4		H		

[†] From a least-squares fit to $E\gamma$, by evaluators.

[‡] (A): $\Delta J=2$ Cascade.

 $\gamma(^{70}\text{Ni})$

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	α	Comments
1259.55	1259.52 5	100	E2	1.62×10^{-4}	B(E2)(W.u.)=10.0 17. Mult.: from Coulomb Excitation from ground state.
1567.1	307.5 [‡]	100	[E2]	0.00853	B(E2)(W.u.)>0.17.
1867.44	607.6 [‡] 2	100 [‡] 7			
	1867.7 [‡] 2	68 [‡] 6			
2229.44	969.88 4	100	E2	2.60×10^{-4}	
2507.4	640 [#] 1	100			
2516.36	1256.8 [‡] 2	100			$E\gamma$: unplaced transition in ^{70}Co β^- decay, placement from $^9\text{Be}(^{72}\text{Ni}, ^{70}\text{Ni}\gamma), (^{73}\text{Cu}, ^{70}\text{Ni}\gamma)$.
2677.82	448.37 3	100	E2	0.00235	B(E2)(W.u.)=1.73 5.
2860.93	183.11 2	100	E2	0.0573	B(E2)(W.u.)=0.656 19.
2912.05	234.1 1	38 4			
	683.1 2	100 9			
3209.6	1950 [#] 2	100			
3510.9	1643.5 [‡]	100 [‡] 30			
	1943.7 [‡]	33 [‡] 10			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ni})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$
3592.2	914.4 3	100
3758.1	846 1	100 50
	1080.3 3	100 13
4871.5	1113.4 2	100
5354.4	482.9 2	100

$\dagger$ From $^{208}\text{Pb}(^{70}\text{Zn},\text{X}\gamma)$, except where noted.

$\ddagger$ From ^{70}Co β^- decay (0.47 s).

$\S$ From $\gamma\gamma(\theta)$ in $^{208}\text{Pb}(^{70}\text{Zn},\text{X}\gamma)$, except where noted. Q transitions are assumed to be E2 in character.

$\#$ From $^9\text{Be}(^{72}\text{Ni},^{70}\text{Ni}\gamma),(^{73}\text{Cu},^{70}\text{Ni}\gamma)$.

(A) $\Delta J=2$ **Cascade** **^{70}Co β^- Decay (112 ms) 2015Pr10,2003Sa40,2000Mu10**

Parent ^{70}Co : $E=0.0$; $J\pi=(6-,7-)$; $T_{1/2}=112$ ms 7; $Q(\text{g.s.})=1.23\times 10^4$ 3; $\%\beta^-$ decay=100.

2000Mu10,1998Fr15: ^{70}Co activity from proton-induced fission of ^{238}U with $E(p)=30$ MeV. Fission products separated using laser ionization and mass separation with the LIGLIS-LISOL setup. Measured E_{γ} , I_{γ} , $\gamma\gamma$, $\beta\gamma$ coincidences using two HPGe detectors and three ΔE plastic scintillator detectors.

2003Sa40,2003GrZZ: ^{70}Co activity from $^{\text{nat}}\text{Ta}(^{86}\text{Kr},\text{X})$ with $E(^{86}\text{Kr})=58$ MeV/nucleon. Reaction products separated with the LISE2000 spectrometer. Measured E_{γ} , I_{γ} , $\beta\gamma$ using four Clover-type EXOGAM Ge detectors and a stack of four Si detectors, one a double-sided Si strip detector.

2015Pr10: ^{70}Co activity from $^9\text{Be}(^{76}\text{Ge},\text{X})$ with $E(^{76}\text{Ge})=130$ MeV/nucleon. Reaction products separated with the A1900 fragment separator and identified with ΔE -TOF measurements. Measured E_{γ} , I_{γ} , $\beta\gamma$, $\gamma\gamma$, $\beta(t)$, $\beta\gamma(t)$ using 16 detectors of the segmented Ge array (SeGA) for γ 's and a planar Ge double-sided strip detector for β 's.

With a Q value of 12.3 MeV 3 and a highest observed level of 3.6 MeV, the evaluators consider this decay scheme to be incomplete and thus, do not provide a normalization or β -feeding intensities.

 ^{70}Ni Levels

The 3146 and 3361-keV levels proposed in 2003Sa40 and 2000Mu10 are not adopted here since subsequent measurements in 2015Pr10 and in the $^{208}\text{Pb}(^{70}\text{Zn},\text{X}\gamma)$ reaction found alternate placements for the 916 γ and 683 γ transitions proposed to depopulate these levels.

E(level) †	$J\pi^{\ddagger}$	$T_{1/2}^{\ddagger}$
0.0	0+	6.0 s 3
1259.0	2+	
2228.7	4+	
2677.2	6+	
2911.8	(5,6+)	
3592.4		

$\dagger$ From at least-squares fit to E_{γ} , by evaluators.

$\ddagger$ From the Adopted Levels.

^{70}Co β^- Decay (112 ms) 2015Pr10,2003Sa40,2000Mu10 (continued) $\gamma(^{70}\text{Ni})$

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Comments
234.6	2911.8	5.2 5	
448.5	2677.2	38 3	$I\gamma$: others: 37 8 (2003GrZZ), 80 5 (2000Mu10), 68 20 (2003Sa40).
$\times 680.3^\S$			
$\times 683.3^\S$			
$\times 846.4^\S$			
915.2	3592.4	29 2	$E\gamma$: a 916 γ with $I\gamma=59$ 19 was placed from a 3146-keV level by 2003Sa40,2003GrZZ; transition not observed by 2000Mu10.
969.7	2228.7	58 4	$I\gamma$: others: 89 12 (2003GrZZ), 97 7 (2000Mu10), 116 35 (2003Sa40).
$\times 1079.9^\S$			
1259.0	1259.0	100 7	$I\gamma$: others: 100 13 (2003GrZZ), 100 10 (2000Mu10), 100 35 (2003Sa40).
$\times 1392.6^\S$			
$\times 1641.5^\S$			
$\times 1676.7^\S$			

 † From 2015Pr10. ‡ From 2015Pr10. Values from 2000Mu10, 2003Sa40, and 2003GrZZ are given in the comments. In each of these works, the authors quoted intensities with different relative normalizations. To enable a better comparison to the values from 2015Pr10, the evaluators have renormalized the 2000Mu10, 2003Sa40, and 2003GrZZ values to $I\gamma(1259.0\gamma)=100$. § Indicated in Figure 1 of 2015Pr10 as originating from the high-spin, β^- -decaying level in ^{70}Co , by not placed in the level scheme. $^\times$ γ ray not placed in level scheme.

⁷⁰Co β⁻ Decay (0.47 s) 2015Pr10,2000Mu10

Parent ⁷⁰Co: E=0+x; Jπ=(3+); T_{1/2}=0.47 s 5; Q(g.s.)=1.23×10⁴ 3; %β⁻ decay=100.

2000Mu10,1998Fr15: ⁷⁰Co activity from proton-induced fission of ²³⁸U with E(p)=30 MeV. Fission products separated using laser ionization and mass separation with the LIGLIS-LISOL setup. Measured Eγ, Iγ, γγ, βγ using 2 HPGe detectors and three ΔE plastic scintillators.

2003Sa40,2003GrZZ: ⁷⁰Co activity from ^{nat}Ta(⁸⁶Kr,X) with E(⁸⁶Kr)=58 MeV/nucleon. Reaction products separated with the LISE2000 spectrometer and identified by E, ΔE, TOF measurements. Measured Eγ, Iγ, βγ using four Clover-type EXOGAM HPGe detectors and a stack of four Si detectors, one a double-sided Si strip detector.

2015Pr10: ⁷⁰Co activity from ⁹Be(⁷⁶Ge,X) with E(⁷⁶Ge)=130 MeV/nucleon. Reaction products separated with the A1900 fragment separator and identified with ΔE-TOF measurements. Measured Eγ, Iγ, βγ, γγ, β(t), βγ(t) using 16 detectors of the segmented Ge array (SeGA) for γ's and a planar Ge double-sided strip detector for β's.

Other: 2016Li30, deduced level density as a function of excitation energy.

With a Q value of more than 12.3 MeV 3 and a highest observed level of 3.5 MeV, the evaluators consider this decay scheme to be incomplete and thus, do not provide a normalization or β-feeding intensities.

⁷⁰Ni Levels

E(level) [†]	Jπ [‡]	T _{1/2}	Comments
0.0	0+	6.0 s 3	
1258.99	2+		
1566.4	(0+)	<70 ns	T _{1/2} : from time difference spectra between β-decay electrons and the 307.5γ (2015Pr10).
1866.45	(2+)		
3510.1			

[†] From a least-squares fit to Eγ, by evaluators.

[‡] From the Adopted Levels.

γ(⁷⁰Ni)

2000Mu10 report a 1256.8 2 transition which they find coincident with the 1259.6γ. In the higher statistics data of 2015Pr10, they report that the 1259.6γ was not observed to be self-coincident. However, in the ⁹Be(⁷²Ni,⁷⁰Niγ),(⁷³Cu,⁷⁰Niγ) reaction, the 1259γ is observed to be self coincident and placed from a level at 2515.8 keV.

Eγ [†]	E(level)	Iγ [†]	Comments
307.5	1566.4	4.6 4	
607.4	1866.45	14 1	Iγ: others: 36 4 (2000Mu10), 35 14 (2003Sa40).
^x 1256.8 2		14 4	
1259.0	1258.99	100 7	Iγ: others: 100 10 (2000Mu10), 100 35 (2003Sa40).
1643.5	3510.1	2.1 6	
1866.4	1866.45	9.5 8	Eγ,Iγ: not observed by 2003Sa40, attributed to a much weaker population of this isomer in their reaction.
			Iγ: other: 27 4 (2000Mu10).
1943.7	3510.1	0.7 2	

[†] From 2015Pr10, except where noted. Values from 2000Mu10 and 2003Sa40 are included in the comments. In each of these works, the authors quoted intensities relative to Iγ(608γ)=100. To enable a better comparison to the values from 2015Pr10, the evaluators have renormalized the 2000Mu10 and 2003Sa40 values to Iγ(1259γ)=100.

[‡] From 2000Mu10.

^x γ ray not placed in level scheme.

Decay Scheme

^{71}Co β^- n Decay 2012Ra10

Parent ^{71}Co : $E=0.0$; $J\pi=(7/2^-)$; $T_{1/2}=80$ ms 3; $Q(\text{g.s.})=6770$ 470; $\%\beta^-$ n decay<3.60.

^{71}Co - $\%\beta^-$ n decay: $\%\beta^-$ n<2.7 9 estimated from γ -ray intensity measurements (2012Ra10).

2012Ra10: ^{71}Co activity from fragmentation of a ^{86}Kr beam with $E=140$ MeV/nucleon on a ^9Be target. Recoil products separated with the A1900 spectrometer and identified by TOF and ΔE techniques. Measured $E\gamma$, $I\gamma$, $\beta\gamma$ coincidences using a DSSD positioned within a Si detector telescope surrounded by the SeGA array consisting of 12 segmented HPGe detectors. Preliminary results presented in 2005Ma95, 2005MaZX.

^{70}Ni Levels

E(level)	$J\pi^\dagger$
0.0	0+
1259.7 9	2+

† From the Adopted Levels.

$\gamma(^{70}\text{Ni})$

$E\gamma$	E(level)	$I\gamma$	Comments
1259.7 9	1259.7	5 2	$I\gamma$: relative to $I\gamma(566.9\gamma)=100$ from ^{71}Co β^- decay.

Decay Scheme

^{72}Co β -2n Decay 2016Mo07

Parent ^{72}Co : E=0+x; $J\pi=(6-,7-)$; $T_{1/2}=51.5$ ms 3; Q(g.s.)=3290 400; % β -2n decay>0.

Parent ^{72}Co : E=0+y; $J\pi=(0+,1+)$; $T_{1/2}=47.8$ ms 5; Q(g.s.)=3290 400; % β -2n decay>0.

$^{72}\text{Co}(0+x)-J,T_{1/2}$: From 2016Mo07. $T_{1/2}$ was measured from decay curve of β -decay activity gated on 454 γ .

$^{72}\text{Co}(0+x)-\%\beta$ -2n decay: Beta-delayed two-neutron emission was claimed by 2016Mo07 to have been seen in the decay of ^{72}Co .

$^{72}\text{Co}(0+y)-J,T_{1/2}$: From 2016Mo07. Half-life was measured from decay curve of β -decay activity gated on 1680 γ , 1689 γ , 1732 γ , 2023 γ , 2538 γ , 650 γ , 22885 γ , 3040 γ and 3383 γ in ^{72}Ni (^{72}Co β -decay).

$^{72}\text{Co}(0+y)-\%\beta$ -2n decay: Beta-delayed two-neutron emission was claimed by 2016Mo07 to have been seen in the decay of ^{72}Co .

^{72}Co isotope produced in $^9\text{Be}(^{238}\text{U},\text{F})$, E=345 MeV/nucleon at RIBF-RIKEN facility. Fission fragments were separated and analyzed through ΔE -Bp-tof technique using BigRIPS separator and ZeroDegree spectrometer. The implanted residues were counted using the WAS3ABi setup equipped with DSSDs for ion, β , conversion electrons and EURICA array of 12 seven-element HPGe detectors for γ -ray detection.

 ^{70}Ni Levels

E(level) [†]	$J\pi$ [‡]
0.0	0+
1260	2+
2230	4+

[†] From E γ values. The order of the levels adopted from the Adopted Levels of ^{70}Ni since no level scheme was given in 2016Mo07.

[‡] From the Adopted Levels.

 $\gamma(^{70}\text{Ni})$

E γ [†]	E(level)	Comments
970	2230	
1260	1260	E γ : 970 in Fig. 1 of 2016Mo07 seems a misprint, energy scale suggests E γ is close to 1260 keV.

[†] From β -gated singles γ spectrum (Fig. 1 in 2016Mo07), assigned by the authors to ^{70}Ni from the β -2n decay of ^{72}Co .

 $^9\text{Be}(^{72}\text{Ni}, ^{70}\text{Ni}\gamma), (^{73}\text{Cu}, ^{70}\text{Ni}\gamma)$ 2015Ch25

Secondary beams of ^{72}Ni and ^{73}Cu with E=75 MeV/nucleon produced in the projectile fragmentation of a 140 MeV/nucleon ^{82}Se beam on a ^9Be production target and separated with the A1900 fragment separator. Reaction products were identified with the S800 spectrograph. Measured E γ , I γ , $\gamma\gamma$ coincidences using the GRETINA array consisting of 36-fold segmented HPGe detectors and a 4 $\times$ 8 array of CsI(Na) detectors behind the focal plane of the S800 (for delayed γ rays).

 ^{70}Ni Levels

E(level) [†]	$J\pi$ [‡]	Comments
0.0	0+	
1259.0 9	2+	
1868.0 9	(2+)	
2227.0 13	4+	
2508.0 13		$J\pi$: (4+) proposed in 2015Ch25 based on the decay pattern and absence of any observed β -feeding to this level.
2515.8 13		E(level): level proposed by 2015Ch25 based on unplaced 1256.8 γ from ^{70}Co β^- decay (0.47 s) (2000Mu10).
		$J\pi$: (0+,2+) proposed by 2015Ch25 based on population of only low-spin ($J\leq 4$) states in this reaction, unlikely presence of J=1 or 3 states based on shell model considerations and absence of any observed β feeding to J=4+ levels.
2678?	6+	
3209.0 22		

[†] From a least-squares fit to E γ , by evaluators.

[‡] From the Adopted Levels. Differences with the $J\pi$ proposed by 2015Ch25 are indicated in the comments.

$^9\text{Be}(^{72}\text{Ni}, ^{70}\text{Ni}\gamma), (^{73}\text{Cu}, ^{70}\text{Ni}\gamma)$ 2015Ch25 (continued) $\gamma(^{70}\text{Ni})$

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Comments
$^x384\ 1$		$3.8\ 4$	
$442\ \S\ 5$	2678?		E γ : a weak 442 γ is observed only in $\gamma\gamma$ -coin data and may correspond to the 448-keV transition from 6+ yrast level.
$609\ 1$	1868.0	$12.3\ 6$	
$640\ 1$	2508.0	$8.1\ 5$	
$^x676\ 1$		$4.7\ 5$	
$968\ 1$	2227.0	$27\ 3$	
$1256.8\ 2$	2515.8		E γ : from $^{70}\text{Co}\ \beta^-$ decay (0.47 s) (2000Mu10). A 1259-keV transition is self-coincident and proposed to correspond to the 1259.6- and 1256.8-keV pair identified in $^{70}\text{Co}\ \beta^-$ decay (0.47 s). Mult.: 2015Ch25 suggest either D or Q for the multipolarity of the 1256.8 γ based on the prompt character of the decay.
$1259\ 1$	1259.0	$100\ 10$	
$^x1682\ 2$		$3.5\ 6$	
$1868\ 1$	1868.0	$11.2\ 7$	
$1950\ 2$	3209.0	$4.2\ 6$	

† From the singles spectrum in 2015Ch25, unless otherwise noted.

‡ From the singles spectrum in 2015Ch25.

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

x γ ray not placed in level scheme.

Coulomb Excitation 2006Pe13

2006Pe13: $^{208}\text{Pb}(^{70}\text{Ni}, ^{70}\text{Ni}'\gamma)$ at $v/c \approx 0.28$. ^{70}Ni beam produced in fragmentation of a ^{76}Ge beam on a ^9Be target, E(^{76}Ge)=60 MeV/nucleon, separated with the LISE3 spectrometer and identified through TOF and ΔE measurements. Measured E γ , I γ , Coulomb excitation cross section using four segmented EXOGAM clover HPGe detectors and particle- γ coincidences using two annular Si detectors mounted behind the target. B(E2) value deduced relative to B(E2)=0.268 8 for the first 2+ state of ^{76}Ge . Subset of results presented in 2008AzZZ.

 ^{70}Ni Levels

E(level) †	J $\pi^\dagger$	$T_{1/2}$	Comments
0.0	0+		
1259.6	2+	1.04 ps 17	B(E2) $\uparrow$ =0.086 14 (2006Pe13). B(E2) $\uparrow$: relative to B(E2)=0.268 8 for the first 2+ state of ^{76}Ge . $T_{1/2}$: deduced by evaluators from B(E2) and adopted γ -ray properties.

† From the Adopted Levels.

 $\gamma(^{70}\text{Ni})$

$E\gamma^\dagger$	E(level)	Mult.	Comments
1259.6	1259.6	E2	Mult.: from Coulomb excitation from ground state.

† From the Adopted Levels.

$^{208}\text{Pb}(^{70}\text{Zn},\text{X}\gamma)$ 2015Ch25

$E(^{70}\text{Zn})=440$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coincidences, $\gamma\gamma(\theta)$ using the Gammasphere array consisting of 100 Compton-suppressed HPGe detectors.

 ^{70}Ni Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}$	Comments
0.0#	0+		
1259.53# 5	2+§		
2229.42# 6	4+§		
2677.80# 7	6+§		
2860.91# 7	8+§	232 ns 1	$T_{1/2}$: from the Adopted Levels.
2912.03 11	(5, 6+)		$J\pi$: (5-) proposed in 2015Ch25 based on the decay pattern and shell model calculations.
3592.2 3			$J\pi$: (6-) proposed in 2015Ch25 based on the decay pattern and shell model calculations.
3758.1 3			$J\pi$: (7-) proposed in 2015Ch25 based on the decay pattern and shell model calculations.
4871.5 4			
5354.4 4			

† From a least-squares fit to $E\gamma$, by evaluators.

‡ From the Adopted Levels. $J\pi$ assignments of 2015Ch25 which differ from the Adopted Levels are indicated in the comments.

§ From the deduced multipolarities from $\gamma\gamma(\theta)$.

(A): Yrast structure based on g.s.

 $\gamma(^{70}\text{Ni})$

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\ddagger$	Mult.#	$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\ddagger$	Mult.#
183.11§ 2	2860.91		Q	914.4 3	3592.2	12 4	
234.1 1	2912.03	16.5 17		969.88§ 4	2229.42		Q
448.37§ 3	2677.80	100 5	Q	1080.3 3	3758.1	24 3	
482.9 2	5354.4	29 6		1113.4 2	4871.5	34 5	
683.1 2	2912.03	43 4		1259.52§ 5	1259.53		
846 1	3758.1	24 12					

† From prompt $\gamma\gamma$ coincidences, unless otherwise noted.

‡ From prompt $\gamma\gamma\gamma$ coincidences.

§ Energy measured in delayed spectrum.

From $\gamma\gamma(\theta)$. Authors stated that the angular correlation of $(970\gamma)(1260\gamma)(\theta)$, $(448\gamma)(1260\gamma)(\theta)$ and $(183\gamma)(1260\gamma)(\theta)$ are consistent with the theoretical curves for E2-E2 correlations.

Ni($^{86}\text{Kr}, X\gamma$), $^9\text{Be}(^{76}\text{Ge}, X\gamma)$ 1998Gr14, 2003Ma50

1999Le68, 1998Gr14, 1997Pf03: $^{nat}\text{Ni}(^{86}\text{Kr}, X\gamma)$, $E(^{86}\text{Kr})=60.3$ MeV/nucleon. Recoil products separated with the Alpha and LISE spectrometers and identified with TOF and $\Delta E-E$ technique. Measured $E\gamma$, $I\gamma$, $\gamma(t)$, $\gamma\gamma$, fragment- γ coincidences using six planar silicon detectors surrounded by five HPGe detectors and a LEPS detector.

2003Ma50: $^9\text{Be}(^{76}\text{Ge}, X\gamma)$, $E(^{76}\text{Ge})=60$ MeV/nucleon. Recoil products separated with the LISE spectrometer and identified by TOF and $\Delta E-E$ technique. Measured $E\gamma$, $\gamma\gamma(t)$ using four BaF_2 detectors and an HPGe detector.

 ^{70}Ni Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}$	Comments
0.0 §	0+	6.0 s ‡ 3	
1259 § 1	2+		
2229 § 1	4+		
2677 § 2	6+	1.049 ns 26	$T_{1/2}$: from $\gamma\gamma(t)$ in 2003Ma50.
2860 § 2	8+	0.232 μs 1	$T_{1/2}$: from $\gamma(t)$ using sum of 183 γ , 448 γ , 970 γ and 1259 γ (1999Le68). Others: 0.21 μs 5 (1998Gr14), 0.200 μs (1997Pf03). $J\pi$: configuration=($\nu g_{9/2}$) $^{+2}$ (1998Gr14).

† From $E\gamma$.

‡ From the Adopted Levels.

§ (A): $\Delta J=2$ cascade.

 $\gamma(^{70}\text{Ni})$

$E\gamma^\dagger$	$E(\text{level})$
183 1	2860
448 1	2677
970 1	2229
1259 1	1259

† From 1998Gr14.

Adopted Levels, Gammas

Q(β⁻)=6588.3 22; S(n)=5311.5 18; S(p)=10287 4; Q(α)=-8993 14 2012Wa38.
S(2n)=13552.0 19; S(2p)=25630 150 (2012Wa38).

⁷⁰Cu Levels

Cross Reference (XREF) Flags

A ⁷⁰Ni β⁻ Decay
B ⁷⁰Cu IT Decay (33 s)
C ⁷⁰Cu IT Decay (6.6 s)
D ⁷⁰Zn(t,³He)
E Coulomb Excitation

E(level) [†]	Jπ	XREF	T _{1/2}	Comments
0.0 [‡]	6-	AB DE	44.5 s 2	%β ⁻ =100; Q=-0.285 14; μ=+1.3666 5. Jπ: from collinear laser spectroscopy (2010Vi07). T _{1/2} : from β(t); a three component exponential decay was used to account for the 6- ground state, 1+ 243-keV isomer and a constant background (2004Va08). Others: 42 s 7 (1999Pr10), 52 s 4 (1975Re09), 42 s 3 (1971Ta03). μ: from collinear laser spectroscopy (2010Vi07). Other: (+)1.50 11 from LASER spectroscopy (2002We03). Q: from collinear laser spectroscopy (2010Vi07). %β ⁻ =52 9; %IT=48 9; Q=-0.13 4; μ=-3.3641 15. Jπ: from collinear laser spectroscopy (2010Vi07). T _{1/2} : from γ(t) of the 209γ, 387γ, 553γ and 708γ from the 3247-keV level in ⁷⁰ Zn (2004Va08). %β ⁻ ,%IT: from 2004Va07,2004Va08. μ: from collinear laser spectroscopy (2010Vi07). Other: (-)3.50 12 from LASER spectroscopy (2002We03). Q: from collinear laser spectroscopy (2010Vi07). E(level): confirmed in high-precision mass measurement where 100.7 keV 26 was deduced (2004Va07).
101.1 3	3-	ABCDE	33 s 2	Jπ: Coulomb excitation from 6- ground state; member of ((π 2p _{3/2})(ν 1g _{9/2})) multiplet. B(E2) (6- to 4-)=0.0069 9 (2011Ra42). B(E2) (3- to 4-)=0.0073 10 (2011Ra42). %β ⁻ =93.2 9; %IT=6.8 9; Q=-0.12 3; μ=+1.7779 15. Jπ: from collinear laser spectroscopy (2010Vi07). T _{1/2} : from β(t); a three component exponential decay was used to account for the 6- ground state, 1+ 243-keV isomer and a constant background (2004Va08). Others: 4 s 1 (1975Re09) and 5 s 1 (1971Ta03) %β ⁻ ,%IT: from 2004Va07,2004Va08. μ: from collinear laser spectroscopy (2010Vi07). Other: +1.86 4 from LASER spectroscopy (2002We03). Q: from collinear laser spectroscopy (2010Vi07). Jπ: from similarity to ⁶⁸ Cu, possible configuration=((π 2p _{3/2})(ν 2p _{1/2}) ⁻¹) (2004Va08). Jπ: 126.5γ to 1+, 140γ to 4-.
228.5 [‡] 4	4-	A DE		Jπ: Coulomb excitation from 3- isomeric state; member of ((π 2p _{3/2})(ν 1g _{9/2})) multiplet. B(E2) (6- to 5-)=0.0011 2 (2011Ra42). B(E2) (3- to 5-)=0.0136 15 (2011Ra42).
242.6 5	1+	A C E	6.6 s 2	
320.7 5	(2+)	A		
368.9 4	(2-)	A D		
511 [‡] 3	5-	DE		
628.3? 5		A		
697.7 5	(1+)	A		Jπ: log ft=5.1 from 0+ parent.
706.1? 5		A		
938.8 5		A		
1278.4 5	(1+)	A		Jπ: log ft=4.2 from 0+ parent.
1520.4 5	(1+)	A		Jπ: log ft=4.6 from 0+ parent.
1980.1 5	(1+)	A		Jπ: log ft=4.8 from 0+ parent.

[†] From a least-squares fit to E_γ, by evaluators.

[‡] Multiplet of states arising from the ((π 2p_{3/2})(ν 1g_{9/2})) configuration.

Adopted Levels, Gammas (continued)

$\gamma(^{70}\text{Cu})$					
E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult.	α	Comments
101.1	101.1 3	100	[M3]	5.35 11	B(M3)(W.u.)=4.9 10. E γ : from ^{70}Cu IT decay (33 s).
228.5	127.4 2	100	[M1]	0.0281	
242.6	141.3	100	[M2]	0.1681	B(M2)(W.u.)= 2.9×10^{-7} 4. E γ : from ^{70}Cu IT decay (6.6 s).
320.7	78.3 1	100	[M1]	0.1042	
368.9	126.5 2	100 80	[E1]	0.0270	
	140.4 6	70 40	[E2]	0.169 4	
	267.8 4	90 18	[M1]	0.00426	
511	511 3	100			E γ : from Coulomb excitation.
628.3?	385.7 § 5	100			
697.7	377.2 1	78 15			
	455.1 1	100 15			
706.1?	385.7 § 5	100			
938.8	232.8 ‡ § 3	14 10			
	618.4 2	100 30			
	696.1 1	72 12			
1278.4	339.6 1	25 4			
	581.1 2	3.5 9			
	650.1 ‡ § 2	9.6 16			
	956.9 3	2.8 15			
	1035.6 2	100 7			
1520.4	1152.3 4	20 10	[E1]	1.14×10^{-4}	
	1277.6 2	100 17			
1980.1	1611.2 3	100	[E1]	3.95×10^{-4}	

[†] From ^{70}Ni β^- decay, except where noted.

[‡] Ordering of the 650 γ –386 γ cascade and the 233 γ –386 γ cascade could not be determined. A reverse ordering resulting in the 628-keV level moving to 892.5 keV and the 706-keV level moving to 553.5-keV is also possible.

§ Placement of transition in the level scheme is uncertain.

^{70}Ni β^- Decay 2004Va08

Parent ^{70}Ni : $E=0.0$; $J\pi=0+$; $T_{1/2}=6.0$ s 3; $Q(\text{g.s.})=3762.5$ 24; $\%\beta^-$ decay=100.

^{70}Ni activity produced in proton-induced fission of natural uranium, with $E(p)=30$ MeV. Fission fragments first thermalized and neutralized in a buffer gas then selectively extracted through resonant laser ionization and electromagnetic separation using the LISOL separator. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\beta\gamma$, and $\gamma(t)$ using two HPGe detectors and a thin plastic ΔE scintillator. Subset of results presented in 2004Va07. See also 2002VaZX, thesis.

A total energy release of 3520 keV 180 is calculated for this decay scheme using the RADLST code, which can be compared to the total Q value of 3762.5 keV 24. Due to the ≈ 1.8 MeV gap in energy between the highest observed excited level and the Q value and also the approximation that has gone into the normalization of the decay scheme, beta-decay feeding intensities and $\log ft$ values should be considered approximate.

 ^{70}Cu Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\ddagger$	Comments
0.0	6-	44.5 s 2	
101.1 3	3-	33 s 2	$E(\text{level})$: confirmed in high-precision mass measurement where 100.7 keV 26 was deduced (2004Va07).
228.5 4	4-		
242.6 5	1+	6.6 s 2	$E(\text{level})$: confirmed in high-precision mass measurement where 242.0 keV 27 was deduced (2004Va07).
320.7 5	(2+)		
368.9 5	(2-)		
628.1?			
697.7 5	(1+)		
706.4?			
938.8 5			
1278.4 5	(1+)		
1520.4 5	(1+)		
1980.1 6	(1+)		

† From a least-squares fit to $E\gamma$, by the evaluators.

‡ From the Adopted Levels.

 β^- radiations

$E\beta^-$	$E(\text{level})$	$I\beta^-^\dagger$	$\log ft$	Comments
(1782.4 25)	1980.1	≈ 1.2	≈ 4.8	
(2242.1 25)	1520.4	≈ 4.6	≈ 4.6	
(2484.1 25)	1278.4	≈ 17	≈ 4.2	
(3064.8 25)	697.7	≈ 5.7	≈ 5.1	
(3519.9 25)	242.6	≈ 71	≈ 4.3	$I\beta^-$: from comparison of observed total activities of ^{70}Ni parent with the 6.6-s ^{70}Cu daughter activities (2004Va08). The latter was derived using absolute $I\gamma(885\gamma)=94\%$ 2 from 6.6-s ^{70}Cu 1+ decay and assuming no ground state β feeding in the 6.6-s ^{70}Cu 1+ decay.

† Absolute intensity per 100 decays.

70Ni β⁻ Decay 2004Va08 (continued)γ(70Cu)

I_γ normalization: from Σ(I(γ+ce) to 243- and 101-keV isomers)=29%. %I_β to 242-keV level = 71 was derived by 2004Va08 from comparison of observed total activities of 70Ni parent with the 6.6-s 70Cu daughter activities. The latter was derived using absolute I_γ(885γ)=94% 2 from 6.6-s 70Cu 1+ decay and assuming no ground state β feeding in the 6.6-s 70Cu 1+ decay.

Eγ [†]	E(level)	I _γ [†] #	Mult. [‡]	α	Eγ [†]	E(level)	I _γ [†] #	Mult. [‡]	α
78.3 1	320.7	34 5	[M1]	0.1042	455.1 1	697.7	27 4		
126.5 2	368.9	4 3	[E1]	0.0270	581.1 2	1278.4	3.5 9		
127.4 2	228.5	3.3 18	[M1]	0.0281	618.4 2	938.8	14 4		
140.4 6	368.9	2.9 16	[E2]	0.169 4	650.1 §@ 2	1278.4	9.6 16		
232.8 §@ 3	938.8	2.0 13			696.1 1	938.8	10.1 16		
267.8 4	368.9	3.6 7	[M1]	0.00426	956.9 3	1278.4	2.8 15		
339.6 1	1278.4	25 4			1035.6 2	1278.4	100 7		
377.2 1	697.7	21 4			1152.3 4	1520.4	6 3	[E1]	1.14×10 ⁻⁴
385.7 §@ 5	628.1?	9.6 16			1277.6 2	1520.4	30 5		
	706.4?	2.0 13			1611.2 3	1980.1	9 2	[E1]	3.95×10 ⁻⁴

[†] From 2004Va08. I_γ are given relative to I_γ(1036γ)=100.

[‡] From the Adopted Levels.

§ Ordering of the 650γ-386γ cascade and the 233γ-386γ cascade could not be determined. A reverse ordering resulting in the 628-keV level moving to 892.5 keV and the 706-keV level moving to 553.5-keV is also possible.

For absolute intensity per 100 decays, multiply by =0.129.

@ Placement of transition in the level scheme is uncertain.

Decay Scheme

⁷⁰Cu IT Decay (33 s) 2004Va08,2004Va07

Parent ⁷⁰Cu: E=101.1 3; J π =3-; T_{1/2}=33 s 2; %IT decay=48 9.

2004Va08,2004Va07: ⁷⁰Cu activity produced through proton-induced fission of a uranium carbide target, E(p)=1 GeV and through low-energy neutron induced fission following a proton-to-neutron converter. Fragments separated using resonant laser-ionization (RILIS) followed by mass separation. In one setup, in-source laser spectroscopy measurements were performed combined with a 4 π cylindrical β detector and a Ge(Li) detector. In another setup, measured E γ , I γ , $\beta\gamma$, γ (t) using two HPGe detectors and three thin plastic ΔE detectors. 2004Va07 also performed high-resolution mass spectroscopy with the Penning trap mass spectrometer ISOLTRAP.

⁷⁰Cu Levels

E(level)	J π [†]	T _{1/2}	Comments
0.0	6-	44.5 s 2	% β^- =100. T _{1/2} : from β (t); a three component exponential decay was used to account for the 6- ground state, 1+ 243-keV isomer and a constant background (2004Va08).
101.1 3	3-	33 s 2	% β^- =52 9; %IT=48 9 (2004Va08). E(level): high precision mass measurement in 2004Va07 gives 100.7 keV 26. T _{1/2} : from γ (t) of the 209 γ , 387 γ , 553 γ and 708 γ from the 3247-keV level in ⁷⁰ Zn (2004Va08).

[†] From the Adopted Levels.

γ (⁷⁰Cu)

E γ [†]	E(level)	I γ [‡]	Mult.	α	I(γ +ce) [‡]	Comments
101.1 3	101.1	15.7 3	[M3]	5.35 11	100	ce(K)/(γ +ce)=0.720 8; ce(L)/(γ +ce)=0.107 3; ce(M)/(γ +ce)=0.0153 4; ce(N)/(γ +ce)=0.000368 10. I γ : from I(γ +ce) and α .

[†] From 2004Va08.

[‡] For absolute intensity per 100 decays, multiply by 0.48 9.

Decay Scheme

Intensity: I(γ +ce)
per 100 parent decays
%IT=48 9

⁷⁰Cu IT Decay (6.6 s) 2004Va08,2004Va07

Parent ⁷⁰Cu: E=242.6 5; J π =1+; T_{1/2}=6.6 s 2; %IT decay=6.8 9.

2004Va08,2004Va07: ⁷⁰Cu activity produced through proton-induced fission of a uranium carbide target, E(p)=1 GeV and through low-energy neutron induced fission following a proton-to-neutron converter. Fragments separated using resonant laser-ionization (RILIS) followed by mass separation. In one setup, in-source laser spectroscopy measurements were performed combined with a 4 π cylindrical β detector and a Ge(Li) detector. In another setup, measured E γ , I γ , $\beta\gamma$, $\gamma(t)$ using two HPGe detectors and three thin plastic ΔE detectors. 2004Va07 also performed high-resolution mass spectroscopy with the Penning trip mass spectrometer ISOLTRAP.

⁷⁰Cu Levels

E(level)	J π [†]	T _{1/2}	Comments
101.1 3	3-	33 s 2	T _{1/2} : from $\gamma(t)$ of the 209 γ , 387 γ , 553 γ and 708 γ from the 3247-keV level in ⁷⁰ Zn (2004Va08).
242.4 3	1+	6.6 s 2	%IT=6.8 9; % β -=93.2 9 (2004Va08). T _{1/2} : from $\beta(t)$; a three component exponential decay was used to account for the 6- ground state, 1+ 243-keV isomer and a constant background (2004Va08).

[†] From the Adopted Levels.

$\gamma(^{70}\text{Cu})$

E γ [†]	E(level)	I γ [‡]	Mult.	α	I(γ +ce) [‡]	Comments
141.3 3	242.4	85.6 2	[M2]	0.168 3	100	ce(K)/(γ +ce)=0.1273 18; ce(L)/(γ +ce)=0.01446 23; ce(M)/(γ +ce)=0.00204 4; ce(N)/(γ +ce)=5.80 $\times$ 10 ⁻⁵ 10. I γ : from I(γ +ce) and α .

[†] From 2004Va08.

[‡] For absolute intensity per 100 decays, multiply by 0.068 9.

Decay Scheme

Intensity: I(γ +ce)
per 100 parent decays
%IT=6.8 9

⁷⁰Cu₄₁

Coulomb Excitation 2011Ra42

2011Ra42: $^{120}\text{Sn}(^{70}\text{Cu}, ^{70}\text{Cu}')$ and $^{120}\text{Sn}(^{70\text{m}}\text{Cu}, ^{70\text{m}}\text{Cu}')$ with $E(^{70}\text{Cu})=2.83\text{ MeV / nucleon}$ and $E(^{70\text{m}}\text{Cu})=2.85\text{ MeV / nucleon}$.

The ^{70}Cu beams were produced through proton induced fission of a UC_x target with $E(p)=1.4\text{ GeV}$, followed by mass separation and isomeric purification through resonant laser ionization using RILIS laser-ion source. The Cu activities were then post-accelerated by REX at ISOLDE. Measured $E\gamma$, $I\gamma$, particle- γ coincidences using the MINIBALL HPGe array and an annular Compact Disk shaped double sided silicon strip detector; deduced transition strengths by comparison of observed excitation cross section to predictions of CLX code based on Winther-De Boer theory. Earlier results on the Coulomb excitation of the ^{70}Cu ground state are given in 2007St03 and preliminary results in 2006Ge18.

The beams studied in 2011Ra42 were a mixture of the ground state and two isomeric levels in ^{70}Cu . For the beam the authors refer to as the ground state ($J\pi=6^-$) experiment, the composition was 85% $5\text{ }^{70}\text{Cu}$ ground state, 7% $2\text{ the } J\pi=3^-, 33\text{-s isomer}$, and 7% $3\text{ the } J\pi=1^+, 6.6\text{-s isomer}$. For the beam the authors refer to as the $J\pi=3^-$ experiment, the composition was 74% $7\text{ }^{70}\text{Cu}$ ground state, 25% $3\text{ the } J\pi=3^-, 33\text{-s isomer}$, and <1% the $J\pi=1^+, 6.6\text{-s isomer}$.

 ^{70}Cu Levels

$E(\text{level})^\dagger$	$J\pi^\dagger$	$T_{1/2}^\dagger$	Comments
0.0 $\frac{1}{2}$	6-	44.5 s 2	
101.1 $\frac{1}{2}$	3-	33 s 2	
228.5 $\frac{1}{2}$	4-		B(E2) (6- to 4-)=0.0069 9 (2011Ra42). B(E2) (3- to 4-)=0.0073 10 (2011Ra42).
242.2	1+	6.6 s 2	
511 $\frac{1}{2}$	5-		B(E2) (6- to 5-) $\leq$ 0.0011 2 (2011Ra42). B(E2) (3- to 5-)=0.0136 15 (2011Ra42).

† From the Adopted Levels.

$\frac{1}{2}$ Multiplet of states from the $\pi 2p_{3/2}v1g_{9/2}$ configuration.

 $\gamma(^{70}\text{Cu})$

$E\gamma$	$E(\text{level})$	Comments
127	228.5	$E\gamma$: observed in both the $J\pi=3^-$ beam and the $J\pi=6^-$ beam.
511 3	511	$E\gamma$: observed in the $J\pi=3^-$ beam, but not in the $J\pi=6^-$ beam.

 $^{70}\text{Zn}(t, ^3\text{He})$ 1977Sh08

$E(t)=24\text{ MeV}$. Measured $\sigma(\theta)$ using Q3D spectrometer and 1 m long helical cathode proportional counter (FWHM=10 keV).

 ^{70}Cu Levels

$E(\text{level})$	$\sigma_{\text{rel}}^\dagger$
0.0 $\frac{1}{2}$	8.08
100 $\frac{1}{2}$ 6	5.84
226 $\frac{1}{2}$ 6	6.50
366 6	1.28
506 6	2.85

† Arbitrary units measured at $\theta=30^\circ$.

$\frac{1}{2}$ Strongly excited states proposed to have dominant $\pi 2p_{3/2}v1g_{9/2}$ configuration.

Adopted Levels, Gammas

Q(β⁻)=-654.6 16; S(n)=9218.4 21; S(p)=11117.5 24; Q(α)=-5983.3 24 2012Wa38.
S(2n)=15700.5 21; S(2p)=20679 4 (2012Wa38).

⁷⁰Zn Levels

Cross Reference (XREF) Flags

A ⁷⁰Cu β⁻ Decay (44.5 s)
B ⁷⁰Cu β⁻ Decay (33 s)
C ⁷⁰Cu β⁻ Decay (6.6 s)
D ⁷⁰Ga ε Decay
E ⁶⁸Zn(t,p)
F ⁷⁰Zn(p,p'),(pol p,p')

G ⁷⁰Zn(p,p'γ)
H ⁷⁰Zn(α,α')
I ⁷⁰Zn(n,n'γ)
J ⁷⁰Zn(e,e')
K Coulomb Excitation
L ⁷¹Ga(d,³He)

M ²⁰⁸Pb(⁶⁴Ni,Xγ)
N ²³⁸U(⁷⁶Ge,Xγ)
O Others:
⁷⁰Zn(d,d')
⁷⁰Zn(³He,³He')
⁷³Ge(n,α)

E(level) [†]	Jπ	XREF	T _{1/2}	Comments
0.0 [‡]	0+	ABCDEFGHIJKLMNO	≥3.8×10 ¹⁸ y	%2β ⁻ =? T _{1/2} : from 2011Be39 for 2v2β ⁻ decay; also determined T _{1/2} ≥3.2×10 ¹⁹ for 0v2β ⁻ decay. Others: ≥2.3×10 ¹⁷ for 2v2β ⁻ decay and ≥1.8×10 ¹⁹ for 0v2β ⁻ decay (2010Be41, 2010BeZO, 2009Be27, earlier results by same group as 2011Be39), ≥2.2×10 ¹⁷ (2007Bl15, 2006Zu02), ≥1.3×10 ¹⁶ for 2v2β ⁻ decay and ≥0.7×10 ¹⁸ for 0v2β ⁻ decay (2005Da47), ≥1.3×10 ¹⁶ (2003Ki08), >4.8×10 ¹⁴ y (1952Fr23).
884.92 [‡] 8	2+	ABC EFGHIJKLMNO	3.65 ps 21	Q=-0.233 22 (1976Ne06); μ=+0.76 4 (2009Mu06). β ₂ =0.20 (1993Mo15). μ: from transient field technique in Coulomb Excitation. Others: +0.76 8 (2002Ke02), 0.82 20 (1979BrZP), 0.60 18 (1977HaZW), all from transient field technique in Coulomb Excitation, and 0.60 14 (1979Fa06) from IMPAC. T _{1/2} : weighted average of 3.67 ps 21 from DSAM and 3.60 ps 35 from RDDS, both in Coulomb Excitation. Others: 3.7 ps 12 from RDDS in ²³⁸ U(⁷⁶ Ge,Xγ), 2.5 ps 2 from B(E2)=0.205 19 in (e,e'), 3.3 ps 3 from B(E2)=0.160 14 in Coulomb Excitation. Jπ: L(t,p)=2. Q: from (e,e'); extracted using anharmonic-vibrator model and is model dependent. β ₂ : from (pol p,p'). Other: 0.220 from (α,α'). T _{1/2} : from (p,p'γ). Jπ: L(t,p)=0.
1070.76 9	0+	C E G I KL	3.90 ns 20	
1554 [#] 5		F H		
1759.16 10	2+	BC EF HIJKL	1.32 ps 21	XREF: E(1767)F(1764). μ=+0.94 44 (2009Mu06). Jπ: L(p,p')=2, L(d, ³ He)=1(+3), strong population in Coulomb excitation. T _{1/2} : from DSAM in Coulomb Excitation. Others: 1.4 ps 4 from B(E2)=0.0050 13 from (e,e'), 0.24 ps +24-12 from DSAM in (n,n'γ). μ: from transient field technique in Coulomb excitation. Other: +0.84 38 from reanalysis of transient field data (2010Mo14). μ=+1.48 56 (2009Mu06). Jπ: L(t,p)=4. T _{1/2} : weighted average of 2.0 ps +9-11 from RDDS in ²³⁸ U(⁷⁶ Ge,Xγ) and 3.4 ps 8 from RDDS in Coulomb Excitation. Other: 1.32 ps 14 from DSAM in Coulomb Excitation (2009Mu06). μ: from transient field technique in Coulomb excitation. Other: +0.84 52 from reanalysis of transient field data (2010Mo14). XREF: H(1945). Jπ: L(t,p)=2. XREF: F(2150)L(2126). Jπ: L(t,p)=0.
1786.75 [‡] 10	4+	AB EF I KLM	2.9 ps 8	
1957.28 12	2+	C EF HI KL O		
2140.64 17	0+	C EF I L		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{70}Zn Levels (continued)

E(level) [†]	J π	XREF	T _{1/2}	Comments
2375# 5	(2, 1, 3)+	F H O		XREF: O(2300?). J π : L(p,p')=2.
2538.31 11	2+	B F I KL	0.21 ps +28-8	T _{1/2} : from DSAM in (n,n'γ). J π : from L(d, ³ He)=1+3 and J=2 from γ(θ) in (n,n'γ). 2004Va08 in ⁷⁰ Cu β ⁻ decay (33 s) assign (3+) to this level, however, this is unlikely given its direct population in Coulomb excitation. L(p,p')=(0) is discrepant.
2665# 5	2+	EF L		J π : L(t,p)=2.
2693.40 11	4+	AB EF I K	0.28 ps +35-14	T _{1/2} : from DSAM in (n,n'γ). J π : L(p,p')=4.
2805# 5		F		
2859.49 11	3-	B EF HI K	0.201 ps 14	β ₃ =0.20 (1993Mo15). J π : L(t,p)=3; analyzing power consistent with 3- in (pol p,p'). β ₃ : from (pol p,p'). T _{1/2} : from DSAM in Coulomb Excitation.
2895.10 [±] 13	(6+)	A K MN		J π : 1108γ to 4+, band assignment.
2949.67 18	1+, 2+, 3+	I KL	0.042 ps +21-14	XREF: L(?). J π : M1+E2 2064γ to 2+.
2954# 5		F		T _{1/2} : from DSAM in (n,n'γ). E(level): possibly the same as 2949.2-keV level, although L(p,p')=(1) is discrepant with Adopted J π .
2978.26 23	4+	B EF K		J π : L(t,p)=4.
3022 [§] 10		L		E(level): possibly the same as 3037.6-keV level, although L(d, ³ He)=(1) is discrepant with Adopted J π .
3038.15 11	5-	AB EF HI K MN	1.04 ps 7	J π : L(p,p')=5, L(t,p)=(5), population in Coulomb Excitation makes J π =4- or 6- unlikely. J π =4- proposed in (n,n'γ) based on population strength and J π =4+ proposed in ²⁰⁸ Pb(⁶⁴ Ni,Xγ). T _{1/2} : from DSAM in Coulomb Excitation.
3222.08 10	1	I		Configuration=((π 2p _{3/2}) ² (v 2p _{1/2}) ⁻¹ (v 1g _{9/2})) (2004Va08). J π : from γ(θ) in (n,n'γ).
3235 5	3+, 4+, 5+	EF		E(level): from (p,p'). J π : from L(p,p')=4.
3246.71 11	(3-, 4+)	B		J π : strong β feeding from J π =3- parent, 209γ to 5-, 708γ to 2+.
3328# 5	(0+)	EF		E(level): possibly the same as the 3235-keV level.
3342.0 3	3-	A E H		J π : L(t,p)=(0).
3419# 5	(3)-	EF		J π : L(α,α')=3.
3464# 5	4+	EF H		J π : L(t,p)=(3), L(p,p')=3.
3476.68 14		A M		J π : L(t,p)=4.
3506# 5	5-	EF H L		J π : L(t,p)=5, L(p,p')=5; L=1 in (d, ³ He) is discrepant.
3598.98 14		A M		
3634.99 22	2+	C EF L		J π : L(t,p)=2.
3680# 5	0+	EF H L		J π : L(t,p)=0; L=1(+3) in (d, ³ He) is discrepant.
3710.7 6	2+	EF I		J π : L(t,p)=2.
3750# 5	(0-, 1-, 2-)	EF		J π : L(p,p')=(1).
3755.4 [±] 10	(8+)	MN		J π : 860γ to (6+), band assignment.
3788.16 22		A M		
3813# 5		EF		E(level): possible doublet; L(p,p')=(1)+4.
3844# 5	1-	EF h		J π : L(t,p)=1.
3848.4 6	(5, 6+)	A		J π : direct β ⁻ feeding from J π =6- parent, 2062γ to 4+.
3888# 5	(4)+	EF h		J π : L(p,p')=4.
3904.0 4	(5, 6+)	A		J π : direct β ⁻ feeding from J π =6- parent, 2117γ to 4+.
3914 10		E		
3948# 5	1-	EF		J π : L(t,p)=1.
3999 10	2+	E H		J π : L(t,p)=2.
4001.46 15	(5, 6, 7-)	A		E(level): from (t,p). J π : direct β ⁻ feeding from J π =6- parent, 963γ to 5-.
4016 10	3+, 4+, 5+	EF		E(level): doublet in (t,p). J π : L(p,p')=4.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
⁷⁰Zn Levels (continued)

E(level) [†]	J π	XREF	Comments
4061.40 16	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1023 γ to 5-.
4066# 10	4+	EF	J π : L(t,p)=4.
4136# 10	2+, 1+, 3+	EF	J π : L(p,p')=2.
4146.1 3		I	J π : proposed as 3- in (n,n' γ) based on population strength.
4172# 10	5-	F H	XREF: H(4200). J π : L(p,p')=5, L(α , α')=5.
4264.5 7	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1226 γ to 5-.
4291 10	2+	EF	E(level): weighted average of 4297 10 from (t,p) and 4284 10 from (p,p'). J π : L(t,p)=L(p,p')=2.
4308.99 18	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1271 γ to 5-.
4367 10	3+, 4+, 5+	F	J π : L(p,p')=4.
4444 10	3+, 4+, 5+	F	J π : L(p,p')=4.
4464.77 17	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1426.5 γ to 5-.
4514.27 23	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1476 γ to 5-.
4558.2 3	(5, 6, 4)	A	J π : direct β^- feeding from J π =6- parent, 2771 γ to 4+.
4588.8 3	(5, 6, 7-)	A	J π : direct β^- feeding from J π =6- parent, 1551 γ to 5-.
4710.1 5	(5, 6, 7)	A	J π : direct β^- feeding from J π =6- parent.
4791.7 10	(5, 6, 7)	A	J π : direct β^- feeding from J π =6- parent.
4849.2 3	(5, 6, 4)	A	J π : direct β^- feeding from J π =6- parent, 3062 γ to 4+.
4935.9 $\frac{1}{2}$ 14	(10+)	MN	J π : 1180.5 γ to (8+), band assignment.
5061.3 5	(5, 6, 7)	A	J π : direct β^- feeding from J π =6- parent.
6116.2 $\frac{1}{2}$ 17	(12+)	MN	J π : 1180.3 γ to (10+), band assignment.

[†] From a least-squares fit to E γ , by evaluators, for levels connected by γ rays. For levels from transfer reactions, corresponding dataset is indicated.

$\frac{1}{2}$ (A): Yrast band.

$\frac{1}{2}$ From (d,³He).

From (p,p'), (pol p,p').

 $\gamma(^{70}\text{Zn})$

E(level)	E γ [†]	I γ [†]	Mult. ^{$\frac{1}{2}$}	δ ^{$\frac{1}{2}$}	α	I(γ +ce)	Comments
884.92	884.88 9	100	E2		3.97×10^{-4}		B(E2)(W.u.)=16.7 10. Mult.: from Coulomb Excitation from 0+ ground state.
1070.76	185.85# 3	100	[E2]		0.0634		B(E2)(W.u.)=37.3 19. E γ : other: 184.4 2 in (n,n' γ). I(γ +ce): for 100 transitions of 185.9 γ as measured in (p,p' γ). Mult.: from internal conversion data in (p,p' γ). E γ : from (p,p' γ).
	1067		E0			<0.3	B(E2)(W.u.)=10 4; B(M1)(W.u.)=0.0095 23. Mult.: D+Q from $\gamma(\theta)$ in (n,n' γ), $\Delta\pi$ =no from level scheme.
1759.16	874.33# 8	100# 9	M1+E2	+0.75 15	3.58×10^{-4} 9		B(E2)(W.u.)=0.60 12. B(E2)(W.u.)=19 6.
	1759.6# 2	68# 7	[E2]		2.86×10^{-4}		
1786.75	901.7 1	100	[E2]		3.78×10^{-4}		
1957.28	1072.2# 1	100					
2140.64	1255.6& 2	100					
2538.31	751.5& 2	=18&	[E2]		6.06×10^{-4}		B(E2)(W.u.)=73 44. I γ : other: 58 in (n,n' γ). B(E2)(W.u.)=4.9 +49-21; B(M1)(W.u.)=0.0040 +40-20. Mult.: D+Q from $\gamma(\theta)$ in (n,n' γ), $\Delta\pi$ =no from level scheme.
	779.1# 2	40# 4					
	1653.9# 2	100# 7	M1+E2	-1.5 3	2.39×10^{-4} 5		
	2537.9& 3	20&	[E2]		6.18×10^{-4}		B(E2)(W.u.)=0.17 10.
2693.40	735.5& 2	11&	[E2]		6.43×10^{-4}		B(E2)(W.u.)=26 +26-14.
	906.5 1	92 12					
	934.9& 3	30&	[E2]		3.46×10^{-4}		B(E2)(W.u.)=21 +21-12.
	1809.2& 3	100& 16	[E2]		3.04×10^{-4}		B(E2)(W.u.)=2.6 +26-15.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Zn})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult. [‡]	$\delta^\S$	α	Comments
2859.49	902					$E\gamma$: observed only in Coulomb Excitation.
	1072.2@ 1	100@ 13	[E1]		1.12×10^{-4}	B(E1)(W.u.)=0.00068 11.
	1100.5@ 2	45@ 5	[E1]		1.15×10^{-4}	B(E1)(W.u.)=0.00028 5.
	1975.0@ 4	93@ 7	[E1]		6.56×10^{-4}	B(E1)(W.u.)=0.000100 13.
2895.10	1108.4 1	100				
2949.67	1191.9& 3	72&				
	2064.1& 2	100&	M1+E2	+3.8 5	4.04×10^{-4}	B(E2)(W.u.)=11 +4-6; B(M1)(W.u.)=0.0022 +10-13. Mult.: D+Q from $\gamma(\theta)$ in (n,n' γ), E1+M2 excluded by comparison to RUL.
2978.26	1191.5@ 2	100				
3038.15	1251.7 1	100	[E1]		1.68×10^{-4}	B(E1)(W.u.)=0.000195 14.
3222.08	2155.0&b 1	=33&				$E\gamma$: level energy difference gives $E\gamma=2151.3$, transition not included in least-squares fitting.
	3222.0& 1	=100&				
3246.71	208.75@ 7	55@ 4				
	387.10@ 5	54@ 4				
	553.2@ 1	28@ 4				
	708.42@ 7	100@ 5				
	1460.4@ 2	20@ 4				
3342.0	1555.2 3	100				
3476.68	438.2 2	22.2 10				
	783.1 2	7.8 10				
	1690.3 2	100.0 16				
3598.98	560.82 8	100				
3634.99	1875.8# 2	100				
3710.7	1951.5& 6	100				
3755.4	860.3 ^a	100				
3788.16	750.0 2	63 4				
	893.1 6	100 5				
3848.4	2061.6 6	100				
3904.0	2117.2 4	100				
4001.46	963.3 1	100				
4061.40	584.7 1	100 8				
	1023.3 2	70 7				
4146.1	1107.9& 3	100				
4264.5	1226.3 7	100				
4308.99	1270.8 2	100 5				
	1413.9 2	43 4				
4464.77	988.0 3	28 3				
	1426.5 2	100 4				
	1569.8 2	32 3				
4514.27	1476.1 2	100				
4558.2	1520.1 3	67 5				
	2771.2 6	100 4				
4588.8	1550.6 3	100				
4710.1	1815.0 5	100				
4791.7	1315 1	100				
4849.2	1954.2 3	100 4				
	3062.1 6	85 4				
4935.9	1180.5 ^a	100				
5061.3	2166.2 5	100				
6116.2	1180.3 ^a	100				

[†] From ^{70}Cu β^- decay (44.5 s), except where noted.[‡] From $\gamma(\theta)$ in (n,n' γ), except where noted.[§] From $\gamma(\theta)$ in (n,n' γ).# From ^{70}Cu β^- decay (6.6 s).@ From ^{70}Cu β^- decay (33 s).& From (n,n' γ).^a From $^{208}\text{Pb}(^{64}\text{Ni},X\gamma)$.^b Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas (continued)

 Bands for ^{70}Zn

(12+) (A)

1180.3

(10+)

1180.5

(8+)

860.3

(6+)

1108.4

4+

901.7

2+

884.88

0+

 $^{70}_{30}\text{Zn}_{40}$

^{70}Cu β^- Decay (44.5 s) 2004Va08

Parent ^{70}Cu : $E=0.0$; $J\pi=6^-$; $T_{1/2}=44.5$ s 2; $Q(\text{g.s.})=6588.3$ 22; $\%\beta^-$ decay=100.

2004Va08,2004Va07: ^{70}Cu activity produced in proton ($E(p)=1$ GeV) and neutron induced fission of uranium carbide and separated with the RILIS ion source followed by mass separation. Measured $E\gamma$, $I\gamma$, $\gamma(t)$, $\beta\gamma$ and $\gamma\gamma$ coincidences using three thin plastic ΔE detectors and two HPGe detectors. See also thesis, 2002VaZX.

1975Re09: ^{70}Cu activity from $^{70}\text{Zn}(n,p)$, $E(n)=14$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma(t)$, $E\beta$, $I\beta$, $\beta\gamma$ coincidences with a Ge(Li) detector, a NaI(Tl) detector and a β spectrometer consisting of a proportional counter backed by a plastic scintillator.

1971Ta03: ^{70}Cu activity from $^{70}\text{Zn}(n,p)$ with $E(n)=14$ MeV. Measured $E\gamma$, $I\gamma$, $E\beta$, $I\beta$, $\gamma(t)$, $\beta\gamma$ and $\gamma\gamma$ coincidences using two Ge(Li) detectors, a NaI(Tl) detector and a plastic scintillator.

Other: 1983Ru06.

A total energy release of 6590 keV 100 is calculated for this decay scheme by the code RADLST, in good agreement with the Q value of 6588.3 keV 22.

 ^{70}Zn Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\ddagger$	Comments
0.0	0+	$\geq 3.8 \times 10^{18}$ y	
884.89 9	2+	3.65 ps 21	
1786.62 13	4+	2.9 ps 8	
2693.24 16	4+	0.28 ps +35-14	
2895.03 16	(6+)		
3038.30 16	5-	1.04 ps 7	
3341.8 3	3-		
3476.68 17			
3599.12 18			
3788.28 24			
3848.3 6	(5,6+)		
3903.9 4	(5,6+)		
4001.60 19	(5,6,7-)		$J\pi$: assigned as 2+ in 2004Va08. However, direct feeding from 6- parent and 963 γ to 5- makes $J=2$ unlikely.
4061.42 19	(5,6,7-)		$J\pi$: assigned as 4+ in 2004Va08. However, direct feeding from 6- parent makes $J=4$ unlikely.
4264.6 7	(5,6,7-)		
4309.03 21	(5,6,7-)		
4464.81 20	(5,6,7-)		
4514.4 3	(5,6,7-)		
4558.3 3	(5,6+)		
4588.9 3	(5,6,7-)		
4710.1 5	(5,6,7)		
4791.7 10	(5,6,7)		
4849.2 3	(5,6+)		
5061.3 5	(5,6,7)		

† From a least-squares fit to $E\gamma$, by evaluators.

‡ From the Adopted Levels.

 β^- radiations

$E\beta^-$	$E(\text{level})$	$I\beta^-^{\dagger\ddagger}$	$\text{Log } ft$	Comments
(1527.0 23)	5061.3	0.50 5	5.8 1	
(1739.1 23)	4849.2	5.19 20	5.0 1	
(1796.6 25)	4791.7	0.57 6	6.0 1	
(1878.2 23)	4710.1	1.04 8	5.8 1	
(1999.4 23)	4588.9	1.40 10	5.8 1	
(2030.0 23)	4558.3	2.98 15	5.5 1	
(2073.9 23)	4514.4	1.35 10	5.9 1	
(2123.5 22)	4464.81	4.15 18	5.4 1	
(2279.3 23)	4309.03	2.36 13	5.8 1	
(2323.7 23)	4264.6	2.16 12	5.9 1	
(2526.9 22)	4061.42	1.41 10	6.2 1	
(2586.7 22)	4001.60	0.74 7	6.5 1	
(2684.4 23)	3903.9	0.57 6	6.7 1	
(2740.0 23)	3848.3	4.9 1	5.8 1	
(2800.0 23)	3788.28	3.25 15	6.0 1	

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⁷⁰Cu β⁻ Decay (44.5 s) 2004Va08 (continued)

β⁻ radiations (continued)

Eβ ⁻	E(level)	Iβ ^{-†‡}	Log <i>ft</i>	Comments
(2989.2 22)	3599.12	1.03 7	6.7 1	
(3111.6 22)	3476.68	6.1 3	6.0 1	
(3246.5 23)	3341.8	0.94 7	6.9 1	Log <i>ft</i> : unrealistically low for a ΔJ=3 transition.
(3550.0 22)	3038.30	58 3	5.2 1	
(3693.3 22)	2895.03	1.4 5	6.9 1	

† From an intensity balance at each level, by evaluators.

‡ Absolute intensity per 100 decays.

γ(⁷⁰Zn)

I_γ normalization: From Σ(I(γ+ce) to g.s.)=100. No ground state β feeding is expected since ΔJ=6.

Eγ [†]	E(level)	I _γ ^{†§}	Mult. [‡]	α	Comments
438.2 2	3476.68	1.40 6			
560.82 8	3599.12	1.03 7			
584.7 1	4061.42	0.83 7			
750.0 2	3788.28	1.25 8			
783.1 2	3476.68	0.49 6			
884.88 9	884.89	100.0 4	E2	3.97×10 ⁻⁴	I _γ : other: 100 5 (1971Ta03).
893.1 6	3788.28	2.00 9			
901.7 1	1786.62	99.7 4	[E2]	3.78×10 ⁻⁴	I _γ : other: 87 4 (1971Ta03).
906.5 1	2693.24	0.24 3			
963.3 1	4001.60	0.74 7			
988.0 3	4464.81	0.72 7			
1023.3 2	4061.42	0.58 6			
1108.4 1	2895.03	9.3 1	[E2]	2.32×10 ⁻⁴	I _γ : other: 8 2 (1971Ta03).
1226.3 7	4264.6	2.16 9			
1251.7 1	3038.30	73.3 3	[E1]	1.68×10 ⁻⁴	I _γ : other: 57 4 (1971Ta03).
1270.8 2	4309.03	1.65 8			I _γ : other: 1.0 4 (1971Ta03).
1315 1	4791.7	0.57 6			
1413.9 2	4309.03	0.71 7			
1426.5 2	4464.81	2.6 1			I _γ : other: 3 1 (1971Ta03).
1476.1 2	4514.4	1.35 8			I _γ : other: 1.3 9 (1971Ta03).
1520.1 3	4558.3	1.20 9			I _γ : other: 1.4 4 (1971Ta03).
1550.6 3	4588.9	1.40 8			
1555.2 3	3341.8	0.94 7	[E1]	3.57×10 ⁻⁴	
1569.8 2	4464.81	0.83 7			
1690.3 2	3476.68	6.3 1			I _γ : other: 4.7 9 (1971Ta03).
1809.1 5	2693.24	0.26 4	[E2]	3.04×10 ⁻⁴	
1815.0 5	4710.1	1.04 7			
1954.2 3	4849.2	2.8 1			I _γ : other: 2.1 4 (1971Ta03).
2061.6 6	3848.3	4.9 1			I _γ : other: 3.7 9 (1971Ta03).
2117.2 4	3903.9	0.57 6			
2166.2 5	5061.3	0.50 5			
2771.2 6	4558.3	1.78 8			
3062.1 6	4849.2	2.39 9			I _γ : other: 1.4 5 (1971Ta03).

† From 2004Va08. I_γ are normalized to I_γ(885γ)=100.

‡ From the Adopted Gammas.

§ For absolute intensity per 100 decays, multiply by 1.00 4.

^{70}Cu β^- Decay (44.5 s) 2004Va08 (continued)

Decay Scheme

^{70}Cu β^- Decay (33 s) 2004Va08

Parent ^{70}Cu : $E = 101.1$ 3; $J\pi = 3^-$; $T_{1/2} = 33$ s 2; $Q(\text{g.s.}) = 6588.3$ 22; β^- decay = 52 9.

$^{70}\text{Cu} - \beta^-$ decay: $\%IT = 48$ 9 (2004Va08).

2004Va08, 2004Va07: ^{70}Cu activity produced in proton ($E(p) = 1$ GeV) and neutron induced fission of uranium carbide and separated with the RILIS ion source followed by mass separation. Measured $E\gamma$, $I\gamma$, $\gamma(t)$, $\beta\gamma$ and $\gamma\gamma$ coincidences using three thin plastic ΔE detectors and two HPGe detectors. See also thesis, 2002VaZX.

1983Ru06: ^{70}Cu activity from $^{nat}\text{W}(^{76}\text{Ge}, X)$ with $E(^{76}\text{Ge}) = 9$ MeV/nucleon. Reaction products stopped in graphite catcher of FEBIAD-E ion source then mass separated in on-line mass separator. Measured $E\gamma$, $I\gamma$, $\gamma(t)$, $\gamma\gamma$, $\beta\gamma$ coincidences using 2 Ge detectors and a plastic scintillator. The 208 γ , 708 γ , 1072 γ , and 1654 γ previously assigned to ^{67}Ni decay by 1975Re09 and 1971Ta03 were assigned to the ^{70}Cu decay. This assignment was confirmed by 2004Va08.

Others: 1971Ta03, 1975Re09.

A total energy release of 3500 keV 300 for this decay scheme is calculated by the code RADLST, in agreement with the effective Q value of 3500 keV 600. However, there is a 3.3 MeV energy difference between the highest observed energy level and the Q value, suggesting that the decay scheme is incomplete.

 ^{70}Zn Levels

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}^{\ddagger}$	Comments
0.0	0+	$\geq 3.8 \times 10^{18}$ y	
884.95 8	2+	3.65 ps 21	
1759.31 10	2+	1.32 ps 21	
1786.86 11	4+	2.9 ps 8	
2538.44 12	(2+)	0.21 ps +28-8	$J\pi$: (3+) in 2004Va08 is in conflict with adopted value which is based on 2538 γ (not reported here) to 0+ and direct population in Coulomb Excitation.
2693.50 13	4+	0.28 ps +35-14	
2859.60 12	3-	0.201 ps 14	

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^{70}Cu β^- Decay (33 s) 2004Va08 (continued) **^{70}Zn Levels (continued)**

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\ddagger$	Comments
2978.37 23	4+		
3038.23 13	5-	1.04 ps 7	
3246.81 12	(3-, 4+)		$J\pi$: (4-) in 2004Va08 is in conflict with adopted value.

† From least-squares fit to $E\gamma$, by evaluators.

‡ From the Adopted Levels.

 β^- radiations

$E\beta^-$	$E(\text{level})$	$I\beta^-^\dagger^\ddagger$	$\text{Log } ft$
(3442.6 23)	3246.81	24 5	5.4 2
(3711.0 23)	2978.37	1.7 5	6.7 2
(3829.8 23)	2859.60	13 3	5.9 1
(3995.9 23)	2693.50	5.3 12	6.4 1
(4151.0 23)	2538.44	1.7 9	7.0 3
(4902.5 23)	1786.86	6 3	6.7 2

† Deduced by the evaluators from γ -ray intensity balance. Total β feeding sums to 52%. Note that corresponding values quoted in 2004Va08 add up to 100%.

‡ Absolute intensity per 100 decays.

 $\gamma(^{70}\text{Zn})$

$I\gamma(101.1\gamma, \text{IT})/I\gamma(884.88\gamma)=0.98$ 16 (2004Va08).

$I\gamma$ normalization: From $\Sigma(I\gamma+\text{ce})$ to g.s.)=52 9. No ground state β feeding is expected since $\Delta J=3$, $\Delta\pi=\text{yes}$.

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\dagger^\S$	Mult. ‡	$\delta^\ddagger$	α
208.75 7	3246.81	10.4 7	[E1]		0.00653
387.10 5	3246.81	10.2 7	[E1]		1.14×10^{-3}
553.2 1	3246.81	5.4 7			
708.42 7	3246.81	19 1	[E2]		7.12×10^{-4}
779.1 2	2538.44	6.4 7			
874.33 8	1759.31	7.9 7	M1+E2	+0.75 15	3.58×10^{-4} 9
884.88 9	884.95	100 5	E2		3.97×10^{-4}
901.7 1	1786.86	51 5	[E2]		3.78×10^{-4}
906.5 1	2693.50	5.2 8			
1072.2 1	2859.60	15 2	[E1]		1.12×10^{-4}
1100.5 2	2859.60	6.8 8	[E1]		1.15×10^{-4}
1191.5 2	2978.37	3.5 7			
1251.7 1	3038.23	10.4 7	[E1]		1.68×10^{-4}
1460.4 2	3246.81	3.8 8			
1653.9 2	2538.44	16 1	M1+E2	-1.5 3	2.39×10^{-4} 5
1759.6 2	1759.31	5.4 5	[E2]		2.86×10^{-4}
1809.1 5	2693.50	11 1	[E2]		3.04×10^{-4}
1975.0 4	2859.60	14 1	[E1]		6.56×10^{-4}

† From 2004Va08. $I\gamma$ are normalized to $I\gamma(885\gamma)=100$.

‡ From the Adopted Gammas.

§ For absolute intensity per 100 decays, multiply by 0.49 9.

^{70}Ga ϵ Decay **1977Sc10**

Parent ^{70}Ga : $E=0.0$; $J\pi=1+$; $T_{1/2}=21.14$ min 3; $Q(\text{g.s.})=654.6$ 16; % ϵ decay=0.41 5.

^{70}Ga - ϵ decay: From ratio of Zn $K\alpha$ x rays to $I\gamma(176\gamma)$ in ^{70}Ge (1977Sc10). Ratio corrected for contamination of ^{68}Ga in the measured activity. Other: 0.24% (1975Bu07, earlier result from the same laboratory as 1977Sc10).

1977Sc10: ^{70}Ga activity from $^{69}\text{Ga}(\text{d,p})$ with $E(\text{d})=8.8, 10.4$, and 11.9 MeV. Branching ratio measurement performed at 8.8 MeV. Measured $E\gamma$, $I\gamma$, $\gamma(\text{t})$, $K\alpha$ x-ray using Ge(Li) detector.

Others: 1975Bu07, 1957Bu41.

 ^{70}Zn Levels

E(level)	$J\pi^\dagger$	$T_{1/2}^\dagger$
0.0	0+	$\geq 3.8 \times 10^{18}$ y

† From the Adopted Levels.

 β^+, ϵ Data

$E\epsilon$	E(level)	$I\epsilon^\dagger$	Log ft	$I(\epsilon+\beta^+)^\dagger$
(654.6 16)	0.0	100	4.72 6	100

† For intensity per 100 decays, multiply by 0.0041 5.

 $^{68}\text{Zn}(\text{t,p})$ **1972Hu06**

$E(\text{t})=11.88$ MeV. Measured $\sigma(\theta)$ for $\theta=35^\circ$ to 175° using multigap spectrograph and Ilford K2 nuclear emulsions (FWHM=20 keV); DWBA analysis using optical-model parameters derived from fits to $^{64,67}\text{Zn}(\text{t,t})$ elastic scattering data.

 ^{70}Zn Levels

E(level)	$L^\dagger$	$\sigma_{\text{max}} (\mu\text{b/sr})^\ddagger$	E(level)	$L^\dagger$	$\sigma_{\text{max}} (\mu\text{b/sr})^\ddagger$	E(level)	$L^\dagger$	$\sigma_{\text{max}} (\mu\text{b/sr})^\ddagger$
0.0	0	4.4×10^3 7	3031 10	(5)	60 9	3802 § 10		21 3
884 10	2	164 25	3232 10	(4)	4 1	3839 10	1	25 4
1069 10	0	164 25	3325 10	(0)	53 8	3883 10		18 3
1767? 10		5 1	3340 10	(3)	45 7	3914 10		14 2
1787 10	4	28 4	3423 10	(3)	6 1	3951 10	1	24 4
1955 10	2	76 11	3458 10	4	18 3	3999 10	2	73 11
2139 10	0	76 11	3502 10	5	41 6	4020 $^\#$ 10		14 2
2661 10	2	70 11	3631 10	2	64 10	4060 10	4	8 1
2690? 10		6 1	3677 10	0	51 8	4140 10		21 3
2856 10	3	59 9	3707 10	2	28 4	4297 10	2	49 7
2971 10	4	46 7	3746 10		13 2			

† From DWBA analysis.

‡ Maximum σ in units of ($\mu\text{b/sr}$).

§ Possible doublet.

$^\#$ Doublet.

$^{70}\text{Zn}(e,e')$ 1976Ne06

E(e)=40–112 MeV. Measured $\sigma(E,\theta)$ at $\theta(\text{lab})=58.0^\circ$ and 128.3° ; DWBA analysis.
Others: 1973NeZC, 1972EhZZ.

 ^{70}Zn Levels

B(E2): extracted using the modified Tassie model with a two-parameter Fermi charge distribution for the ground state. Use of a specific model for the transition charge density introduces some model dependence into the extracted B(E2) strengths.

E(level) [†]	J π [†]	Comments
0.0		
884.5	2+	Q=−0.233 22; B(E2) [†] =0.205 19. Q: extracted using anharmonic–vibrator model and is model dependent; a model-independent method using energy-weighted sum rule gives −0.235 27 (1981Ko06); another anharmonic–vibrator model analysis gives −0.21 3 (1972Li12). $\beta_2 R=1.23$ 6.
1758.8	2+	B(E2) [†] =0.0050 13.

[†] From the Adopted Levels.

 $^{70}\text{Zn}(n,n'\gamma)$ 1982Ko35

1982Ko35: E(n)=reactor fast neutrons. Measured E γ , I γ using Compton-suppressed Ge(Li) detector; compared level populations with analysis using Hauser–Feshbach Moldauer (HFM) approximation.
1985Ko42: E(n)=reactor fast neutrons. Measured E γ , I γ , $\gamma(\theta)$ using Compton-suppressed Ge(Li) detector.
1985Ko27: E(n)=reactor fast neutrons. Measured E γ , I γ using Compton-suppressed Ge(Li) detector; deduced T $_{1/2}$ using Doppler Shift Attenuation Method (DSAM).
Others: 1985KoZL, 1982HaZH, 1976SmZT.

 ^{70}Zn Levels

E(level) [†]	J π [†]	T $_{1/2}$ [§]	Comments
0.0	0+		
884.8 1	2+		
1068.2 2	0+		
1759.1 1	2+	0.24 ps +24–12	
1786.5 1	4+		J π : proposed as 2+ in 1982Ko35 from population strength in (n,n' γ).
1957.7 2	2+		J π : proposed as 4+ in 1982Ko35 from population strength in (n,n' γ).
2140.4 2	0+		
2538.0 1	2+	0.21 ps +28–8	
2693.6 2	4+	0.28 ps +35–14	
2858.5 4	3–		
2949.6 2	1+, 2+, 3+	0.042 ps +21–14	J π : proposed as 3+ in 1982Ko35 from population strength in (n,n' γ).
3038.5 2	5–		J π : proposed as 4– in 1982Ko35 from population strength in (n,n' γ).
3222.3 1	1		J π : Proposed as 1+ in 1982Ko35.
3710.6 6	2+		
4146.4 4			J π : proposed as 3– in 1982Ko35 from population strength in (n,n' γ).

[†] From a least-squares fit to E γ , by evaluators.

[‡] From the Adopted Levels. Differences in the assignments suggested by 1982Ko35 are given in the comments.

[§] From DSAM in 1985Ko27.

 $\gamma(^{70}\text{Zn})$

E(level)	E γ [†]	I γ [‡]	Mult. [§]	δ [§]	Comments
884.8	884.9 1	100			
1068.2	184.4 2	100			
1759.1	874.4 1	100	D+Q	+0.75 15	
	1759.2 1	41			
1786.5	901.7 1	100			
1957.7	1072.5 2	100			

Continued on next page (footnotes at end of table)

$^{70}\text{Zn}(\text{n},\text{n}'\gamma)$ 1982Ko35 (continued) $\gamma(^{70}\text{Zn})$ (continued)

E(level)	$E_\gamma^\dagger$	$I_\gamma^{\dagger\ddagger}$	Mult.§	$\delta^\S$	Comments
2140.4	354.0 2	54			E γ : not included in Adopted Gammas. Adopted $J\pi$ of initial and final levels would require E4 or M5 multipolarity for the transition. In addition, transition is not observed in ^{70}Cu β^- decay (6.6 s).
	1255.6 2	100			
2538.0	751.5 2	≈ 18			
	778.9 2	58			
	1653.2 2	100	D+Q	-1.5 3	
	2537.9 3	20			
2693.6	735.5 2	11			
	934.9 3	30			
	1809.2 3	100			
2858.5	1073.0# 2	45			
	1099.9 7	90			
	1973.5 4	100			
	1191.9 3	72			
2949.6	2064.1 2	100	D+Q	+3.8 5	
3038.5	1252.0 3	61			E γ : not included in Adopted Gammas. Transition is not observed in ^{70}Cu β^- decay or Coulomb excitation and such a placement would require an E3 or M4 transition which strongly violates RUL.
	2153.7 2	100			
3222.3	2155.0 2	≈ 33			
	3222.0 1	100			
3710.6	1951.5 6	100			
4146.4	1107.9 3	100			

† From 1982Ko35. Uncertainties on E_γ are from 1976SmZT.

‡ Relative photon branching from each level.

§ From $\gamma(\theta)$ in 1985Ko42.

Placement of transition in the level scheme is uncertain.

 $^{70}\text{Zn}(\text{p},\text{p}'),(\text{pol p},\text{p}')$ 1987Ja05,1993Mo15

1993Mo15: E(pol p)=20.4 MeV. Measured $\sigma(\theta)$ and analyzing power using cooled surface-barrier detectors (FWHM=35 keV); DWBA analysis.

1987Ja05: E(p)=22 MeV. Measured $\sigma(\theta)$ for $\theta=10^\circ$ to 50° in 2.5° steps, $\theta=50^\circ$ to 80° in 5° steps and $\theta=80^\circ$ to 110° in 10 steps using a split-pole magnetic spectrograph and high resolution position sensitive proportional counter (FWHM=24 keV); DWBA and coupled channel analysis.

1968Le23: E(p)=50 MeV. No experimental details provided; DWBA and strong coupling approximation analysis.

1967Ca15,1967Ca19: E(p)=49.08 MeV. Measured $\sigma(\theta)$ using acoustic spark chamber and scintillator telescope; DWBA analysis.

Others: (p,p') :1992Ke07, 1982Za06, 1980Fa07, 1977Lu01, 1976Kr16, 1973An28; (pol p,p'): 1985MaZO.

 ^{70}Zn Levels

E(level) †	$L^\ddagger$	$d\sigma/d\Omega$ (76 $^\circ$) §	Comments
0.0	0		
886 5	2	0.339	β_2 : 0.20 (1993Mo15), 0.229 (1968Le23), 0.240 17 (1987Ja05). $J\pi$: analyzing power consistent with $J\pi=2+$ (1993Mo15).
1554# 5	(1)+2	0.015	E(level): other: 1560 20 (1967Ca15).
1764 5		0.083	E(level): other: 1760 20 (1967Ca15).
1790 5			
1960 5	2	0.026	E(level): other: 1950 20 (1967Ca15).
2150 5			
2375 5	2		
2536 5	(0)		
2665 5	2		
2694 5	4		
2805 5			

Continued on next page (footnotes at end of table)

$^{70}\text{Zn}(\text{p},\text{p}'),(\text{pol p},\text{p}')$ 1987Ja05,1993Mo15 (continued) **^{70}Zn Levels (continued)**

E(level) [†]	L [‡]	dσ/dΩ (76°) [§]	Comments
2863 5	3	0.430	β ₃ : 0.20 (1993Mo15), 0.216 (1968Le23), 0.210 15 (1987Ja05). Jπ: analyzing power consistent with 3- (1993Mo15). E(level): other: 2870 20 (1967Ca15).
2954 5	(1)		
2975 5	4		
3042 5	5		
3235 5	4		
3328 5	(0)	0.062	E(level): other: 3320 20 (1967Ca15).
3419 5	3		
3464 5	4	0.052	E(level): other: 3460 20 (1967Ca15).
3506 5	5		
3635 5	2		
3680 5			
3712 5	2	0.060	E(level): other: 3710 25 (1967Ca15).
3750 5	(1)		
3813 [#] 5	(1)+4		
3844 5	(1)		
3888 5	4		
3948 5	(1)		
4016 10	4	0.033	E(level): other: 4010 30 (1967Ca15).
4066 10	4		
4136 10	2		
4172 10	5		
4284 10	2		
4309 10			
4367 10	4		
4444 10	4		

[†] From 1987Ja05.[‡] From DWBA analysis in 1987Ja05.[§] From 1967Ca15 in units of mb/sr.[#] Doublet. **$^{70}\text{Zn}(\text{p},\text{p}'\gamma)$ 1977Re04**

E(p)=3.825 MeV. Measured E(ce), I(ce) using an intermediate-image β spectrometer and a flow proportional counter.

 ^{70}Zn Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	0+		
883	2+		
1067	0+	3.90 ns 20	T _{1/2} : quoted by 1977Re04 from F.E. Blumenberg, Univeristy of Bonn, thesis, 1973.

[†] From the Adopted Levels. **$\gamma(^{70}\text{Zn})$**

E _γ	E(level)	Mult.	α	I(γ+ce)	Comments
184	1067	E2	0.0658	100	Mult.: from the Adopted Gammas.
1067	1067	E0		<0.3	I(γ+ce): for 100 transition of 184γ. Mult.: from internal conversion data normalized to 184γ assumed to be E2. p(E0)<0.05 obtained using the Adopted T _{1/2} of 3.90 ns 20.

$^{70}\text{Zn}(\text{d},\text{d}')$ 1968Al20

$E(\text{d})=13.6$ MeV. Measured $\sigma(\theta)$ using Si(Li) E- Δ E detectors (FWHM=200 keV).

 ^{70}Zn Levels

E(level)	Comments
0.0	
887	$\beta_2\text{R}=1.19$.

 $^{70}\text{Zn}(^3\text{He},^3\text{He}')$ 1971Ha45

$E(^3\text{He})=24$ MeV. Measured $\sigma(\theta)$ for $\theta=15^\circ$ to 100° in 5° intervals using three Si(Li) Δ E-E telescopes; analysis using coupled-channel theory.

 ^{70}Zn Levels

E(level)	L	$\beta_{\text{L}}\text{R}^\dagger$	Comments
0.0			
884	2	1.16	$\beta_{\text{L}}\text{R}'$: average of values ranging from 1.10 to 1.23.
2850	3	0.842	$\beta_{\text{L}}\text{R}'$: average of values ranging from 0.791 to 0.898.

† From coupled-channel calculations assuming one-phonon transfer. Value given is an average of the results using five different optical model potentials.

 $^{70}\text{Zn}(\alpha,\alpha')$ 1971Al18,1970Co31

1988Ba71: $E(\alpha)=25$ MeV. Measured $\sigma(\theta)$ for $\theta=15^\circ$ to 172.5° in 2.5° steps using Si surface-barrier detectors (FWHM=100–200 keV); coupled-channel analysis.

1971Al18: $E(\alpha)=31$ MeV. Measured $\sigma(\theta)$ using semiconductor detectors (FWHM=70–100 keV); DWBA analysis.

1970Co31: $E(\alpha)=42$ MeV. Measured $\sigma(\theta)$ for $\theta=20^\circ$ to 54° in 2° steps using Si(Li) detectors (FWHM=150 keV).

Others: 1990Bu25, 1979PaZO, 1978Lu06, 1975Ba77, 1971Al11.

 ^{70}Zn Levels

E(level) †	$\text{L}^\ddagger$	$\beta_{\text{L}}\text{R}^\ddagger$	Comments
0.0			
882 10	2	1.09 6	$\beta_2=0.220$ (1990Bu25). $\beta_2\text{R}$: other: 0.868 (harmonic vibrational model) and 0.815 (asymmetric-rotor model) (1988Ba71). E(level): other: 880 30 (1971Al18).
1550 § 30			
1760 15			$J\pi$: 1970Co31 assign (4+) according to 2J+1 intensity rule. E(level): other: 1780 30 (1971Al18).
1945 15			E(level): other: 1950 30 (1971Al18).
2370 20			
2845 10	3	0.92 5	$\beta_3\text{R}$: 0.764 (harmonic-vibrational model) (1988Ba71). E(level): other: 2870 30 (1971Al18).
3040? 20			
3335 15	3	0.43 3	E(level): other: 3370 30 (1971Al18).
3460 20			
3520 § 30			
3660 § 30			
3860 § 30			
3980 § 30			
4200 § 30	5	0.32 3	

† From 1970Co31, except noted.

‡ From DWBA analysis in 1971Al18.

§ From 1971Al18.

Coulomb Excitation 2013Ce01,2009Mu06,2002Ke02

- 2013Ce01: $^{70}\text{Zn}(^{238}\text{U}, ^{238}\text{U}'\gamma)$ with $E(^{238}\text{U})=6.76$ MeV/nucleon. Measured $E\gamma$, $I\gamma$, particle- γ coincidences using segmented HPGe Clover detectors of the EXOGAM array. Target-like reaction products separated with the VAMOS spectrometer; deduced $T_{1/2}$ using Cologne plunger device and Recoil Distance Doppler Shift (RDDS) method.
- 2009Mu06: $^{nat}\text{C}(^{70}\text{Zn}, ^{70}\text{Zn}'\gamma)$ with $E(^{70}\text{Zn})=180$ and 200 MeV. Measured $E\gamma$, $I\gamma$, $\gamma(\theta)$, particle- γ coincidences using four HPGe Clover detectors and a Canberra PIPS Si detector; deduced g factor with transient field technique and $T_{1/2}$ with Doppler-shift Attenuation Method (DSAM). The g -factor data from 2009Mu06 is reanalyzed in 2010Mo14 using a technique which introduces less uncertainty in the background subtraction of spectra.
- 2002Ke02: $^{nat}\text{C}(^{70}\text{Zn}, ^{70}\text{Zn}'\gamma)$ with $E(^{70}\text{Zn})=160$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma(\theta)$, particle- γ coincidences using BaF_2 scintillators and a Si detector; deduced g factor with transient field technique. Also measured $T_{1/2}$ with HPGe detector placed at 0° to the beam directions using the Doppler Shift Attenuation Method (DSAM). Earlier results in 2001KeZZ.
- 2002So03: $^{208}\text{Pb}(^{70}\text{Zn}, ^{70}\text{Zn}'\gamma)$ with $E(^{70}\text{Zn})=65.9$ MeV/nucleon. Measured $E\gamma$, $I\gamma$, particle- γ coincidences using four segmented HPGe Clover detectors and two annular Si detectors; deduced $B(E2)$. Earlier results by same group: 2000LeZW, 1998Le02.
- 1998Si25: $^{70}\text{Zn}(p, p'\gamma)$ with $E(p)=2.0$ MeV to 4.5 MeV. Measured $E\gamma$, $I\gamma$ using a Compton-suppressed $\text{Ge}(\text{Li})$ detector; deduced $B(E2)$.
- 1979Fa06: $^{70}\text{Zn}(^{16}\text{O}, ^{16}\text{O}'\gamma)$ with $E(^{16}\text{O})=36$ MeV. Measured $E\gamma$, $I\gamma$, particle- γ coincidences using four $\text{NaI}(\text{Tl})$ detectors and an annular Si surface detector; deduced g factor of first $2+$ state with IMPAC.
- 1977HaZW, 1979BrZP: Measured $E\gamma$, $I\gamma$; deduced g factor with transient field technique.
- 1965Ro09: $^{70}\text{Zn}(\alpha, \alpha'\gamma)$ with $E(\alpha)=6-9$ MeV. Measured $E\gamma$ of first $2+$ level using $\text{Ge}(\text{Li})$ detector.
- 1962St02: $^{70}\text{Zn}(p, p'\gamma)$ with $E(p)=4-8$ MeV. Measured $E\gamma$, $I\gamma$ with $\text{NaI}(\text{Tl})$ detector; deduced $B(E2)$.

 ^{70}Zn Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	Comments
0.0	0+		
884.9	2+	3.65 ps 21	$B(E2)^\uparrow=0.160$ 14 (1962St02); $g=+0.38$ 2 (2009Mu06). $T_{1/2}$: weighted average of 3.67 ps 21 from DSAM (2002Ke02) and 3.60 ps 35 from RDDS (2013Ce01). Others: 3.3 ps 3 deduced from $B(E2)$ (1962St02), 2.2 ps 2 deduced from $B(E2)$ (1998Si25), and 3.3 ps 6 deduced from $B(E2)$ (2002So03). $B(E2)^\uparrow$: other: 0.160 28 (2002So03), 0.235 25 (1998Si25). g : from transient field technique (2009Mu06), same result obtained in reanalysis of data in 2010Mo14. g : Others: +0.38 4 from transient field technique (2002Ke02), 0.41 10 from transient field technique (1979BrZP), 0.30 8 from transient field technique (1977HaZW) and 0.30 7 from IMPAC (1979Fa06).
1070.8	0+		
1759.2	2+	1.32 ps 21	$g=+0.47$ 22 (2009Mu06). g : from transient field technique (2009Mu06). Other: +0.42 19 (2010Mo14, reanalysis of transient field data).
1786.8	4+	3.4 ps 8	$g=+0.37$ 14 (2009Mu06). $T_{1/2}$: from RDDS in 2013Ce01. Other: 1.32 ps 14 from DSAM (2009Mu06). $T_{1/2}$: result from RDDS method is adopted here since 1) the DSAM results of 2009Mu06 cites difficulties in integrating the total 902 γ peak shape due to a degeneracy with the 902 γ from the 3- state and 2) the RDDS method is consistent with the result from $^{238}\text{U}(^{76}\text{Ge}, X\gamma)$. g : from transient field technique (2009Mu06). Other: +0.21 13 (2010Mo14, reanalysis of transient field data).
1957.3	2+		
2538.3	2+		
2693.4	4+		
2859.1	3-	0.201 ps 14	
2895.1	(6+)		
2949.7	1+, 2+, 3+		
2978.3	4+		
3038.2	5-	1.04 ps 7	

 † Rounded values from the Adopted Levels. ‡ From the Adopted Levels. § From DSAM in 2009Mu06, except where noted.

Coulomb Excitation 2013Ce01,2009Mu06,2002Ke02 (continued) $\gamma(^{70}\text{Zn})$

$E\gamma^\dagger$	E(level)	Mult.	Comments
186	1070.8		
874	1759.2		
883.7 7	884.9	E2	$E\gamma$: From 1962St02.
902 $\frac{1}{2}^\S$	1786.8		
	2859.1		
1072 $\frac{1}{2}^\S$	1957.3		
	2859.1		
1101	2859.1		
1108	2895.1		
1192 $\frac{1}{2}^\S$	2949.7		
	2978.3		
1252	3038.2		
1654	2538.3		
1759	1759.2		
1809	2693.4		
1975	2859.1		
*2472			

† From 2009Mu06, except where noted.

$\frac{1}{2}$ Multiple placement is deduced by 2009Mu06 based on observation of two different mean-decay velocities associated with these transitions.

§ Multiply placed.

* γ ray not placed in level scheme.

 $^{71}\text{Ga}(\text{d},^3\text{He})$ 1977Ro22

Target: $J\pi=3/2^-$.

$E(\text{d})=26$ MeV. Measured $\sigma(\theta)$ using split-pole magnetic spectrograph and four solid-state position sensitive detectors (FWHM=18-20 keV); DWBA analysis. Subset of results given in 1978RoYT.

EC^2S compared to theory is as follows:

L	expt	theory
---	----	-----
1	2.76	
3	0.25	
sum	3.01	3

 ^{70}Zn Levels

E(level)	$L^\dagger$	$\text{C}^2\text{S}^\frac{1}{2}$	Comments
0.0	1	0.5	
880 10	1+3	0.21+0.13	
1069 10	1	0.11	
1756 10	1(+3)	0.25+0.0	C^2S : 0.22+0.22.
1786? 10	3	0.1	
1949 10	1(+3)	1.4+0.0	C^2S : 1.4+0.23.
2126? 10	1	0.011	
2524? 10	1+3		C^2S : 0.004+0.006.
2652 10	1(+3)	0.096+0.0	C^2S : 0.074+0.17.
2930? 10	1(+3)	0.024+0.0	C^2S : 0.016+0.038.
3022 10	(1)	0.055	L: adopted $J\pi=5^-$ is inconsistent with $L=1$.
3503? 10	1+3	0.02+0.02	L: adopted $J\pi=5^-$ is inconsistent with $L=1$. C^2S : 0.008+0.1.
3616? 10	1(+3)	0.027+0.0	C^2S : 0.022+0.049.
3661? 10	1(+3)	0.052+0.0	C^2S : 0.039+0.087.

† From DWBA analysis of $\sigma(\theta)$.

$\frac{1}{2}$ For $L=1$ computed assuming p3/2 transfer. For mixed transitions the authors provide two spectroscopic factors for each level corresponding to the extreme mixing coefficients compatible with observed angular distribution; the second set of values are given in the level comment.

$^{73}\text{Ge}(\text{n},\alpha)$ 1965Ai01Target $J\pi=9/2+$. $E(\text{n})=14.1$ and 14.8 MeV. Measured $E\alpha$ with a Ge(Li) detector. ^{70}Zn Levels

<u>E(level)</u>
0.0
880
1950? 100
2300? 100

 $^{208}\text{Pb}(^{64}\text{Ni},\text{X}\gamma)$ 2000Wi18

$E(^{64}\text{Ni})=360$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma\gamma$ using Gammasphere array consisting of 83 Compton-suppressed HPGe detectors.
 Similar results are given in 1997Be77.

 ^{70}Zn Levels

<u>E(level)[†]</u>	<u>$J\pi^{\ddagger}$</u>	<u>Comments</u>
0.0 §	0+	
885.4 §	2+	
1787.6 §	4+	
2896.5 §	(6+)	
3039.7	5-	$J\pi$: proposed as $J\pi=4+$ in 2000Wi18.
3477.7		
3600.8		$J\pi$: proposed as $J\pi=(5+)$ in 2000Wi18.
3756.8 §	(8+)	
3790.1		$J\pi$: proposed as $J\pi=(6+)$ in 2000Wi18.
4937.3 §	(10+)	
6117.7 §	(12+)	

[†] From a least-squares fit to $E\gamma$, by evaluators.[‡] From the Adopted Levels. Differences in assignments as proposed by 2000Wi18 are indicated in the comments.

§ (A): Yrast band.

 $\gamma(^{70}\text{Zn})$

<u>$E\gamma$</u>	<u>E(level)</u>	<u>Comments</u>
561.1	3600.8	
750.4	3790.1	
860.3	3756.8	
885.4	885.4	
902.2	1787.6	
1108.9	2896.5	
1180.3	6117.7	
1180.5	4937.3	
1252.1	3039.7	
1690.1	3477.7	
2154.3	3039.7	$E\gamma$: The adopted J^π requires E3 or M4 for this transition. This transition depopulates another level in $^{70}\text{Zn}(\text{n},\text{n}')$ dataset. The evaluators adopted the $^{70}\text{Zn}(\text{n},\text{n}')$ placement for this transition in Adopted Levels.

$^{238}\text{U}(^{76}\text{Ge},\text{X}\gamma)$ 2013Lo04

$E(^{76}\text{Ge})=577$ MeV. Measured $E\gamma$, $I\gamma$, particle- γ coincidences using the AGATA Demonstrator consisting of four triple cluster HPGe modules. Projectile-like reaction products separated by the magnetic spectrometer PRISMA and detected at the focal plane with ten parallel plate avalanche counters and an ionization chamber; deduced $T_{1/2}$ using the Cologne plunger and the Recoil Distance Doppler Shift (RDDS) method.

 ^{70}Zn Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$
0.0	0+	
884 2	2+	3.7 ps 12
1786 3	4+	2.0 ps +9-11
2894 4	(6+)	
3036 2	5-	
3754 4	(8+)	
4934 4	(10+)	
6115 4	(12+)	

† From $E\gamma$.

‡ From the Adopted Levels.

§ From RDDS in 2013Lo04.

 $\gamma(^{70}\text{Zn})$

$E\gamma^\dagger$	$E(\text{level})$
860 2	3754
884 2	884
902 2	1786
1108 2	2894
1180.3 ‡	6115
1180.5 ‡	4934
1250 § 2	3036

† From 2013Lo04, except where noted.

‡ From the Adopted Levels. 2013Lo04 give a partially Doppler shifted value of 1163 keV 2 in the spectra of their Figure 3, which corresponds to the closely spaced doublet of 1180.5 keV and 1180.3 keV.

§ Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

$Q(\beta^-)=1651.7\ 15$; $S(n)=7653.65\ 17$; $S(p)=7781.5\ 15$; $Q(\alpha)=-5077.0\ 14$ 2012Wa38.

$S(2n)=17967.0\ 19$; $S(2p)=17921.0\ 20$ (2012Wa38).

Earlier studies suggested the first excited state in ^{70}Ga to be a 20-ms isomeric level at 188 keV (1966Me02,1966Re05). Subsequent studies using (p,n γ) have found no evidence for such a level, in particular a dedicated study by 1973Ca31.

 ^{70}Ga Levels**Cross Reference (XREF) Flags**

A $^{68}\text{Zn}(\alpha, d)$	E $^{69}\text{Ga}(d, p\gamma)$
B $^{68}\text{Zn}(\alpha, pn\gamma)$	F $^{70}\text{Zn}(p, n)$
C $^{69}\text{Ga}(n, \gamma)$ E=thermal	G $^{70}\text{Zn}(p, n\gamma)$
D $^{69}\text{Ga}(d, p)$	H $^{71}\text{Ga}(d, t)$

E(level) [†]	J π	XREF	T _{1/2} [‡]	Comments
0.0	1+	ABCDEFGH	21.14 min 5	$\% \beta^- = 99.59\ 5$; $\% \epsilon = 0.41\ 5$; $Q = +0.105\ 7$; $\mu = +0.571\ 2$. T _{1/2} : weighted average of 21.15 min 5 (1977Sc10); 21.15 min 6 (1975Bu07); and 21.10 min 7 (1957Bu41). Other: 2015DuZZ. J π : J=1 from atomic beam (1976Fu06); parity from L(d,p)=1. μ, Q : from collinear laser spectroscopy (2012Pr11). $\% \beta^-, \% \epsilon$: from measurements of Zn K α x-rays and 176 γ in ^{70}Ge (1977Sc10). $\delta \langle r^2 \rangle^{71,70} = -0.096\ \text{fm}^2\ 21$ (2012Pr11). J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=1. J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=1+3. J π : $\gamma(\theta)$ in (p,n γ) and E1 691 γ to 1+. $\mu = -0.26\ 10$. J π : $\gamma(\theta)$ in (p,n γ) and E2 188 γ to 2-. T _{1/2} : from $\gamma\gamma(t)$ in (p,n γ). Others: 22 ns 2 from $\gamma\gamma(t)$ in $^{68}\text{Zn}(\alpha, pn\gamma)$, 28 ns 3 from recoil- $\gamma\gamma(t)$ in $^{198}\text{Pt}(^{76}\text{Ge}, X\gamma)$ (1997Is13). μ : from TDPAD in $^{69}\text{Ga}(d, p\gamma)$ (1976Ta09). J π : M1+E2 393 γ to 2+, L(d,p)=L(d,t)=3. J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=L(d,t)=1+3.
508.17 8	2+	BCDEFGH		
651.12 9	1+, 2+	CDEFGH		
690.89 9	2-	BCDEFGH		
879.01 13	4-	BCDEFGH	22.7 ns 5	
901.41 12	1+, 2+, 3+	B D FGH	<1.4 ns [#]	
995.45 10	2+	CD FGH		
1002.8 10		G		
1009.2 10		d fGh		
1009.41 21	1+, 2+, 3+	Cd fGh		J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=1+3.
1014.90 13	1+, 2+, 3+	CD fGH		J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=1+3.
1023.89 12	2+, 3+	CD FGH		J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=L(d,t)=1+3.
1034.03 14	(5)-	B D GH		J π : D 155 γ to 4-, L(d,p)=L(d,t)=4, yield function in ($\alpha, pn\gamma$) consistent with J=5.
1086.31? 16		B	24 ns [#] 4	
1101.49 22	2-, 3-, 4-	D FGH		J π : L(d,p)=2+4.
1135.40 10	1, 2	d fGh		J π : $\gamma(\theta)$ in (p,n γ).
1140.42 9	1, 2	Cd fGh		J π : $\gamma(\theta)$ in (p,n γ).
1180.52 15	5	B		J π : $\gamma(\theta)$ in ($\alpha, pn\gamma$).
1203.83 20	2+	CDEFGH	>220 fs	J π : $\gamma(\theta)$ in (p,n γ) and L(d,t)=1.
1234.38 15	(6)-	B D GH		J π : D(+Q) 200 γ to 5-, L(d,p)=L(d,t)=4; yield function in ($\alpha, pn\gamma$) consistent with J=6.
1244.61 10	2	a D FG	>500 fs	J π : $\gamma(\theta)$ in (p,n γ).
1253.45 16	3-, 4-	a CD G		J π : M1 374.5 γ to 4-, 562 γ to 2-.
1258.72 15	1+ to 4+	a fGH		XREF: H(1250). J π : $\gamma(\theta)$ in (p,n γ).
1263.5 6		aBCD f H		E(level): in (n, γ) E=thermal two depopulating transitions of 612.3 keV and 755 γ are observed while in $^{67}\text{Zn}(\alpha, p\gamma)$ a single depopulating transition of 1263.5 keV is observed; the lack of overlap of depopulating transitions could indicate a closely spaced doublet.
1306.11 19		Cd Gh		J π : L(d,t)=1 for the doublet.
1307.0 4		d Gh		J π : L(d,t)=1 for the doublet.
1312.1 3	1+, 2+	CD FGH	170 fs +50-25	J π : $\gamma(\theta)$ in (p,n γ) and L(d,t)=1.
1325 3	-	D		J π : L(d,p)=2.
1336.61 21	2-	D FG		J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=2.
1359.42 18	2+	CD FG		J π : $\gamma(\theta)$ in (p,n γ) and L(d,p)=1+3.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{70}Ga Levels (continued)

E(level) [†]	J π	XREF	T _{1/2} [‡]	Comments
1371.50 16	(7-)	B		J π : Q 337 γ to (5)-, yield function in (α ,p γ) consistent with J=7; tentative parity based on assumption that Q=E2.
1413.2 3		C FG		
1445.93 19	1+, 2+	CD FGH	0.27 ps +56-9	J π : γ (θ) in (p,n γ) and L(d,p)=1+3.
1456.47 24	1+, 2+	CD FGH		J π : γ (θ) in (p,n γ) and L(d,p)=1+3.
1501.2 5	1+, 2+	D FGH		J π : γ (θ) in (p,n γ) and L(d,t)=1.
1518.3 3	1+, 2+	CD FGH		J π : γ (θ) in (p,n γ) and L(d,p)=L(d,t)=1+3.
1523.48 18		B		
1533.51 13	2+	CD FGH		J π : γ (θ) in (p,n γ) consistent with J=2 or 3, D+Q 1533 γ to 1+ rules out J=3, L(d,p)=1.
1538.79 16	(6)	B		J π : J=(6,8) from γ (θ) in (α ,pn γ); D+Q 304 γ to (6)-.
1554.3 5	2+	CD FGH		J π : γ (θ) in (p,n γ) and L(d,t)=1.
1598 [§] 5		F		
1621.2 4	1-, 2-	CD FGH		J π : γ (θ) in (p,n γ) and L(d,p)=2.
1633.56 20	1, 2, 3	C FG		J π : γ (θ) in (p,n γ).
1646 2	2-, 3-, 4-	D		J π : L(d,p)=2+4.
1661 2	-	D F		J π : L(d,p)=4.
1687.60 18	6-	B D		J π : J=6,7,8 from γ (θ) in (α ,pn γ); L(d,p)=4 rules out 7,8.
1691.5 8		C F		
1720.6 9	1+, 2+, 3+	CD H		J π : L(d,p)=1+3.
1725.8 6		C FG		
1735.4 10		CD F		E(level): L(d,p)=2 and L(d,t)=1 for 1734 3 suggests possible doublet at this energy.
1794.3 6	1+, 2+, 3+	CD FGH		J π : L(d,p)=1+3.
1807.5 10		D FGH		
1824.0 8		CD FGH		E(level): L(d,p)=2+4 for 1822 2 and L(d,t)=1 for 1823 3 require two levels with opposite parities near this energy.
1846.4 20		C		
1865.2 7		CD FGH		
1877 3		D		
1905.1 9	+	C GH		J π : L(d,t)=1.
1914 2	1-, 2-	D F		J π : L(d,p)=0.
1930.8 7	+	CD GH		J π : L(d,t)=1.
1937.4 20	+	C F H		J π : L(d,t)=1.
1970.4 10	+	CD F H		J π : L(d,t)=1.
1984.4 10		CD F		
2016.4 20	-	CD F H		J π : L(d,p)=2.
2026.4 20		C F		
2074.4 10		C F		
2093 [§] 4		F		
2100 3	+	D		J π : L(d,p)=1.
2115.2 17		C FG		
2128 [§] 4		C F		
2142.6 17	-	CD FG		J π : L(d,p)=2.
2164.3 10		C F		
2189.7 14		C FG		
2213.7 14		C FG		
2232.2 14		CD FG		
2254.5 20		C F		
2300 3	+	D		J π : L(d,p)=1.
2319.6 9		C FG		
2351.2 9		C FG		
2374 [§] 5		F		
2388.5 10		C F		
2409.8 9		C FG		
2430.5 10		C F		
2446 3	-	D		J π : L(d,p)=2.
2464.4 10		C F		
2477.5 10		C F		XREF: F(2484).
2520.5 10	-	CD F		J π : L(d,p)=2.
2548.5 20		C F		
2571.5 10	-	CD F		J π : L(d,p)=2.

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Adopted Levels, Gammas (continued) ^{70}Ga Levels (continued)

E(level) [†]	J π	XREF	Comments
2601.41 18	(8)	B	J π : D(+Q) 1230 γ to (7), γ (θ) and yield function in (α ,pn γ) favor J=8.
2624.5 20		C F	
2651.51 18	—	B D	J π : L(d,p)=2.
2654.5 10		C F	
2682 $\S$ 5		F	
2698.0 17		C F	
2726 $\S$ 5		F	
2886.21 21	(9)	AB	XREF: A(2880).
			J π : D(+Q) 285 γ to (8) and yield function in (α ,pn γ) consistent with J=9.
(7653.67 22)	1-, 2-	C	J π : Assuming s-wave neutron capture on J π =3/2- target. E(level): 2012Wa38 give 7653.65 17.

[†] From a least-squares fit to E γ , by evaluators, for level connected by gammas. Otherwise from (d,p) except where noted.

[‡] From DSAM in (p,n γ), except where noted.

$\S$ From (p,n).

From $\gamma\gamma$ (t) in (α ,pn γ).

 $\gamma(^{70}\text{Ga})$

E(level)	E γ [†]	I γ [†]	Mult. [‡]	δ $\S$	α	Comments
508.17	508.1 1	100	M1		1.20 $\times 10^{-3}$	α (K)exp=9.7 $\times 10^{-4}$ 12 (1984Fe03).
651.12	651.2 1	100				
690.89	690.8 1	100	E1		3.01 $\times 10^{-4}$	α (K)exp=2.8 $\times 10^{-4}$ 10 (1984Fe03).
879.01	188.1 [#] 1	100	E2		0.0652	B(E2)(W.u.)=5.80 13. Mult.: Q from γ (θ) in (p,n γ) and (α ,pn γ); M2 excluded by comparison to RUL. δ : 0.00 +(-14 from γ (θ) in (p,n γ).
901.41	393.2 $\&$ 1	100 $\&$ 9	M1+E2	<0.7	0.0026 5	α (K)exp=2.2 $\times 10^{-3}$ 4 (1984Fe03). B(E2)(W.u.)>0.7; B(M1)(W.u.)>0.00016. δ : from α (K)exp.
995.45	902.5 ^a 10 344.5 2	<15 50 13	M1		0.00296	α (K)exp=2.6 $\times 10^{-3}$ 8 (1984Fe03).
	487.2 1	100 9				
	995.9 3	66 11				
1002.8	1002.8 10	100				
1009.2	1009.2 10	100				
1009.41	318.5 2	100	E1+M2		0.00225 14	α (K)exp=3.8 $\times 10^{-3}$ 10 (1984Fe03). Mult.: M1 or E1+M2 from α (K) exp in (p,n γ); $\Delta\pi$ =no from level scheme.
1014.90	1009.8 10 363.8 1	24 45	M1		0.00260	α (K)exp=2.2 $\times 10^{-3}$ 5 (1984Fe03).
	1014.4 6	100				
1023.89	515.7 1	100 6				
	1023.3 5	10 6				
1034.03	154.9 1	100	M1		0.0218	α (K)exp=1.4 $\times 10^{-2}$ 5 (1984Fe03). Mult.: D from α (K)exp in (p,n γ), $\Delta\pi$ =no from level scheme. δ : 0.00 1 from γ (θ) in (α ,pn γ).
1086.31?	184.9 ^{#a} 1	100				
1101.49	410.6 2	100				
1135.40	444.3 4	12 5				
	1135.4 1	100 5				
1140.42	632.3 2	49 5				
	1140.4 1	100 5				
1180.52	146.8 [#] 1	35 [#]	D+Q $\&$	+1.1 $\&$ 3		
	301.2 [#] 1	100 [#]	D(+Q) $\&$	0.0 $\&$ 1		
1203.83	1203.8 2	100	M1+E2	-0.10 7	1.99 $\times 10^{-4}$	B(E2)(W.u.)<1.4; B(M1)(W.u.)<0.06. Mult.: D+Q from γ (θ) in (p,n γ), $\Delta\pi$ =no from level scheme.
1234.38	200.3 [#] 1	100 [#]	M1(+E2)	0.0 $\&$ 1	0.0113 5	Mult.: D(+Q) from γ (θ) in (α ,pn γ), $\Delta\pi$ =no from level scheme.

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ga})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [‡]	$\delta^{\S}$	α	Comments
1234.38	355.8 [#] 1	6 [#]				
1244.61	1244.6 1	100	D+Q	-0.05 4		
1253.45	374.5 1	100 6	M1		0.00243	$\alpha(\text{K})_{\text{exp}}=2.1\times 10^{-3}$ 5 (1984Fe03).
	561.7 4	12 6				
1258.72	234.8 1		M1		0.00756	$\alpha(\text{K})_{\text{exp}}=7.3\times 10^{-3}$ 17 (1984Fe03).
	608.5 ^a 5					
1263.5	612.3 6	55				$E\gamma, I\gamma$: from (n, γ) E=thermal.
	755 2	100				$E\gamma, I\gamma$: from (n, γ) E=thermal.
	1263.5 15					
1306.11	426.8 2	72 7				
	798.6 3	100 7				
1307.0	1307.0 4	100				
1312.1	1312.1 3	100				
1336.61	645.7 2	100 4	M1+E2	+1.8 3	0.00094 3	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
	1337.0 10	9 4	E1+M2	+0.51 27	2.44×10^{-4} 19	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =yes from level scheme.
1359.42	708.6 ^a 10					
	851.1 2	100 13	M1+E2	-0.19 2	3.92×10^{-4}	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
	1359.8 4	59 8	M1+E2	+0.20 8	1.84×10^{-4}	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
1371.50	137.6 [#] 1	100 [#]	D(+Q) [@]	0.0 [@] 1		
	337.1 [#] 1	15 [#]	Q [@]			$\delta: \delta(\text{O/Q})=0.0$ 1 from $\gamma(\theta)$ in (α ,pn γ).
1413.2	904.9 3	100				
1445.93	755.0 2	9 2				
	794.4 10	2 2				
	1446.1 5	100 10				
1456.47	432.3 8	25 7				
	554.3 5					
	948.5 3	14 6				
	1456.6 8	100 7				
1501.2	1501.2 5	100				
1518.3	867.0 3	37 5				
	1518.7 6	100 10				
1523.48	289.1 1	100				
1533.51	393.1 ^{&} 1	72 ^{&} 11				
	882.8 10	40 9				
	1533.2 8	100 9	M1+E2	+0.5 4	2.03×10^{-4} 8	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
1538.79	167.4 [#] 1	40 [#]	D(+Q) [@]	+0.1 [@] 1		
	304.3 [#] 1	100 [#]	D+Q [@]	+0.4 [@] 1		
1554.3	1045.3 8	100 10	M1+E2		2.73×10^{-4} 19	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
	1554.3 8	49 6	M1+E2	+0.25 9	2.03×10^{-4} 4	Mult.: D+Q from $\gamma(\theta)$ in (p,n γ), $\Delta\pi$ =no from level scheme.
1621.2	930.4 6	<8				
	969.5 10	92 9				
	1620.5 8	100 10				
1633.56	982.6 10	57 7				
	1125.4 2	100 10				
	1633.1 10	28 6				
1687.60	316.1 [#] 1	100	M1(+E2) [@]	+0.05 [@] 10	0.00366 14	
1691.5	427 2	100				$E\gamma, I\gamma$: from (n, γ) E=thermal.
	1038 ^a 2	45				$E\gamma, I\gamma$: from (n, γ) E=thermal.
1720.6	362 ^a 2	100				$E\gamma, I\gamma$: from (n, γ) E=thermal.
1725.8	1725.5 7	100				
1794.3	1794.2 7	100				
1807.5	1807.5 10	100				
1824.0	1823.2 15	100				
1865.2	1865.0 7	100				
1905.1	1904.8 10	100				
1930.8	1930.8 7	100				

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ga})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. ‡	$\delta^{\S}$	Comments
2115.2	2118 2	100			
2142.6	2143 2	100			
2164.3	2163 3	100			$E\gamma, I\gamma$: from (n, γ) E=thermal.
2189.7	2190 2	100			
2213.7	2214 2	100			
2232.2	2231 2	100			
2319.6	2320 2	100			
2351.2	2350 2	100			
2409.8	2411 2	100			
2464.4	2464 3	100			
2601.41	1229.9 [#] 1	100	D(+Q) [@]	0.0 [@] 2	
2651.51	1280.0 [#] 1	100			
2698.0	2699 3	100			$E\gamma, I\gamma$: from (n, γ) E=thermal.
2886.21	284.8 [#] 1	100	D(+Q) [@]	0.0 [@] 2	
(7653.67)	4956 2	45 6			
	4999 1	23 4			
	5029 2	3.7 6			
	5082 1	26 4			
	5105 2	8.0 16			
	5133 1	26 4			
	5176 1	11.8 20			
	5189 1	17 3			
	5223 1	11.2 20			
	5244 1	3.7 6			
	5265 ^a 1	3.3 6			
	5302 1	9.8 16			
	5334 1	16 3			
	5399 2	7.3 12			
	5420 2	2.0 6			
	5440 2	6.3 10			
	5464 2	2.7 6			
	5489 1	61 10			
	5511 2	15.1 22			
	5527 3	2.0			
	5539 2	25 4			
	5579 1	14.3 22			
	5627 2	34 5			
	5637 2	11.8 20			
	5669 1	11.6 20			
	5683 1	9.6 16			
	5716 2	3.9 6			
	5723 2	16 3			
	5747 2	28 4			
	5787 2	2.7 6			
	5807 2	43 6			
	5829 1	13.5 20			
	5859 1	9.6 16			
	5918 1	4.9 2			
	5927 1	17 3			
	5933 ^a 1	6.3 10			
	5961 1	5.9 10			
	6020 1	4.3 6			
	6031 1	3.7 6			
	6098 1	20 3			
	6120 1	20 3			
	6135 1	26 4			
	6196 1	17 3			
	6207 1	13.9 20			
	6239 1	11.2 16			
	6293 1	12.9 20			
	6341 2	19 3			
	6346.5 10	39 6			
	6391 2	100			

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ga})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$
(7653.67)	6401 2	11.2 16
	6449 1	7.3 10
	6513.6 10	82 14
	6629.7 15	12.4 20
	6639 2	3.3 6
	6658.5 10	13.5 20
	6963.3 10	6.1 20
	7003.6 10	53 8
	7147.4 10	4.1 8
	7655 1	<33

† From (p,n γ), except where noted.

‡ From $\alpha(\text{K})\text{exp}$ in (p,n γ), except where noted.

§ From $\gamma(\theta)$ in (p,n γ), except where noted.

$^\#$ From (α ,pn γ).

$^\textcircled{a}$ From $\gamma(\theta)$ in (α ,pn γ).

$^\&$ Multiply placed; intensity suitably divided.

$^\text{a}$ Placement of transition in the level scheme is uncertain.

 $^{68}\text{Zn}(\alpha,\text{pn}\gamma)$ 1977Mo01

1977Mo01: $E(\alpha)=23-40$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\gamma(\theta)$, excitation function, $\gamma\gamma(t)$ using Ge(Li) detectors.

Others: 1971Ar12: $^{67}\text{Zn}(\alpha,\text{p}\gamma)$ with $E(\alpha)=14$ MeV. Measured $E\gamma$, γ -p coincidences with coaxial Ge detector. With the exception of a 1263.0 γ , all γ -rays observed by 1971Ar12 were also observed in 1977Mo01. 1971Ar12 provides placements for only a few of these transitions which are consistent with the placements of 1977Mo01. Also 1975EbZZ, $E(\alpha)=13$ MeV. Measured $E\gamma$ with Ge(Li) detector. Observed 5 γ rays and their placement consistent with the results of 1977Mo01.

 ^{70}Ga Levels

E(level) †	$J\pi^\ddagger$	$T_{1/2}^\S$	Comments
0.0	1+		
508.5 10	2+		
691.0 10	2-		
879.1 10	4-	22 ns 2	
901.8 10	1+, 2+, 3+	<1.4 ns	$J\pi$: J=3,4 from $\gamma(\theta)$, absence of ground-state transition favors 4.
1034.2 10	(5)-		$J\pi$: $\gamma(\theta)$ consistent with J=5.
1086.7?		24 ns 4	E(level): difficulty in extracting information about the 185 γ mixed with the strong 188 γ makes this level questionable. $J\pi$: $\gamma(\theta)$ suggests J=6.
1180.7 10	5		$J\pi$: from $\gamma(\theta)$.
1234.3 11	(6)-		$J\pi$: $\gamma(\theta)$ for 200 γ shows dipole character and yield function consistent with J=6.
1263.0			
1371.6 11	(7-)		$J\pi$: $\gamma(\theta)$ of 138 γ shows dipole character and yield function consistent with J=7.
1523.4 15			
1538.8 11	(6)		$J\pi$: J=(6,8) from $\gamma(\theta)$.
1687.7 11	6-		$J\pi$: J=6,7,8 from $\gamma(\theta)$.
2601.5 11	(8)		$J\pi$: $\gamma(\theta)$ and yield function favor J=8.
2651.6 15	-		
2886.3 11	(9)		$J\pi$: from $\gamma(\theta)$ and yield function for 285 γ favor J=9 assuming J=8 for 2602 level.

† From a least-squares fit to $E\gamma$, by evaluators.

‡ From the Adopted Levels. Additional support provided by the information from this dataset is included in the comments.

§ From $\gamma\gamma(t)$ in 1977Mo01. For levels other than the 897-keV, 902-keV and 1087-keV levels, an upper limit on the half-life of $T_{1/2} < 4$ ns was found.

$^{68}\text{Zn}(\alpha, \text{pn}\gamma)$ 1977Mo01 (continued) $\gamma(^{70}\text{Ga})$

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Mult.§	$\delta^\S$	Comments
137.6 1	1371.6	26	D(+Q)	0.0 1	Mult., δ : $A_2=-0.29$ 3, $A_4=-0.01$ 3 (1977Mo01).
146.8 1	1180.7	5.3	D+Q	+1.1 3	Mult., δ : $A_2=+0.23$ 5, $A_4=-0.2$ 1 (1977Mo01).
155.5 1	1034.2	75	D(+Q)	0.0 1	Mult., δ : $A_2=-0.27$ 4, $A_4=-0.06$ 5 (1977Mo01).
167.4 1	1538.8	2.3	D(+Q)	+0.1 1	Mult., δ : $A_2=-0.37$ 7, $A_4=+0.25$ 8 (1977Mo01).
184.9# 1	1086.7?	6			$A_2=+0.38$ 21, $A_4=+0.2$ 1 (1977Mo01).
188.1 1	879.1	90	Q		Mult.: $A_2=+0.26$ 4, $A_4=-0.03$ 6 (1977Mo01).
					δ : $\delta(\text{O/Q})=0.0$ 1 (1977Mo01).
200.3 1	1234.3	43	D(+Q)	0.0 1	Mult., δ : $A_2=-0.23$ 1, $A_4=-0.07$ 1 (1977Mo01).
284.8 1	2886.3	6.0	D(+Q)	0.0 2	Mult., δ : $A_2=-0.22$ 10, $A_4=-0.2$ 1 (1977Mo01).
289.1 1	1523.4				
301.2 1	1180.7	15	D(+Q)	0.0 1	Mult., δ : $A_2=-0.22$ 3, $A_4=-0.1$ 1 (1977Mo01).
304.3 1	1538.8	5.7	D+Q	+0.4 1	Mult., δ : $A_2=+0.38$ 7, $A_4=-0.1$ 1 (1977Mo01).
316.1 1	1687.7	9.0	D(+Q)	+0.05 10	Mult., δ : $A_2=-0.25$ 5, $A_4=+0.03$ 6 (1977Mo01).
337.1 1	1371.6	3.8	Q		Mult.: $A_2=+0.22$ 10, $A_4=+0.04$ 10 (1977Mo01).
					δ : $\delta(\text{O/Q})=0.0$ 1.
355.8 1	1234.3	2.7			$I\gamma$: from $I\gamma(200\gamma)/I\gamma(356\gamma)=0.94/0.06$ and $I\gamma(200\gamma)=43$.
393.3 1	901.8	13	Q		Mult.: $A_2=+0.25$ 5, $A_4=+0.03$ 7 (1977Mo01).
					δ : $\delta(\text{O/Q})=0.16$ 20 (1977Mo01).
508.5 1	508.5				
691.0 1	691.0	100			
1229.9 1	2601.5	20	D(+Q)	0.0 2	Mult., δ : $A_2=-0.23$ 13, $A_4=+0.02$ 20 (1977Mo01).
1263.0 15	1263.0				$E\gamma$: from 1971Ar12.
1280.0 1	2651.6				

† From 1977Mo01, except where noted.

‡ From 1977Mo01, given relative to $I\gamma(691\gamma)=100$.

§ From $\gamma(\theta)$ in 1977Mo01.

Placement of transition in the level scheme is uncertain.

 $^{68}\text{Zn}(\alpha, \text{d})$ 1969Lu07

$E(\alpha)=50$ MeV. Measured $\sigma(\theta)$ for $\theta=14^\circ$, 20° , 34° , and 40° using Si(Li) $\Delta E-E$ detector telescope (FWHM=170 keV). See also 1968LuZY, thesis. Subset of results given in 1968Lu05.

 ^{70}Ga Levels

E(level)	Comments
(0.0)	
1250 30	
2880 30	E(level): probable configuration: $(1g_{9/2})^2$ coupled to a $9+$ state.

⁶⁹Ga(n,γ) E=thermal 1970Li04,1971Ve03

Target: Jπ=3/2-.

1971Ar12: Measured Eγ with Ge(Li) detector.

1971Ve03: Measured Eγ, Iγ with a Ge(Li)-NaI(Tl) pair spectrometer.

1970Li04: Measured Eγ, Iγ with a Ge(Li)-NaI(Tl) pair spectrometer.

1972St06: polarized neutrons. Measured polarization function R proportional to the circular polarization of primary capture γ-rays.

The ⁶⁹Ga(n,γ) level scheme is mainly that proposed by 1970Li04 and 1971Ve03. Many γ placements are not adopted by the evaluators as 1) they are inconsistent with the results of both (p,nγ) and (α,pnγ) studies and 2) 1970Li04 base some placements on a tentative 188-keV level which subsequent studies found no evidence for. Additional primary and secondary γ rays have been placed by the evaluators on the basis of ⁷⁰Ga levels known to exist from other reactions.

⁷⁰Ga Levels

E(level) [†]	Jπ [‡]	Comments
0.0	1+	
508.94 24	2+	
651.02 18	1+, 2+	
691.16 20	2-	
878.7 3	4-	
995.1 6	2+	
1009.6 4	1+, 2+, 3+	
1014.6 20	1+, 2+, 3+	
1024.9 3	2+, 3+	
1140.0 4	1, 2	
1200.4 3	2+	
1252.6 20	3-, 4-	
1263.4 6		
1307.5 6		
1312.3 14	1+, 2+	
1359.2 7	2+	
1414.3 9		
1448.9 5	1+, 2+	
1457.1 8	1+, 2+	
1518.6 8	1+, 2+	
1533.3 4	2+	
1555.2 8	2+	
1622.7 10	1-, 2-	
1633.7 10	1, 2, 3	
1691.7 9		
1720.8? 9	1+, 2+, 3+	
1726.3 9		
1735.7 10		
1794.3? 9	1+, 2+, 3+	
1824.1 9		
1846.7 20		
1866.2? 17		
1906.8 17	+	
1930.5 17	+	
1937.7 20	+	
1970.7 10	+	
1984.7 10		
2016.7 20	-	
2026.7 20		
2074.7 10		
2115.4 17		
2127 3		
2142.8 17	-	
2164.5 10		
2189.7 20		
2213.7 20		
2233.7 20		
2254.7 20		
2319.7 10		
2351.7 10		
2388.7 10		

Continued on next page (footnotes at end of table)

$^{69}\text{Ga}(\text{n},\gamma)$ E=thermal 1970Li04,1971Ve03 (continued) ^{70}Ga Levels (continued)

$E(\text{level})^\dagger$	$J\pi^\ddagger$	Comments
2409.8 10		
2430.7 10		
2464.7 10		
2477.7 10		
2520.7 10	—	
2548.7 20		
2571.7 10	—	
2624.7 20		
2654.7 10		
2698.1 17		
(7653.9 3)	1-, 2-§	E(level): 2012Wa38 gives 7653.65 17.

 † From a least-squares fit to E_γ , by evaluators. ‡ From the Adopted Levels.§ s-wave neutron capture on $J\pi=3/2^-$ target. $\gamma(^{70}\text{Ga})$

$E_\gamma^\dagger$	$E(\text{level})$	I_γ^a	Comments
154.2	1359.2	4.8	
187.5# 2	878.7	31	E_γ : placement by evaluators. 1970Li04 tentatively place this γ as depopulating a tentative 188-keV level. E_γ : other: 188.2 (1970Li04).
318.4# 4	1009.6	18	E_γ : placement by evaluators. 1970Li04 place this γ as depopulating 508-keV level. E_γ : other: 319.2 (1970Li04).
362 ^b 2	1720.8?	2.2	
374.1# 4	1024.9	6.6	E_γ : other: 374.2 (1970Li04).
393.2	1533.3	13	
^x 410.2		3.2	
427.2	1691.7	2.9	
508.4# ^c 3	508.94	<75 ^c	E_γ : other: 508.5.5 (1970Li04).
	1533.3	<75 ^c	
515.7# 4	1024.9	0.5	E_γ : other: 516.2 (1970Li04).
553.2	1200.4	1.1	
561.2	1555.2	0.6	
^x 574& 2		3.2	
^x 596& 2		0.7	
612.3# 6	1263.4	1.1	E_γ : other: 613.2 (1970Li04).
632.2	1140.0	2.5	
^x 646.2		3.7	
651.2# 2	651.02	16	E_γ : other: 651.2 (1970Li04).
691.2# ^c 2	691.16	<48 ^c	E_γ : other: 691.2 (1970Li04).
	1200.4	<48 ^c	E_γ : other: 691.2 (1970Li04).
^x 748.2		0.5	
755 ^b 2	1263.4	2	
798.7# ^b ^c 6	1307.5	<1.6 ^c	E_γ : other: 798.2 (1970Li04).
	1448.9	<1.6 ^c	E_γ : other: 798.2 (1970Li04).
828.2	1518.6	0.7	
850.2	1359.2	1.3	
904 ^c 2	1414.3	<0.6 ^c	
	1555.2	<0.6 ^c	
^x 933.2		0.9	
947.2	1457.1	0.7	
995.2# 7	995.1	2.2	E_γ : other: 995.2 (1970Li04).
1038 ^{§b} 2	1691.7	1.3	
1044 ^{§b} 2	1555.2	1.9	
^x 1058.2		0.4	
^x 1135.2		4.5	
1139.9# 4	1140.0	5.0	E_γ : other: 1139.2 (1970Li04).
^x 1171.2			
1203.2	1200.4	2.6	

Continued on next page (footnotes at end of table)

⁶⁹Ga(n,γ) E=thermal 1970Li04,1971Ve03 (continued)

γ(⁷⁰Ga) (continued)

Eγ [†]	E(level)	Iγ ^a	Comments
x1244 2		2.6	
1312 2	1312.3	3	
1359 2	1359.2	1.7	
1456 2	1457.1	1.7	
x1485b 2		0.7	
1518 2	1518.6	2.2	
1532b 2	1533.3	1.3	
1725 2	1726.3	1.5	
1793 2	1794.3?	0.8	
1865 3	1866.2?	1.1	
1907 3	1906.8	1.3	
1930 3	1930.5	0.9	
2117 3	2115.4	1.4	
2143 3	2142.8	1.3	
2163 3	2164.5	0.6	
2410 3	2409.8	0.3	
2464 3	2464.7	0.6	
x2581 3		0.8	
x2613 3		0.5	
2699 3	2698.1	0.4	
x2830 3		0.9	
x3129 3		0.6	
x3361 3		0.5	
x3377 3		0.4	
x3395 3		0.1	
x3424 3		0.3	
x3476 3		0.5	
x3486 3		0.2	
x3498 3		0.1	
x3560 3		0.1	
x3570 3		0.3	
x3581 3		0.3	
x3659 3		0.3	
x3745 3		0.6	
x3760 3		0.3	
x3774 3		0.3	
x3795 3		0.3	
x3827 3		0.7	
x3865 3		0.5	
x3920 3		0.6	
x3944 3		0.4	
x4033 3		0.5	
x4137 3		0.2	
x4152 3		0.2	
x4180 3		0.5	
x4206 3		0.4	
x4317 3		0.5	
x4323 3		0.4	
x4414 3		0.9	
x4431 3		0.9	
x4467 3		0.7	
x4494 3		0.5	
x4501 2		0.16 3	
x4511 2		0.11 3	
x4525 2		0.15 3	
x4547 2		0.32 5	
x4565 2		0.18 3	
x4571 2		0.29 5	
x4581 2		0.26 5	
x4589 2		0.24 5	
x4596 1		0.63 10	
x4620b 2		0.10 2	
x4631 1		0.21 5	

Continued on next page (footnotes at end of table)

$^{69}\text{Ga}(\text{n},\gamma)$ E=thermal 1970Li04,1971Ve03 (continued) $\gamma(^{70}\text{Ga})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^a$	Comments
$^{x}4660^b$ 3		0.03 2	
$^{x}4672$ 1		0.16 3	
$^{x}4682$ 3		0.10 3	
$^{x}4696$ 1		2.40 4	
$^{x}4711$ 1		1.8 3	
$^{x}4721$ 1		0.36 5	
$^{x}4753$ 1		1.36 21	
$^{x}4773$ 3		0.26 6	
$^{x}4779$ 3		0.29 8	
$^{x}4796$ 2		0.21 5	
$^{x}4813$ 2		0.42 8	
$^{x}4823$ 1		1.71 26	
$^{x}4842$ 2		0.45 8	
$^{x}4853$ 2		0.70 13	
$^{x}4863$ 1		1.02 16	
$^{x}4872$ 2		0.27 5	
$^{x}4896$ 2		0.14 3	
$^{x}4910$ 2		0.40 6	
$^{x}4922$ 2		0.23 5	
4956 2	(7653.9)	2.2 3	
$^{x}4979$ 2		0.45 10	
4999 1	(7653.9)	1.13 18	
$^{x}5003^b$ 2		0.24 6	
5029 2	(7653.9)	0.18 3	
$^{x}5038$ 1		0.61 10	
$^{x}5051$ 1		0.32 6	
$^{x}5068$ 1		0.57 11	
$^{x}5072^b$ 2		0.47 10	
5082 1	(7653.9)	1.29 19	
$^{x}5096$ 2		0.29 6	
5105 2	(7653.9)	0.39 8	
5133 1	(7653.9)	1.26 19	
$^{x}5143$ 2		0.06 2	
5176 1	(7653.9)	0.58 10	
5189 1	(7653.9)	0.82 13	
$^{x}5193^b$ 1		0.50 10	
$^{x}5215$ 1		0.37 6	
5223 1	(7653.9)	0.55 10	
5244 1	(7653.9)	0.18 3	
$^{x}5265^b$ 1	(7653.9)	0.16 3	
$^{x}5272$ 1		0.57 8	
5302 1	(7653.9)	0.48 8	
$^{x}5312$ 1		0.60 10	
5334 1	(7653.9)	0.79 13	
$^{x}5342$ 2		0.24 5	
5399 2	(7653.9)	0.36 6	
5420 2	(7653.9)	0.10 3	
5440 2	(7653.9)	0.31 5	
5464 2	(7653.9)	0.13 3	
5489 1	(7653.9)	3.0 5	
5511 2	(7653.9)	0.74 11	
$^{x}5527^{\circ}$ 3	(7653.9)	0.1	
5539 2	(7653.9)	1.24 19	
5579 1	(7653.9)	0.70 11	
5627 2	(7653.9)	1.65 26	
5637 2	(7653.9)	0.58 10	
5669 1	(7653.9)	0.57 10	
5683 1	(7653.9)	0.47 8	
5716 2	(7653.9)	0.19 3	
5723 2	(7653.9)	0.78 13	
5747 2	(7653.9)	1.36 21	
5787 2	(7653.9)	0.13 3	
5807 2	(7653.9)	2.1 3	

Continued on next page (footnotes at end of table)

$^{69}\text{Ga}(\text{n},\gamma)$ E=thermal 1970Li04,1971Ve03 (continued) $\gamma(^{70}\text{Ga})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^a$	Comments
5829 1	(7653.9)	0.66 10	
5859 1	(7653.9)	0.47 8	
5918 1	(7653.9)	0.24 5	
5927 1	(7653.9)	0.84 13	
5933 ^b 1	(7653.9)	0.31 5	
5961 1	(7653.9)	0.29 5	
6020 1	(7653.9)	0.21 3	
6031 1	(7653.9)	0.18 3	
6098 1	(7653.9)	0.99 14	
6120 1	(7653.9)	0.99 14	
6135 1	(7653.9)	1.28 19	
6196 1	(7653.9)	0.81 13	
6207 1	(7653.9)	0.68 10	
6239 1	(7653.9)	0.55 8	
6293 1	(7653.9)	0.63 10	
6341 2	(7653.9)	0.95 16	
6346.5 [#] 10	(7653.9)	1.9 3	
6391 2	(7653.9)	4.9	Polarization function $R=-0.44$ 14 (1972St06).
6401 2	(7653.9)	0.55 8	
6449 1	(7653.9)	0.36 5	
6513.6 [#] 10	(7653.9)	4.0 7	Polarization function $R=-0.04$ 6 for the unresolved 6514 γ and the 6521 γ from neutron capture in ^{71}Ga (1972St06).
6629.7 [#] 15	(7653.9)	0.61 10	
6639 2	(7653.9)	0.16 3	
6658.5 [#] 10	(7653.9)	0.66 10	
6963.3 [#] 10	(7653.9)	0.3 1	
7003.6 [#] 10	(7653.9)	2.6 4	Polarization function $R=0.55$ 12 (1972St06).
7147.4 [#] 10	(7653.9)	0.20 4	
7655 1	(7653.9)	0.6 10	

[†] The γ 's below 4501 are based on the data of 1970Li04; those at or above 4501 are based on 1971Ve03, except where noted.

[§] Either of these γ 's may be the 1040 γ from ^{70}Ga decay to ^{70}Ge .

[#] From 1971Ar12.

@ From 1970Li04.

& Probably from $^{69}\text{Ga}(\text{n},\text{n}'\gamma)$.

^a Absolute intensities in photons per 100 n captures, assuming the thermal-capture cross sections of ^{69}Ga and nickel to be 2.1 barn and 4.6 barn, respectively, and $I\gamma=6.1\%$ for the 7814 γ of nickel as reported by 1967Ba79. The uncertainties in intensities estimated by 1970Li04 are about 20% for strong lines and increase up to 100% for weak lines and many lines in the low energy region. Relative intensities given by 1971Ve03 are normalized to 4.9 photons/100 n capture for the 6391 γ to obtain absolute intensities.

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

^c Multiply placed; undivided intensity given.

^x γ ray not placed in level scheme.

$^{69}\text{Ga}(\text{d},\text{p})$ 1975Do02,1973Yn01Target: $J\pi=3/2^-$.1975Do02: $E(\text{d})=10$ MeV. Measured $\sigma(\theta)$ for $\theta=10^\circ$ to 90° (5° steps up to 50° and 10° steps beyond) using Enge split-pole magnetic spectrograph and photographic emulsions (FWHM=7–11 keV); DWBA analysis.1973Yn01: $E(\text{d})=12$ MeV. Measured $\sigma(\theta)$ for $\theta=10^\circ$ to 135° using split-pole spectrograph and photographic emulsions (FWHM=18 keV); DWBA analysis.

Others: 1971Ar12, 1970Sa22.

 ^{70}Ga Levels

$E(\text{level})^\dagger$	$L^\ddagger$	$(1/4)(2J+1)S^\S$	Comments
0.0	1	0.34	$d\sigma/d\Omega_{\text{max}}=1.7$ mb/sr (1973Yn01). (1/4)(2J+1)S: other: 0.38 (1973Yn01).
508 1	1	0.57	$d\sigma/d\Omega_{\text{max}}=2.4$ mb/sr (1973Yn01). E(level): others: 510 3 (1973Yn01), 506 6 (1971Ar12). (1/4)(2J+1)S: other: 0.52 (1973Yn01).
651 1	1+3	0.10+0.15	$d\sigma/d\Omega_{\text{max}}=0.54$ mb/sr (1973Yn01). E(level): others: 653 3 (1973Yn01), 651 3 (1971Ar12). L,(1/4)(2J+1)S: other: L=1, 1/4(2J+1)S=0.13 (1973Yn01). E(level): other: 689 3 (1971Ar12).
691 2			$d\sigma/d\Omega_{\text{max}}=0.45$ mb/sr (1973Yn01).
878 3	2+4	0.07+1.60	E(level): others: 881 3 (1973Yn01), 875 5 (1971Ar12). L,(1/4)(2J+1)S: other: L=4, 1/4(2J+1)S=1.4 (1973Yn01).
902 1	3	0.41	$d\sigma/d\Omega_{\text{max}}=0.225$ mb/sr (1973Yn01). E(level): others: 904 3 (1973Yn01), 895 8 (1971Ar12). (1/4)(2J+1)S: other: 0.7 (1973Yn01).
996 2	1+3	0.09+0.05	E(level): other: 995 3 (1971Ar12).
1010 2	1+3	0.07+0.19	(1/4)(2J+1)S: summed value for levels at 1010, 1015 and 1023.
1015 3	1+3	0.07+0.19	(1/4)(2J+1)S: summed value for levels at 1010, 1015 and 1023.
1023 3	1+3	0.07+0.19	(1/4)(2J+1)S: summed value for levels at 1010, 1015 and 1023.
1033 2	4	4.14	$d\sigma/d\Omega_{\text{max}}=0.9$ mb/sr (1973Yn01). E(level): others: 1035 3 (1973Yn01), 1030 6 (1971Ar12). (1/4)(2J+1)S: other: 2.7 (1973Yn01).
1099 4	2+4	0.05+0.57	$d\sigma/d\Omega_{\text{max}}=0.225$ mb/sr (1973Yn01). E(level): others: 1103 3 (1973Yn01), 1098 5 (1971Ar12). (1/4)(2J+1)S: other: 0.13+0.6 (1973Yn01).
1136 4			
1204 4			
1235 4	4	2.45	$d\sigma/d\Omega_{\text{max}}=0.6$ mb/sr (1973Yn01). E(level): others: 1237 3 (1973Yn01), 1230 6 (1971Ar12). (1/4)(2J+1)S: other: 1.9 (1973Yn01).
1246 4			
1254 3	2+4	0.13+0.54	$d\sigma/d\Omega_{\text{max}}=0.63$ mb/sr (1973Yn01). E(level): others: 1256 3 (1973Yn01), 1252 10 (1971Ar12). L,(1/4)(2J+1)S: other: L=1, 1/4(2J+1)S=0.15 (1973Yn01). Note that L=1 is not consistent with Adopted $J\pi$ of this level.
1262 4			
1305 4	(2)	0.1	L: from 1973Yn01. Not consistent with $L(\text{d,t})=1$ and Adopted $\pi=+$. E(level): others: 1308 3 (1973Yn01), 1302 8 (1971Ar12).
1313 4			
1325 3	2	0.06	E(level): other: 1320 10 (1971Ar12). A 1330 keV 3 level observed by 1973Yn01 could correspond to this or the 1336-keV level.
1336 3	2	0.05	E(level): other: 1335 6 (1971Ar12).
1359 3	1+3	0.02+0.03	E(level): other: 1355 8 (1971Ar12).
1444 3	1+3	0.02+0.04	E(level): other: 1445 10 (1971Ar12).
1456 4	1+3	0.05+0.06	$d\sigma/d\Omega_{\text{max}}=0.36$ mb/sr (1973Yn01). E(level): others: 1454 3 (1973Yn01), 1457 10 (1971Ar12). L,(1/4)(2J+1)S: other: L=1, 1/4(2J+1)S=0.08 (1973Yn01).
1502 4			
1518 4	1+3	0.01+0.03	
1534 3	1	0.07	L,(1/4)(2J+1)S: from 1973Yn01. $d\sigma/d\Omega_{\text{max}}=0.33$ mb/sr (1973Yn01). E(level): others: 1537 3 (1973Yn01), 1534 10 (1971Ar12).
1555 3	1+3	0.11+0.08	$d\sigma/d\Omega_{\text{max}}=0.72$ mb/sr (1973Yn01). E(level): others: 1558 3 (1973Yn01), 1550 8 (1971Ar12). L,(1/4)(2J+1)S: other: L=1, 1/4(2J+1)S=0.16 (1973Yn01).

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$^{69}\text{Ga}(\text{d},\text{p})$ 1975Do02,1973Yn01 (continued) ^{70}Ga Levels (continued)

E(level) [†]	L [‡]	(1/4)(2J+1)S [§]	Comments
1622 2	2	0.21	$\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.63$ mb/sr (1973Yn01). E(level): others: 1627 3 (1973Yn01), 1620 6 (1971Ar12). (1/4)(2J+1)S: other: 0.16 (1973Yn01).
1646 2	2+4	0.04+0.32	E(level): others: 1662 3 (1973Yn01), 1656 8 (1971Ar12). L: tentatively assigned as (2) in 1973Yn01.
1661 2	4	0.68	
1687 3	4	0.79	$\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.17$ mb/sr (1973Yn01). E(level): others: 1689 3 (1973Yn01), 1679 10 (1971Ar12). (1/4)(2J+1)S: other: 0.5 (1973Yn01).
1720 3	1+3	0.03+0.06	E(level): L=1 in (d,t) for E=1734 indicates a doublet. $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.45$ mb/sr (1973Yn01). E(level): others: 1735 3 (1973Yn01), 1730 6 (1971Ar12). (1/4)(2J+1)S: other: 0.11 (1973Yn01).
1734 3	2	0.15	
1796 3	1+3	0.01+0.02	E(level): L=1 in (d,t) for E=1822 indicates a doublet. $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.15$ mb/sr (1973Yn01). E(level): other: 1824 3 (1973Yn01). L,(1/4)(2J+1)S: other: L=2, 1/4(2J+1)S=0.03 (1973Yn01).
1807 4			
1822 2	2+4	0.04+0.17	
1864 3			E(level): other: 1917 3 (1973Yn01).
1877 3			
1914 2	0	0.08	
1931 4			
1968 3			
1982 4			$\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.5$ mb/sr (1973Yn01). E(level): other: 2019 3 (1973Yn01). (1/4)(2J+1)S: other: 0.12 (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.27$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.36$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.16$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.59$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.32$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.68$ mb/sr (1973Yn01). $\text{d}\sigma/\text{d}\Omega_{\text{max}}=0.5$ mb/sr (1973Yn01).
2015 2	2	0.21	
2100 [#] 3	1 [#]	0.06 [#]	
2148 [#] 3	2 [#]	0.08 [#]	
2234 [#] 3			
2300 [#] 3	1 [#]	0.03 [#]	
2446 [#] 3	2 [#]	0.14 [#]	
2524 [#] 3	2 [#]	0.07 [#]	
2574 [#] 3	2 [#]	0.15 [#]	
2650 [#] 3	2 [#]	0.11 [#]	

[†] From 1975Do02, except where noted.[‡] From DWBA analysis of $\sigma(\theta)$ in 1975Do02, except where noted.[§] From 1975Do02, except where noted. Defined as $(\text{d}\sigma/\text{d}\Omega)_{\text{exp}}=(1/4)(2J+1)S(\text{d}\sigma/\text{d}\Omega)_{\text{DWBA}}$.[#] From 1973Yn01. **$^{69}\text{Ga}(\text{d},\text{p}\gamma)$ 1971Ar12,1976Ta09**1971Ar12: E(d)=7 MeV. Measured $\text{E}\gamma$, p- γ coincidences using coaxial Ge detector and surface-barrier detector.1976Ta09: E(d)=5 MeV. Measured $\gamma(\theta,\text{H},\text{t})$ using Ge(Li) detector. ^{70}Ga Levels

E(level)	J π [†]	Comments
0.0	1+	
508.4 5	2+	
651.2 5	1+, 2+	
691.2 5	2-	
878.7 10	4-	$g=-0.066$ 25. g: from TDPAD in 1976Ta09.

[†] From the Adopted Levels.

$^{69}\text{Ga}(\text{d},\text{p}\gamma)$ $^{1971}\text{Ar}12,^{1976}\text{Ta}09$ (continued) $\gamma(^{70}\text{Ga})$

$E\gamma^\dagger$	E(level)	$E\gamma^\dagger$	E(level)	$E\gamma^\dagger$	E(level)
$^{\times}154.6\ 5$		$^{\times}202.9\ 5$		$^{\times}342.9\ 6$	
$^{\times}159.1\ 5$		$^{\times}212.3\ 6$		508.4 3	508.4
187.5 2	878.7	$^{\times}278.1\ 6$		651.2 $^{\ddagger} 2$	651.2
$^{\times}199.2\ 5$		$^{\times}317.9\ 6$		691.2 2	691.2

† From 1971Ar12. All γ rays were observed in coincidence with protons.

‡ Placement of transition in the level scheme is uncertain.

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

 $^{70}\text{Zn}(\text{p},\text{n})$ $^{1970}\text{Ta}01$

E(p)=2.74–5.26 MeV. Measured E(level) using time-of-flight spectrometer system (FWHM=10 keV) with neutrons detected after 7.9- and 9.2-m flight paths at reaction angles of 49° and 131°, respectively.

Other: 1970Fi03, E(p)=3.96 and 4.50 MeV. Measured E(level) using time-of-flight spectrometer. Levels observed by 1970Fi03 are in excellent agreement with those from 1970Ta01.

 ^{70}Ga Levels

E(level)	E(level)	E(level)
0.0	1556 4	2166 4
509 3	1598 5	2192 4
651 3	1620 4	2216 4
692 3	1633 4	2233 4
877 3	1661 4	2259 5
902 3	1694 4	2322 5
995 3	1726 4	2350 5
1012 3	1738 4	2374 5
1024 3	1795 4	2389 5
1101 4	1809 4	2411 5
1138 3	1827 4	2435 5
1203 3	1870 4	2469 5
1245 3	1912 4	2484 5
1260 3	1936 4	2525 5
1310 † 3	1971 3	2550 5
1335 † 3	1984 4	2574 5
1360 † 3	2019 4	2622 5
1414 3	2029 4	2654 5
1446 3	2078 4	2682 5
1457 3	2093 4	2702 5
1503 4	2116 4	2726 5
1518 4	2128 4	
1535 4	2143 4	

† Inadvertently omitted from 1970Ta01 (private communication to 1972Al56).

$^{70}\text{Zn}(\text{p},\text{n}\gamma)$ 1984Fe03,1973Na17

1984Fe03: E(p)=3, 3.5 and 4 MeV. Measured $E\gamma$, $I\gamma$ using two Ge(Li) detectors and E(ce), Ice using a superconducting-magnet transporter with Si(Li) detector and mini-orange Si(Li) electron spectrometers.
 1975Hu06: E(p)=2.85, 3.4 MeV. Measured $E\gamma$, $\gamma(\theta, t)$ using coaxial Ge(Li) detector; deduced $T_{1/2}$ of 879-keV level.
 1974Ca14: E(p)=3.0 MeV. Measured $E\gamma$, $I\gamma$ with Ge(Li) detector; $T_{1/2}$ using Doppler Shift Attenuation Method (DSAM).
 1973Na17: E(p)=1.7–3.2 MeV. Measured $E\gamma$, $I\gamma$, $\gamma(\theta)$ using Ge(Li) detector.
 1971Ar12: E(p)=1.4–4.0 MeV. Measured $E\gamma$, $\gamma\gamma$ -coin, $p\gamma$ -coin using Ge(Li) detector.
 Others: 1966Re05, 1970Sa22, 1971Mi24, 1973Ca31, 1973KrZT, 1976KrZO.
 The level scheme and spin assignments are based mainly on 1984Fe03 and 1973Na17.

 ^{70}Ga Levels

Results from $\gamma(\theta)$ analysis provided in the comments are from 1973Na17, except where noted.

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}^{\S}$	Comments
0.0	1+		
508.1 1	2+		$J\pi$: $\gamma(\theta)$ gives J=2.
651.1 1	1+, 2+		$J\pi$: $\gamma(\theta)$ consistent with J=1 or J=2.
690.9 1	2-		$J\pi$: $\gamma(\theta)$ consistent with J=1 or J=2.
878.6 2	4-	22.7 ns 5	$T_{1/2}$: from $\gamma\gamma(t)$ in 1975Hu06. $J\pi$: $\gamma(\theta)$ consistent with J=4 (1975Hu06).
901.3 1	1+, 2+, 3+		$J\pi$: $\gamma(\theta)$ consistent with J=1–4.
995.4 1	2+		$J\pi$: $\gamma(\theta)$ gives J=2.
1002.6 10			
1009.2 10			
1009.5 2	1+, 2+, 3+		$J\pi$: $\gamma(\theta)$ consistent with J=1,2,3.
1014.9 1	1+, 2+, 3+		$J\pi$: $\gamma(\theta)$ consistent with J=1,2,3.
1023.9 1	2+, 3+		$J\pi$: $\gamma(\theta)$ consistent with J=2,3.
1033.5 2	(5)-		
1101.5 2	2-, 3-, 4-		$J\pi$: $\gamma(\theta)$ consistent with J=1–4.
1135.4 1	1, 2		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1140.4 1	1, 2		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1203.8 2	2+	>220 fs	$J\pi$: $\gamma(\theta)$ gives J=2.
1236.1	(6)-		
1244.5	2	>500 fs	$J\pi$: $\gamma(\theta)$ gives J=2.
1253.1 2	3-, 4-		$J\pi$: $\gamma(\theta)$ consistent with J=1–4.
1258.7 2	1+ to 4+		
1305.8 2			$J\pi$: $\gamma(\theta)$ consistent with J=1–4.
1307.0 4			
1312.1 3	1+, 2+	170 fs +50–25	$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1336.6 2	2-		$J\pi$: $\gamma(\theta)$ gives J=2.
1359.4 2	2+		$J\pi$: $\gamma(\theta)$ gives J=2.
1413.0 3			
1445.9 2	1+, 2+	0.27 ps +56–9	$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1456.4 2	1+, 2+		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1501.2 5	1+, 2+		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1518.3 3	1+, 2+		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1533.5 1	2+		$J\pi$: $\gamma(\theta)$ consistent with J=2,3.
1553.9 6	2+		$J\pi$: $\gamma(\theta)$ gives J=2.
1621.0 5	1-, 2-		$J\pi$: $\gamma(\theta)$ consistent with J=1,2.
1633.5 2	1, 2, 3		$J\pi$: $\gamma(\theta)$ consistent with J=1,2,3.
1725.4 10			
1793.9 10	1+, 2+, 3+		
1807.4 10			
1823.2 15			
1865.0			
1904.9 10			
1930.8 7			
2118 2			
2143 2			
2190 2			
2214 2			
2231 2			
2320 2			
2350 2			
2411 2			

[†] From a least-squares fit to $E\gamma$, by evaluators.

$^{70}\text{Zn}(\text{p},\text{n}\gamma)$ 1984Fe03,1973Na17 (continued) ^{70}Ga Levels (continued)

[‡] From the Adopted Levels. Cases where supporting evidence for $J\pi$ assignments originates from this dataset are indicated in the comments.

[§] From Doppler Shift Attenuation Method measurements in 1974Ca14, except where noted.

 $\gamma(^{70}\text{Ga})$

$\alpha(\text{K})_{\text{exp}}$ normalized to Hager-Seltzer value of 5.86×10^{-2} for the 187.6 γ assumed to be E2; estimated uncertainty in data 10–36% (1984Fe03).

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\ddagger}$	Mult.#	$\delta^{\oplus}$	α	$I\gamma^{\S}$	Comments
	^x 114.1 ^a 10						
	^x 118.3 ^a 10						
	^x 138.9 ^a 10						
	^x 198.8 ^b 10						
	^x 240.0 ^b 10						
	^x 328.2 ^b 8						
	^x 417.9 ^b 8						
	^x 481.7 ^b 10						
	^x 552.2 ^b 8						
	^x 584.3 ^b 6						
	^x 598.1 ^a 10						
	^x 655.8 ^b 5						
	^x 803.3 ^b 10						
	^x 872.3 ^b 4						
	^x 927.6 ^b 10						
	^x 944.3 ^b 10						
	^x 961.9 ^b 10						
	^x 975.2 ^b 10						
	^x 1000.1 ^a 10						
	^x 1030 ^b 1						
	^x 1036 ^b 1						
	^x 1064.4 ^b 10						
	^x 1107.6 ^b 8						
	^x 1121.9 ^b 8						
	^x 1173.2 ^a 10						
	^x 1180.7 ^b 10						
	^x 1211.7 ^a 10						
	^x 1222.2 ^b 8						
	^x 1227.4 ^a 10						
	^x 1230.5 ^b 10						
	^x 1236.1 ^b 10						
	^x 1273.3 ^b 10						
	^x 1275.1 ^b 10						
	^x 1285.5 ^a 10						
	^x 1368.4 ^b 5						
	^x 1396.2 ^a 10						
	^x 1462.1 ^b 8						
	^x 1629.5 ^b 10						
	^x 1763.1 ^a 15						
508.1	508.1 1	100	M1		0.00121	109 7	$\alpha(\text{K})_{\text{exp}}=9.7 \times 10^{-4}$ 12 (1984Fe03). Mult.: $A_2=-0.27$ 5, $A_4=+0.05$ 5 (1973Na17). δ : 0.00 +10-7 from $\gamma(0)$ in 1973Na17.
651.1	651.2 1	100				37 3	Mult.: $A_2=-0.20$ 5, $A_4=+0.05$ 5 (1973Na17). δ : -0.09 or +2.6 +6-2 if 651-keV level has J=2, from $\gamma(0)$ in 1973Na17.
690.9	690.8 1	100	E1			100 10	$\alpha(\text{K})_{\text{exp}}=2.8 \times 10^{-4}$ 10 (1984Fe03). Mult.: $A_2=-0.31$ 8, $A_4=+0.13$ 8 (1973Na17), $A_2=-0.30$ 2, $A_4=+0.05$ (1975Hu06). δ : -0.07 +10-12 from $\gamma(0)$ in 1973Na17, 0.00 6 or 2.7 5 (1975Hu06).
878.6	187.6 3	100	E2			30 5	$\alpha(\text{K})$ exp normalized to Hager Seltzer value for pure E2, $\alpha(\text{K})=0.0586$ (1984Fe03). Mult.: $A_2=+0.17$ 10, $A_4=+0.08$ 9 (1973Na17). δ : $\delta(\text{O/Q})=0.00$ +9-14 from $\gamma(0)$ in 1973Na17.

Continued on next page (footnotes at end of table)

$^{70}\text{Zn}(\text{p},\text{n}\gamma)$ 1984Fe03,1973Na17 (continued) $\gamma(^{70}\text{Ga})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\ddagger}$	Mult.#	$\delta^{\oplus}$	$I\gamma^{\S}$	Comments
901.3	393.1 1	100 9	M1+E2	<0.7	14.1 13	$\alpha(\text{K})\text{exp}=2.2\times 10^{-3}$ 4 (1984Fe03). Mult.: $A_2=+0.20$ 5, $A_4=-0.02$ 5 (1973Na17). δ : from $\alpha(\text{K})\text{exp}$.
995.4	902.5 ^{b c} 10 344.5 2	<15 50 13	M1		1.1 1	$\alpha(\text{K})\text{exp}=2.6\times 10^{-3}$ 8 (1984Fe03). Mult.: $A_2=-0.27$ 9, $A_4=+0.14$ 9 (1973Na17). δ : +0.1 2 from $\gamma(\theta)$ in 1973Na17.
	487.2 1 995.9 3	100 9 66 11			<7.6 4.4 7	Mult.: $A_2=-0.35$ 3, $A_4=+0.07$ 3 (1973Na17). δ : 0.34 9 or 1.2 2 from $\gamma(\theta)$ in 1973Na17.
1002.6	1002.8 10	100			<1	
1009.2	1009.2 ^b 10	100			4.8 13	$I\gamma$: summed intensity for 1009.2 and 1010.3 doublet.
1009.5	318.5 2	100	D+Q		<19.8	$\alpha(\text{K})\text{exp}=3.8\times 10^{-3}$ 10 (1984Fe03). Mult.: $A_2=-0.10$ 3, $A_4=-0.06$ 3 (1973Na17). Mult.: M1 or E1+M2 from $\alpha(\text{K})\text{exp}$ (1984Fe03). Decay scheme requires E1+M2.
	1010.3 ^b 10	24			4.8 13	$I\gamma$: summed intensity for 1009.2 and 1010.3 doublet.
1014.9	363.8 1	45	M1		4.0 2	$\alpha(\text{K})\text{exp}=2.2\times 10^{-3}$ 5 (1984Fe03). Mult.: $A_2=-0.05$ 3, $A_4=+0.03$ 3 (1973Na17).
	1014.4 ^{b c} 6	100			<8.8	
1023.9	515.7 1 1023.3 5	100 6 10 6			6.2 13 0.6 2	Mult.: $A_2=-0.22$ 3, $A_4=-0.02$ 3 (1973Na17).
1033.5	154.9 1	100	D		7.7 4	$\alpha(\text{K})\text{exp}=1.4\times 10^{-2}$ 5 (1984Fe03).
1101.5	410.6 2	100			3.5 2	Mult.: $A_2=+0.21$ 16, $A_4=-0.11$ 15 (1973Na17).
1135.4	444.3 4 1135.4 1	12 5 100 5			2.6 2 17.3 28	Mult.: $A_2=-0.03$ 8, $A_4=-0.16$ 9 (1973Na17). Mult.: $A_2=+0.08$ 1, $A_4=-0.03$ 2 (1973Na17).
1140.4	632.3 2 1140.4 1	49 5 100 5			4.5 4 11.8 20	Mult.: $A_2=+0.06$ 8, $A_4=-0.06$ 7 (1973Na17). Mult.: $A_2=-0.03$ 2, $A_4=+0.01$ 2 (1973Na17).
1203.8	1203.8 2	100	D+Q	-0.10 7	<8.2	Mult.: $A_2=-0.36$ 4, $A_4=-0.16$ 4 (1973Na17).
1236.1	203.2 ^c 2	100			1.1 1	
1244.5	1244.6 1	100	D+Q	-0.05 4	10.7 20	Mult.: $A_2=-0.37$ 6, $A_4=-0.05$ 5 (1973Na17).
1253.1	374.5 1	100 6	M1		9.3 6	$\alpha(\text{K})\text{exp}=2.1\times 10^{-3}$ 5 (1984Fe03). Mult.: $A_2=-0.10$ 7, $A_4=-0.09$ 7 (1973Na17).
	561.7 4	12 6			3.1 3	
1258.7	234.8 1 608.5 ^{b c} 5	100	M1		2.2 3 <1.6	$\alpha(\text{K})\text{exp}=7.3\times 10^{-3}$ 17 (1984Fe03).
1305.8	426.8 2 798.6 3	72 7 100 7			3.4 3 5.1 6	Mult.: $A_2=-0.24$ 9, $A_4=-0.08$ 9 (1973Na17).
1307.0	1307.0 4	100			3.4 4	
1312.1	1312.1 3	100			11.7 13	Mult.: $A_2=-0.02$ 3, $A_4=0.00$ 3 (1973Na17).
1336.6	645.7 2 1337.0 10	100 4 9 4	D+Q D+Q	+1.8 3 +0.51 27	11.0 10 <0.8	Mult.: $A_2=+0.25$ 4, $A_4=+0.06$ 3 (1973Na17). Mult.: $A_2=+0.28$ 9, $A_4=-0.15$ 10 (1973Na17).
1359.4	708.6 ^{b c} 10 851.1 2	<10 100 13				
	1359.8 4	59 8	D+Q	-0.19 2 +0.20 8	4.5 6 4.0 5	Mult.: $A_2=+0.10$ 1, $A_4=-0.01$ 1 (1973Na17). Mult.: $A_2=+0.03$ 4, $A_4=-0.07$ 5 (1973Na17).
1413.0	904.9 3	100			1.5 3	
1445.9	755.0 2 794.6 10	9 2 2 2			4.5 4 1.0 3	
	1446.1 ^b 5	100 10				Mult.: $A_2=-0.01$ 2, $A_4=-0.02$ 2 (1973Na17).
1456.4	432.3 ^b 8 554.3 5 948.5 3	25 7 14 6			<1 <9.3 1.4 3	$E\gamma$: no placement given in Table 1 of 1973Na17, however, γ ray is placed in Figure 2.
	1456.6 ^b 8	100 7				Mult.: $A_2=-0.09$ 2, $A_4=-0.03$ 2 (1973Na17).
1501.2	1501.2 ^b 5	100				$A_2=+0.02$ 3, $A_4=-0.04$ 3 (1973Na17).
1518.3	867.0 3	37 5			1.1 4	$E\gamma$: no placement given in Table 1 of 1973Na17, however, γ ray is placed in Figure 2.
	1518.7 ^b 6	100 10				$A_2=+0.04$ 3, $A_4=-0.03$ 3 (1973Na17).
1533.5	393.1 ^b 1 882.8 ^b 10	72 11 40 9				
	1533.2 ^b 8	100 9	D+Q	+0.5 4		Mult.: $A_2=+0.34$ 5, $A_4=-0.12$ 6 (1973Na17).
1553.9	1045.3 ^b 8	100 10	D+Q		6.8 10	Mult.: $A_2=+0.17$ 3, $A_4=-0.01$ 3 (1973Na17). δ : =0.12 6 or +2.93 3 from $\gamma(\theta)$ in 1973Na17.

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$^{70}\text{Zn}(\text{p},\text{n}\gamma)$ 1984Fe03,1973Na17 (continued) **$\gamma(^{70}\text{Ga})$ (continued)**

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\ddagger}$	Mult.#	$\delta^{\@}$	$I\gamma^{\S}$	Comments
1553.9	1554.3 ^b 8	49 6	D+Q	+0.25 9		Mult.: $A_2=+0.00$ 7, $A_4=+0.10$ 7 (1973Na17).
1621.0	930.4 6	4 4			0.6 2	
	969.5 ^b 10	92 9				
	1620.5 ^b 8	100 10				Mult.: $A_2=+0.09$ 4, $A_4=-0.07$ 5 (1973Na17).
1633.5	982.2 ^b 10	57 7			2.7 5	
	1125.4 2	100 10			5.0 8	Mult.: $A_2=-0.09$ 4, $A_4=+0.01$ 4 (1973Na17).
	1633.1 ^b 10	28 6				Mult.: $A_2=-0.00$ 5, $A_4=-0.06$ 5 (1973Na17).
1725.4	1725.5 ^{&} 7	100				
1793.9	1794.2 ^{&} 7	100				
1807.4	1807.5 ^{&} 10	100				
1823.2	1823.2 ^{&} 15	100				
1865.0	1865.0 ^{&} 7	100				
1904.9	1904.8 ^{&} 10	100				
1930.8	1930.8 ^{&} 7	100				
2118	2118 ^a 2					
2143	2143 ^a 2					
2190	2190 ^a 2					
2214	2214 ^a 2					
2231	2231 ^a 2					
2320	2320 ^a 2					
2350	2350 ^a 2					
2411	2411 ^a 2					

[†] From 1984Fe03, except where noted.[‡] Relative photon branching from each level from 1973Na17.[§] From 1984Fe03, normalized to $I\gamma(691\gamma)=100$.

Based on internal conversion data of 1984Fe03, except where noted.

[@] From $\gamma(0)$ in 1973Na17, except where noted.[&] From 1970Sa22.^a From 1971Ar12.^b From 1973Na17.^c Placement of transition in the level scheme is uncertain.^x γ ray not placed in level scheme. **$^{71}\text{Ga}(\text{d},\text{t})$ 1975Do02,1973Yn01**Target: $J\pi=3/2^-$.1975Do02: E(d)=16 MeV. Measured $\sigma(\theta)$ for $\theta=15^\circ$ to 90° in 5° steps using Enge split-pole magnetic spectrograph and Ilford K-1 emulsions (FWHM=5-8 keV); DWBA analysis.1973Yn01: E(d)=22.6 MeV. Measured $\sigma(\theta)$ for $\theta=15^\circ$ to 53° in 3° steps using E-dE/dx telescope; DWBA analysis.1971Ar12: E(d)=12.1 MeV. Measured $\sigma(\theta)$ at 60° and 90° using single-gap, broad-range, magnetic spectrograph and photographic plates (FWHM=3-8 keV). **^{70}Ga Levels**

E(level) [†]	$L^{\ddagger}$	$C^2S^{\S}$	Comments
0.0	1+3	0.30+0.19	L,C ² S: other: L=1, C ² S=0.33 (1973Yn01).
507 1	1+3	0.50+0.46	E(level): others: 509 10 (1973Yn01), 505 5 (1971Ar12). L,C ² S: other: L=1, C ² S=0.5 (1973Yn01).
649 2	1+3	0.18+0.15	E(level): others: 663 10 (1973Yn01), 646 6 (1971Ar12). L,C ² S: other: L=1, C ² S=0.17 (1973Yn01).
686 10			E(level): from 1971Ar12, level observed only at 60° .
876 2	2+4	0.02+0.11	
899 2	3	1.38	E(level): others: 904 10 (1973Yn01), 897 5 (1971Ar12). L,C ² S: other: L=1, C ² S=1.5 (1973Yn01).
995 2	1+3	0.37+0.36	E(level): other: 991 5 (1971Ar12).
1010 2	1 [#]	0.10	C ² S: sum for doublet at 1010 keV and 1014 keV. E(level): others: 1018 10 (1973Yn01), 1019 5 (1971Ar12), likely both correspond to unresolved doublet.

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$^{71}\text{Ga}(\text{d},\text{t})$ 1975Do02,1973Yn01 (continued) **^{70}Ga Levels (continued)**

E(level) [†]	L [‡]	C ² S [§]	Comments
1014 2	1 [#]	0.10	C ² S: sum for doublet at 1010 keV and 1014 keV. E(level): others: 1018 10 (1973Yn01), 1019 5 (1971Ar12), likely both correspond to unresolved doublet.
1023 2	1+3	0.09+1.03	
1035 4	4	0.50	
1098 4			
1138 4			
1202 3	1	0.03	E(level): other: 1195 10 (1971Ar12).
1231 3	4	0.33	E(level): other: 1227 10 (1971Ar12).
1250 4	1	0.1	E(level): others: 1250 10 (1973Yn01), 1256 6 (1971Ar12). L,C ² S: from 1973Yn01.
1262 4	1	0.02	
1306 2	1 [#]	0.11	C ² S: sum for doublet at 1306 keV and 1313 keV. E(level): other: 1303 6 (1971Ar12).
1313 4	1 [#]	0.11	C ² S: sum for doublet at 1306 keV and 1313 keV. E(level): other: 1320 10 (1973Yn01). L,C ² S: L=1, C ² S=0.12 (1973Yn01).
1357 3	1	0.11	E(level): other: 1353 6 (1971Ar12).
1443 4	1	0.11	
1455 2	1	0.23	E(level): others: 1450 10 (1973Yn01), 1445 10 (1971Ar12). L,C ² S: other: L=1, C ² S=0.25 (1973Yn01).
1498 4	1	0.03	
1517 2	1+3	0.13+0.06	
1532 2	1+3	0.12+0.03	
1554 3	1	0.63	E(level): other: 1570 10 (1973Yn01). L,C ² S: other: L=1, C ² S=0.5 (1973Yn01).
1620 3	2+4	0.03+0.08	
1718 3	1	0.20	
1734 3	1	0.14	E(level): L=2 in (d,p) for E=1734 indicates a doublet.
1793 3	1	0.03	
1805 3			
1823 3	1	0.06	E(level): L=2 in (d,p) for E=1822 indicates a doublet.
1865 3			
1906 3	1	0.06	
1928 3	1	0.08	
1937 3	1	0.04	
1968 2	1	0.12	
2012 4			

[†] From 1975Do02, except where noted.[‡] From DWBA analysis of $\sigma(\theta)$ in 1975Do02, except where noted.[§] From 1975Do02, except where noted. Derived using $d\sigma/d\Omega_{\text{exp}}=3.33\text{C}^2\text{S}(d\sigma/d\Omega)_{\text{DWBA}}$.[#] From closely spaced doublet.

Adopted Levels, Gammas

Q(β⁻)=-6220 50; S(n)=11532.5 16; S(p)=8523.0 15; Q(α)=-4087.7 11 2012Wa38.
S(2n)=19725.7 21; S(2p)=15132.9 11 (2012Wa38).

⁷⁰Ge Levels

Cross Reference (XREF) Flags

A ⁷⁰Ga β⁻ Decay
B ⁷⁰As ε Decay
C ⁷⁰Zn 2β⁻ Decay
D ¹²C(⁶⁶Zn,⁸Beγ)
E ⁴⁶Ti(²⁸Si,4pγ)
F ⁶⁴Ni(¹²C,α2nγ)
G ⁶⁵Cu(⁷Li,2nγ),⁶⁰Ni(¹²C,2pγ)
H ⁶⁶Zn(⁶Li,d)
I ⁶⁸Zn(α,2nγ),⁶⁷Zn(α,nγ)

J ⁶⁹Ga(p,γ)
K ⁶⁹Ga(d,n)
L ⁶⁹Ga(α,t)
M ⁶⁹Ga(³He,d)
N Coulomb Excitation
O Others:
⁷⁰Ge(γ,γ')
⁷⁰Ge(pol γ,γ')
⁷⁰Ge(n,n'γ)

⁷⁰Ge(p,p'γ)
⁷⁰Ge(p,p'),(pol p,p')
⁷⁰Ge(d,d')
⁷⁰Ge(⁶Li,⁶Li')
⁷⁰Ge(α,α')
⁷⁰Ge(e,e')
⁷²Ge(p,t)
⁷⁴Se(d,⁶Li)

E(level) [†]	Jπ	XREF	T _{1/2}	Comments
0.0 ^a	0+	ABCDEFGHIJKLMNO	stable	R=4.055 fm 8; where R is the rms value of charge distribution from (e,e'). Q=+0.04 3 (2003Su01); μ=+0.91 5. T _{1/2} : from B(E2)=0.179 3 in Coulomb excitation. Others: 1.38 ps 8 from B(E2)=0.169 10 from (e,e'), 1.32 ps 14 from DSAM in ¹² C(⁶⁶ Zn, ⁸ Be), 1.3 ps 3 from DSAM in ⁶⁸ Zn(α,2nγ), ⁶⁷ Zn(α,nγ) and >5 ps in (⁷ Li,2nγ). Jπ: from 1039.49γ E2 to 0+. Q: from multiple Coulomb Excitation (2003Su01). μ: from weighted average of 0.88 8 (2013Gu23, from g-factor using TF), 0.90 16 (2007Bo41, from g-factor using TF), 0.86 24 (2006Le24, from g-factor using TF), 0.740 178 (1987La20, from g-factor using TF), 0.94 52 (1984Pa20, from g-factor using TF), 0.94 20 (1977Fa07, from g-factor using IMPAC). Others: 0.76 16 (1977Fa07), 1.18 58 (1969He11); the same data reanalyzed by 1974Hu01 gave μ=1.76 42; the same data reanalyzed by 1977Fa07 according to the latest understanding of the experiment and corrections μ = 0.94 20 (from g=0.47 10) (this value is included in the weighted average). T _{1/2} : from electron spectrometer measurement with pulsed-cyclotron beam in (p,p'γ). Others: 2.9 ns 4 from ⁷⁰ Ga β ⁻ decay; 4.8 ns 7 from B(E2) in Coulomb excitation. Jπ: L=0 from ⁷² Ge(p,t) and ⁶⁶ Zn(⁶ Li,d); E0 transition to g.s.. The level interpreted as deformed-intruder state (2003Su01). Q=-0.07 4 (2003Su01); μ=+1.3 7 (2013Gu23). Jπ: from 1708γ E2 transition to g.s. T _{1/2} : from DSAM in ¹² C(⁶⁶ Zn, ⁸ Be). Other: 1.1 ps +10-4 from (α,2nγ), (α,nγ), 4.2 ps +26-14 from Coulomb excitation and > 7 ps in ⁶⁵ Cu(⁷ Li, 2nγ), ⁶⁰ Ni(¹² C,2pγ). Q: from multiple Coulomb Excitation. μ: from g-factor measurements using TF in Coulomb excitation. Other: 0.8 12 from ¹² C(⁶⁶ Zn, ⁸ Be) using TF. Q=+0.22 5 (2003Su01); μ=+1.7 8. T _{1/2} : from DSAM in ¹² C(⁶⁶ Zn, ⁸ Be). Others: 4 ps 1 from DSAM in ⁶⁵ Cu(⁷ Li,2nγ), ⁶⁰ Ni(¹² C,2pγ) and 1.7 ps 4 from Coulomb excitation and 0.8 ps 2 from DSAM in ⁶⁸ Zn(α,2nγ), ⁶⁷ Zn(α,nγ). Jπ: from 1113.60γ E2 to 2+; assumed E2 cascade member. Q: from multiple Coulomb Excitation (2003Su01). μ: from g-factor measurements using TF in Coulomb excitation (2013Gu23,2007Bo41).
1039.506 ^a 9	2+	AB DEFG IJ LMNO	1.31 ps 2	
1215.621 ^d 15	0+	AB DE GHIJKLMNO	3.7 ns 2	
1707.689 ^b 14	2+	B DEFG IJ LMNO	1.94 ps 28	
2153.084 ^a 20	4+	B DEFG IJ L NO	0.76 ps 14	

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Adopted Levels, Gammas (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π	XREF	T _{1/2}	Comments
2156.744 ^d 21	2+	B D G J MNO		Q=+0.26 10 (2003Su01). J π : 941.10 γ E2 to 0+. Q: from multiple Coulomb Excitation.
2160				O
2307.0 5	0+	J LM O	≤ 40 ps	T _{1/2} : centroid-shift time measurement in (p,p' γ). J π : E0 transition to g.s.
2451.313 ^b 21	3+	B D FG IJ LM O	1.7 ps [§] +10-3	J π : from 743.62 γ M1(+E2) to 2+; J = 3 from angular distribution and yield function in (α ,2n γ).
2534.95 4	2+	B D IJ LM O	0.6 ps [§] 2	J π : L(p,t)=2; J π not consistent with observed log ft=7.8 from 4+.
2562.049 ^c 20	3-	B DE G I LMNO	0.50 ps 7	T _{1/2} : Other: >0.4 ps from DSAM in (n,n' γ). μ =0.3 9 (2007Bo41). T _{1/2} : weighted average of 0.55 ps 7 in $^{12}\text{C}(^{66}\text{Zn}, ^8\text{Be}\gamma)$ (from DSAM) and 0.4 ps 1 in $^{65}\text{Cu}(^7\text{Li}, 2\text{n}\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2\text{p}\gamma)$ (from DSAM). Others: 2.3 ps 5 from $^{65}\text{Cu}(^7\text{Li}, 2\text{n}\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2\text{p}\gamma)$. J π : L(p,t)=3. B(E3)=0.073 10 in $^{70}\text{Ge}(\text{e},\text{e}')$; 0.068 from Coulomb excitation. μ : from transient field method in Coulomb excitation (2007Bo04).
2806.25 ^b 3	4+	B DEFG IJ LM O	0.6 ps [§] 2	J π : L(p,t)=4; 1098.54 γ E2 to 2+. Discrepant with L(α,α')=3 for E=2800 keV 10 which may be a different level.
2887.4 7	0+			J π : from L(p,t)=0.
2945.0 10	2+	J LM O		J π : from L(p,t)=2.
3046.439 20	3+	B LM O		J π : from 889.72 γ D+Q to 2+; 893.59 γ D+Q to 4+, log ft=5.75 from 4+ parent.
3058.695 ^d 16	4+	B DE G I m O	1.4 ps [§] 3	T _{1/2} : other: 1.0 ps 5 from DSAM in $^{65}\text{Cu}(^7\text{Li}, 2\text{n}\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2\text{p}\gamma)$. J π : L(p,t)=4. J π : from excitation function in (p,p' γ).
3105.7 7	(0+)			O
3130 10				O
3180.6 10	2+		0.015 ps 6	J π : L(p,t)=2. T _{1/2} : from DSAM in (n,n' γ).
3194.2 6	4+			J π : L(p,t)=4; discrepant with L(α,α')=(5) for E=3200 keV 10. Also, L(p,p')=4.
3240.5 10	1+			J π : 1 from $\gamma(\theta)$ in (γ,γ') and $\pi=+$ from L=1 in ($^3\text{He},\text{d}$).
3294.79 8	3+, 4+	B e O		J π : from 1587 γ to 2+ and L(p,p') = 4.
3296.98 ^a 3	6+	eFG I O	0.5 ps [§] 1	T _{1/2} : others: 2.6 ps 6 from DSAM in $^{65}\text{Cu}(^7\text{Li}, 2\text{n}\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2\text{p}\gamma)$. J π : from 1143.89 γ E2 to 4+; band assignment.
3308				O
3314.5 7	1-			M O
3334.8 10	0+ to 3+			LM O
3345 2				O
3351 2				O
3371.57 10	(3, 4)	B O	0.3 ps 2	J π : log ft=7.7 1 from 4+ in ϵ decay; J=5 unlikely because of 2333 γ to 2+ level. T _{1/2} : from DSAM in (n,n' γ).
3416.32 ^c 4	5-	DE G I M O	13.7 ps [#] 10	J π : L(p,t)=5. T _{1/2} : Other: > 14 ps in $^{65}\text{Cu}(^7\text{Li}, 2\text{n}\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2\text{p}\gamma)$.
3423 2	(2+)			J π : from L(p,t)=(2).
3428 2	5-			O
3432 2	3-			M O
3456 2	4+			O
3466? 6				M
3482.3 5	1+, 2+, 3+			M O
3488.276 21	(3, 4+)	B O		J π : from L=1+3 in ($^3\text{He},\text{d}$). J π : log ft=6.0 1 from 4+ in ϵ decay; J=4- and 5 unlikely because of 2449 γ to 2+ level.
3517? 6				M

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Adopted Levels, Gammas (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π	XREF	T _{1/2}	Comments
3540?			O	
3562.7 6			M O	
3570.44 7	(3)−	B	M O	J π : from 2531.7 γ to 2+; 1471.24 γ to 4+; L=4(+2) in ($^3\text{He},d$).
3580.7 10	4+		O	J π : L(α,α')=4.
3590.3 5			M O	T _{1/2} : from DSAM in (n,n' γ).
3631.5 10	(2)+		LM O	J π : from L(p,t)=(2); $\pi=+$ from L($^3\text{He},d$)=1.
3637 10	0+		O	T _{1/2} : from DSAM in (n,n' γ).
3666.78 c 6	6−	E G I	M O	J π : L(α,α')=0.
			35 ps [#] 3	J π : J=6 from $\gamma(0)$ in $^{46}\text{Ti}(^{28}\text{Si},4p\gamma)$, π from 250 γ M1(+E2) to 5−.
				T _{1/2} : others: 40 ps 8 in $^{68}\text{Zn}(\alpha,2n\gamma)$, $^{67}\text{Zn}(\alpha,n\gamma)$ and 74 ps 6 in (HI,xn γ).
3669.4 b 10	(5+)	F I M	1 ps [§] 1	J π : 1218 γ to 3+; band assignment.
3675.76 7	4+	B	L O	J π : from L(α,α')=4.
3683 3	0+		O	J π : from L(p,t)=0.
3687 3	1+, 2+, 3+		M O	J π : L=1+3 in ($^3\text{He},d$).
3708.5 9			M O	
3733 3	1+, 2+, 3+		M	J π : L=1+3 in ($^3\text{He},d$).
3740 3	0+		O	J π : L(p,t)=0.
3753.2 b 4	6+	EFG I	O	J π : from stretched 946.7 γ E2 to 4+, L(p,p')=(6); band assignment.
			1.6 ps [§] 5	
3776 2	3−		O	J π : from L(α,α')=3.
3782 2	2+		M O	XREF: M(3775).
				J π : from L(p,t)=2.
3850 3			LM O	
3856 2	(2)−		O	J π : from L=4+2(+0) in ($^3\text{He},d$).
3870 2	3−		O	J π : from L(α,α')=3.
3890 3	1+, 2+, 3+		M O	J π : from L=1+3 in ($^3\text{He},d$).
3895.2 10	1		L O	J π : from 3895.1 γ D to 0+.
3900.6 7	(4−, 5, 6, 7−)	E		J π : from 234 γ to 6−, 484 γ to 5−.
3903.9 7	+		M O	J π : L=1+3 in ($^3\text{He},d$), L(p,p')=(0).
				E(level): from (p,p' γ).
3911 3			O	
3928 3	4+		O	J π : from L(p,t)=4.
3941? 10			O	
3955.11 c 8	7−	E G I	O	J π : J=7 from $\gamma(0)$ in ($\alpha,2n\gamma$), π from 288 γ M1+(E2) to 6−.
			17.0 ps [#] 10	
3964 3	(2)−		LM O	J π : from L=4+2(+0) in ($^3\text{He},d$).
3976 3	1+, 2+, 3+		O	J π : from L(α,α')=2.
3990 3			M O	
4003 2			O	
4024 3	4+		M O	J π : from L(p,t)=4.
4037 3	(4+)		O	J π : from L(α,α')=(4).
4053.3 10		E		
4054 3			M O	
4061 2	1+, 2+, 3+		O	J π : from L=1+3 in ($^3\text{He},d$).
4080 3	1+, 2+, 3+		M	J π : from L=1+3 in ($^3\text{He},d$).
4086 3	4+		O	J π : L(p,t)=4.
4096.1 20	3−		O	J π : from L(α,α')=3.
4101.45 5	3−, 4−	B	O	J π : from 688 γ to 5− and L(p,p')=3.
4103.5 [±] d 5	6+	G		J π : 1295 γ Q to 4+; band assignment in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ (2010Su05).
4119 3			M O	
4131 2	2−		M O	J π : from L=4+2+0 in ($^3\text{He},d$).
4144.7 20	1−		O	J π : from L(α,α')=1.
4155 2	1+, 2+, 3+		M O	J π : L=1+3 in ($^3\text{He},d$).
4166 3			O	
4180 3	2+		O	J π : L(p,t)=2.
4203.5 a 4	8+	EFG I	M O	J π : from 906.6 γ E2 to 6+; band assignment.
4212 3	3+, 4+, 5+		M O	J π : from L(p,p')=4.
4226 3	2+		O	J π : from L(p,t)=2.

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Adopted Levels, Gammas (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π	XREF	T _{1/2}	Comments
4238 3	1+, 2+, 3+			J π : from L=1+3 in (^3He ,d).
4243.11 15		B		
4261 10	2+			J π : from L(p,t)=2.
4268 10	5-			J π : from L(α , α')=5.
4282 10	3+, 4+, 5+			J π : from L(p,p')=4.
4287 3	1+, 2+, 3+			J π : from L(^3He ,d)=1+3.
4299.3 3	7-	E G I	3 ps [#] 1	J π : from L(α , α')=7.
4330 3				L=4+2(+0) in (^3He ,d); L(α , α')=(3+5), L(p,t)=0.
4352 3	(2)-			J π : from L=4+2(+0) in (^3He ,d).
4356.7 7	1(-)@			B(E1) $\uparrow$ =0.0023 4. B(E1) from ^{70}Ge (pol γ , γ').
4357 10	+			L(p,t)=2 at 4357 20; L(p,p')=4 at 4357 10.
4365 10	(3-)			J π : from L(α , α')=(3) for 4373 10.
4378 10				
4391 3	1+, 2+, 3+			J π : from L(^3He ,d)=1+3.
4409 10	4+			J π : from L(α , α')=4.
4419 3	2-, 3-, 4-			J π : from L(^3He ,d)=4+2.
4431.4 4	8+	EFG I	0.4 ps [§] 2	J π : from 1134.6 γ E2 to 6+ and yield function in $^{68}\text{Zn}(\alpha,2n\gamma)$.
4447.5 8	1-@			B(E1) $\uparrow$ =0.0036 7. B(E1) from ^{70}Ge (pol γ , γ').
4448 2	2+			J π : from L(p,t)=2.
4473 2	4+			J π : from L(p,t)=4. Other: L(α , α')=(3+5) is discrepant.
4520 3	2-, 3-, 4-			J π : from L(^3He ,d)=4+2.
4520.9 8	1-			B(E1) $\uparrow$ <0.0005. B(E1) from ^{70}Ge (pol γ , γ').
4534 10	(4+)			J π : from L(α , α')=(4).
4539 3	0+			J π : from L(p,t)=0.
4546 10				
4552.1 10	(8)	I	104 ps [#] +70-35	J π : from 253 γ to 7+ and 1253.2 γ to 6+.
4555 3				
4574 3				
4577.18 15	(3, 4+)	B		J π : log ft=6.4 from 4+ in ϵ decay; J=5 unlikely because of 2421 γ to 2+ level.
4606 10				
4613 3	1+, 2+, 3+			J π : from L(^3He ,d)=1+3.
4629 3	(4+)			J π : L(α , α')=(4).
4642 3	(2)-			J π : L(^3He ,d)=4+2(+0).
4657 10				E(level): multiplet.
4675.39 21	(3, 4+)	B		J π : log ft=6.2 2 from 4+ in ϵ decay; J=5 or 4- are unlikely because of 2968.1 γ to 2+ level.
4687 2	(2)-			J π : L=4+2(+0) in (^3He ,d).
4707 10				
4716 10	(2+)			J π : from L(p,t)=(2).
4727 10				
4736 3				
4768 3	(2)-			J π : L(^3He ,d)=4+2(+0).
4775 10	(4+)			J π : from L(α , α')=(4).
4790.6 19	1(-)@			
4810 10	3-			J π : from L(α , α')=3.
4820.2b 11	(8+)	F		J π : 1067 γ to 6+; band assignment.
4851.9 4	(8-)&	E G I	>3 ps [§]	J π : from (M1+E2) γ to 7-.
4877 3	2-			J π : L=4+2+0 in (^3He ,d).
4886.6 13	1@			
4905 3	3-			J π : from L(α , α')=3.
4908.1c 10	(9-)&	E		
4915 10				
4935 3	1-			J π : from L(p,t)=1.
4940 10	3-			J π : from L(α , α')=3.
4943 3	(2)-			J π : L(^3He ,d)=4+2(+0).
4979 3	(2)-			J π : L=4+2(+0) in (^3He ,d).
4985.0 10		I		
5008 3	2-			J π : from L=4+2+0 in (^3He ,d); L(α , α')=(3).

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Adopted Levels, Gammas (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π	XREF	T _{1/2}	Comments
5024 3	2+		O	J π : from L(p,t)=2.
5040 10	(3-)	I M O		J π : L(α,α')=(3).
5048.4 10	(4-)	I M		J π : from L($^3\text{He,d}$)=4+2+0; 1381.g γ to 2-.
5050 3	0+	L O		J π : from L(p,t)=0.
5078 3	1+, 2+, 3+	M O		J π : L=1+3 in ($^3\text{He,d}$).
5102 3	1+, 2+, 3+	M		J π : L=1+3 in ($^3\text{He,d}$).
5113 10	(3-)	O		J π : L(α,α')=(3).
5129.6 7	1-@	O		B(E1) $\uparrow$ =0.0029 8. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
5145 3	(3-)	M O		J π : L(α,α')=(3); discrepant with L($^3\text{He,d}$)=(4+2+0).
5184 3	0+	O		J π : L(p,t)=0.
5195 10	(4+)	O		J π : L(α,α')=(4).
5222.3 14		E		
5227 10	(3-)	O		J π : L(α,α')=(3).
5242.7 ^a 11	10+	EFG I		J π : from 1039.2 γ Q to 8+; band assignment.
5263.4 8	1(-)@	O		B(E1) $\uparrow$ =0.0022 4. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
5265.82 14		B		
5290 3	0+	O		J π : L(p,t)=0.
5299.2 4	9(-)	E G I		J π : from 1344.1 γ (E2) to 7-, 1273 γ from 11(-); inconsistent with (6,7,8) from $\gamma(0)$ in ($^7\text{Li},2n\gamma$).
5338 3	0+	O		J π : L(p,t)=0.
5370.11 5		B		
5403 3	0+	O		J π : L(p,t)=0.
5410 3		O		
5435.5 ^{‡d} 11	8+	G		J π : from 1332 γ Q to 6+; band assignment in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ (2010Su05).
5441 3	(2+)	O		J π : L(p,t)=(2).
5465.3 8	1-@	O		B(E1) $\uparrow$ =0.0023 4. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
5467 3	0+	O		J π : L(p,t)=0.
5512.5 10	1(-)@	O		B(E1) $\uparrow$ =0.0019 3. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
5539.7 5	(10)	FG I	5 ns 2	T _{1/2} : from electronic timing in $^{68}\text{Zn}(\alpha,2n\gamma)$, $^{67}\text{Zn}(\alpha,n\gamma)$. J π : T _{1/2} of this level suggests that the 1108 γ to 8+ may be M2, suggesting an assignment of J π =10-. However, level is assigned as side band member based on 8+ in $^{64}\text{Ni}(^{12}\text{C},\alpha 2n\gamma)$, suggesting an assignment of J π =10+. Other: 9+ in $^{65}\text{Cu}(^7\text{Li},2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C},2p\gamma)$.
5552.5 [‡] 5	9(-)	G		J π : 1253.2 γ Q to 7-.
5876.9 7	1(-)@	O		B(E1) $\uparrow$ =0.0014 4. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
5989.7 7	1(+)@	O		
6006.9 11		E		
6160.1 ^c 14	(11-)@	E		
6297.0 14	1@	O		
6362.8 8	1@	O		
6549.1 14		E		
6572.2 11	11(-)	G		J π : from 1273 γ Q to 9(-).
6587.7 8	1(+)@	O		
6604.2 11		E		
6636.6 15	1@	O		
6702.5 13	1(-)@	O		B(E1) $\uparrow$ =0.0027 5. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
6716.8 ^a 15	12+	FG		J π : Q 1474 γ to 10+; band assignment.
6779.7 11	(12)	F		
6786.1 ^c 17	(13-)@	E		
7306.3 8	1(+)@	O		
7426.0 8	1(-)@	O		B(E1) $\uparrow$ =0.0022 4. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
7619.7 15	(14)	F		J π : Q 840 γ to (12).

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Adopted Levels, Gammas (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π	XREF	Comments
7753.5 10	1(-)@	O	B(E1) $\uparrow$ =0.0026 6. B(E1) from $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.
7767.8 ^a 18	14+	F	J π : Q 1051 γ to 12+, band assignment.
8058.1 ^c 20	(15-)&	E	
8245.7 18	(16)	F	J π : Q 626 γ to (14).
8283.7 15	1(+)@	O	
8878.5 14	1@	O	
9423.7 21	(18)	F	J π : Q 1178 γ to (16).
9619.2 ^c 22	(17-)&	E	
10269.7 23	(20)	F	J π : 846 γ to (18).
11336.2 ^c 25	(19-)&	E	
13173 ^c 3	(21-)&	E	

[†] From a least-squares fit for levels connected by γ 's and from reaction data sets for others.[‡] This level was only reported in 2010Su05 in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.[§] From DSAM in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$.[#] From RDM in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ (1982C102).@ From mult in (pol γ, γ').& From ($^{28}\text{Si}, 4p\gamma$) based on DCO, and level cascades.^a (A): Sequence based on g.s.^b (B): Sequence based on 2+, 1707.7 keV level.^c (C): Sequence based on 3-, 2562.05 keV level.^d (D): Sequence based on 0+, 1215.62 keV level. $\gamma(^{70}\text{Ge})$

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult.	δ	α	I(γ +ce)	Comments
1039.506	1039.513 10	100	E2 ^d		3.23×10^{-4}		B(E2)(W.u.)=20.8 4. E γ : from ^{70}Ga β^- decay.
1215.621	176.115 13	100 9	E2 ^f		0.0894		B(E2)(W.u.)=48 7. E γ : from ^{70}Ga β^- decay.
	1215.8 ^b		E0 ^f			1.00 4	I(γ +ce): for 100 transitions of 176 γ from (p,p' γ) (1985Pa15).
1707.689	492.09 5	4.9 4	E2		0.00247		B(E2)(W.u.)=16 3. Mult.: from RUL and decay pattern.
	668.21 4	100 6	M1+E2	-3.6 +11-6	9.80×10^{-4} 2		B(E2)(W.u.)=64 11; B(M1)(W.u.)=0.0015 9. Mult., δ : from RUL, δ and decay pattern. δ as evaluated by 1977Kr17.
	1707.61 2	79.2 23	E2		2.87×10^{-4}		B(E2)(W.u.)=0.50 8. Mult.: from angular distribution in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL.
2153.084	445.6 10	0.7 4	[E2]		0.00338 6		B(E2)(W.u.)=17 10.
	1113.60 4	100 6	E2		2.77×10^{-4}		B(E2)(W.u.)=25 5. Mult.: from $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. δ = -0.1 2 in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives a large B(M3) which is excluded by RUL.
2156.744	450.4 5	4.7 24	E2		0.00327		Mult.: from (p,p' γ). Other: D from $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
	941.10 4	62 3	E2		4.09×10^{-4}		Mult.: from (p,p' γ).
	1117.28 4	100 6	E2		2.75×10^{-4}		Mult.: from (p,p' γ).
	2156.65 6	17.1 9	[E2]		4.60×10^{-4}		

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult.	δ	α	I(γ +ce)	Comments
2307.0	599.1 ^b 1091.3 ^b	82 [#] 7	E2 ^b E0 ^f		1.36 $\times 10^{-3}$	0.013 2	B(E2)(W.u.)>4.8. I(γ +ce): for 100 transitions of 1268 γ from (p,p' γ) (1985Pa15).
	1267.5 ^b 2307.1 ^b	100 [#] 7	E2 ^b E0 ^f		2.28 $\times 10^{-4}$	0.040 9	B(E2)(W.u.)>0.14. I(γ +ce): for 100 transitions of 1268 γ from (p,p' γ) and includes pair production (1985Pa15).
2451.313	294.60 16 297.88 8 743.62 4	0.37 15 2.4 4 100 7	M1 (+E2)	+0.04 8	5.78 $\times 10^{-4}$ 9		B(E2)(W.u.)<0.5; B(M1)(W.u.)=0.022 +14-5. Mult., δ : D+Q from ⁶⁵ Cu(⁷ Li,2n γ), ⁶⁰ Ni(¹² C,2p γ), M1+(E2) from RUL. Other: δ =+3.5 9 from $\gamma(\theta)$ in (n,n' γ).
	1411.86 4	39.3 23	M1+E2	-2.2 +5-3	2.18 $\times 10^{-4}$ 4		B(E2)(W.u.)=0.79 +48-17; B(M1)(W.u.)=0.00022 +15-10. Mult.: D+Q from $\gamma(\theta)$ in (n,n' γ); M1+E2 from RUL. δ : from $\gamma(\theta)$ in (n,n' γ).
2534.95	827.24 10 1319.6	32 4 9.5 10					I γ : from (n,n' γ); I γ (827)/I γ (1495)=76 10/100 10, in (n,n' γ) which ratio is different from the adopted I γ from ⁷⁰ As ϵ decay.
	1495.43 5	100 8	M1+E2	-0.75	2.15 $\times 10^{-4}$		B(E2)(W.u.)=1.9 7; B(M1)(W.u.)=0.0050 18. Mult., δ : D+Q from $\gamma(\theta)$ in (n,n' γ); M1+E2 from RUL.
2562.049	1522.55 2	100	E1+M2 ^d	-0.11 ^d 10	3.42 $\times 10^{-4}$		B(E1)(W.u.)=0.00022 4. δ : other: -0.11 4 from $\gamma(\theta)$ in (n,n' γ); 0.02 5 from ⁶⁵ Cu(⁷ Li,2n γ).
2806.25	653.15 6	11.8 14	(M1)		7.66 $\times 10^{-4}$		B(M1)(W.u.)=0.014 5. Mult.: D from ⁶⁵ Cu(⁷ Li,2p γ), ⁶⁰ Ni(¹² C,2p γ) based on ΔJ = 0 dipole transition; $\Delta\pi$ =no from level scheme.
	1098.54 4	100 6	E2		2.84 $\times 10^{-4}$		B(E2)(W.u.)=31 11. Mult.: from ⁶⁸ Zn(α ,2n γ), ⁶⁷ Zn(α ,n γ) and RUL; δ =-0.2 2 in ⁶⁸ Zn(α ,2n γ), ⁶⁷ Zn(α ,n γ) gives a large B(M3) which is excluded by RUL.
2887.4	730.8 [‡] 1179.5 [‡]	100 [‡] 10 100 [‡] 15					
2945.0	1237.3 ^b	100 ^b					
3046.439	239.90 10 595.11 4 889.72 4 893.50 4 1338.76 4 2006.87 3	1.1 3 100 6 14.0 9 10.0 5 48 3 14.8 5	[M1+E2] M1+E2 ⁱ M1+E2 ⁱ M1+E2 ⁱ M1+E2 ⁱ				
3058.695	252.46 4	16.3 10	[M1+E2]				

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult.	δ	α	Comments
3058.695	496.74 4	15.3 10	[E1]		7.15×10^{-4}	B(E1)(W.u.)=0.00015 4. Mult.: D from $\gamma(\theta)$ in $^{65}\text{Cu}(^7\text{Li}, 2p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
	607.34 4	26.2 15	M1+(E2) i			
	901.95 5	5.9 4	[E2]		4.54×10^{-4}	B(E2)(W.u.)=1.00 23.
	905.61 2	67 4	[M1+E2]			
	1350.90 6	2.8 3	[E2]		2.21×10^{-4}	B(E2)(W.u.)=0.063 16.
	2019.16 2	100.0 25	E2		4.02×10^{-4}	B(E2)(W.u.)=0.30 7. Mult.: from $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. M3 is ruled out because $\delta=+0.2$ 2 from $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives a large B(M3).
3105.7	1397.9 $\frac{1}{2}$	33 $\frac{1}{2}$ 10				
	2066.3 $\frac{1}{2}$	100 $\frac{1}{2}$ 7				
3180.6	2141.1 $\frac{1}{2}$	100				
3240.5	3240.4	100	M1		8.29×10^{-4}	E γ : from (γ, γ') . Mult.: D from $\gamma(\theta)$ in (γ, γ') , $\Delta\pi=\text{yes}$ from level scheme.
3294.79	760.2 5	80 40				
	1587.17 12	100 13				
	2255.16 11	44 6				
3296.98	490 ^h	0.80 ^h 20	[E2]			
	1143.89@ 2	100 ^h	E2		2.62×10^{-4}	B(E2)(W.u.)=34 7. Mult.: From angular distribution in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. $\delta =$ 0.0 2 from $\gamma(\theta)$.
3314.5	2274.6 $\frac{1}{2}$					
	3314.8		E1		1.41×10^{-3}	E γ : from (γ, γ') . Mult.: D from $\gamma(\theta)$ in (γ, γ') , $\Delta\pi=\text{yes}$ from level scheme.
3334.8	2295.3 $\frac{1}{2}$	100				
3371.57	1218.57 11	100 21				
	2331.59 24	26 6				
3416.32	357.72 5	59 4	E1 ^d		1.68×10^{-3}	B(E1)(W.u.)=0.000146 16. Mult.: From $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. $\delta = -0.06$ 3 in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives a large B(M2). δ : Other: 0.00 4 in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
	854.6 4	97 6	E2		5.20×10^{-4}	B(E2)(W.u.)=2.00 21. Mult.: From $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. $\delta = 0.02$ 5 in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives a large B(M3).
	1263.09@ 6	100 6	E1(+M2) ^d	-0.05 ^d 5	1.90×10^{-4} 4	B(E1)(W.u.)=5.5 $\times 10^{-6}$ 6; B(M2)(W.u.)=0.040 4.
3488.276	953.30 7	11.3 11				
	1036.99 4	64 5				
	1331.58 7	10.0 9				
	1335.28 10	8.1 9				
	1780.52 2	100.0 22				
	2448.82 9	7.7 5				
3570.44	1417.24 7	100 10				
	2531.7 2	6.0 20				
3580.7	1427.6 $\frac{1}{2}$	100				
3631.5	2591.9 $\frac{1}{2}$	100				
3666.78	250.46@ 5	100	M1(+E2) ^d	0.03 ^d +2-5	0.00727	B(E2)(W.u.)=0.85 7; B(M1)(W.u.)=0.040 3. δ : Other: +0.05 2 in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
3669.4	1218.1@	100				
3675.76	1523.2 7	100 19				
	2636.20 7	43.6 19				

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult.	δ	α	Comments
3753.2	946.7 ^s 4	100 ^s	E2		4.03×10^{-4}	B(E2)(W.u.)=27 9. Mult.: Q from $\gamma(0)$ in $(\alpha, 2n\gamma)$, M2 excluded by comparison to RUL.
3895.2	3895.1	100	D		1.07×10^{-3}	$E\gamma$: from (γ, γ') . Mult.: from $\gamma(0)$ in (γ, γ') .
3900.6	234					$E\gamma$: From $^{46}\text{Ti}(^{28}\text{Si}, 4p\gamma)$.
	484					$E\gamma$: From $^{46}\text{Ti}(^{28}\text{Si}, 4p\gamma)$.
3955.11	288.33 [@] 5	100 [@] 10	M1 (+E2) ^d	0.01 ^d 3	0.00512	B(E2)(W.u.)=0.081 12; B(M1)(W.u.)=0.045 7.
	658.1 [@] 4	19 [@] 4	E1 (+M2)	+0.02 5	3.67×10^{-4} 10	B(E1)(W.u.)= 1.3×10^{-5} 3; B(M2)(W.u.)=0.056 13. Mult., δ : D+Q from $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $\Delta\pi$ = yes from level scheme.
4053.3	1247 ^s	100 ^s				
4101.45	688 [#]					
	1045 [#]					
	1295.24 6	100 11	Q			Mult.: Q from $\gamma(0)$ in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
	1539.29 20	31 9				
	1944.21 16	25 4				
	1948.35 11	59 5				
4103.5	688 ^c	7.3 ^c 6				
	1045 ^c	100 ^c 9				
	1295 ^c	14.8 ^c 13	Q			Mult.: from angular distribution of oriented nuclei (ADO) radios in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ (2010Su05).
	1948 ^c	5.5 ^c 6				$E\gamma$: 1948 γ populates 2+ state according to level scheme given in 2010Su05. Placement of 1948 γ is questionable due to ΔJ .
4203.5	450 ^h	2.9 ^h 6	[E2]			
	906.6 [#] 4	100 ^h 10	E2		4.48×10^{-4}	B(E2)(W.u.)=6.7 17. Mult.: from angular distribution and linear-polarization data in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. $\delta=-0.2$ 2 is $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives a large B(M3) value, M3 is not possible because of RUL.
4243.11	1196.66 15	100				
4299.3	344.1 [@] 4	73 [@] 15	M1 (+E2)	0.1 3	0.0034 6	B(E2)(W.u.)=10 4; B(M1)(W.u.)=0.08 3. Mult., δ : D+Q from angular distribution data in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $\Delta\pi$ = no from level scheme.
	1002.4 [@] 4	100 [@] 20	E1+M2	0.11 2	1.59×10^{-4} 4	B(E1)(W.u.)= 8×10^{-5} 4. Mult., δ : D+Q from angular distribution data in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $\Delta\pi$ = yes from level scheme.
4356.7	4356.6 ^a 7	100	E1 ^a		0.00182	
4431.4	677	3.4 10	[E2]			
	1134.6 [#] 4	100 9	E2		2.66×10^{-4}	B(E2)(W.u.)=44 22. Mult.: from angular distribution in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL. $\delta=-0.1$ 2 in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ gives large B(M3). RUL rules out M3.
4447.5	4447.3 ^a 8	100	E1 ^a		0.00185	
4520.9	4520.7 ^a 8	100	E1 ^a		0.00188	
4552.1	252.8 [@]	100				
4577.18	2419.88 24	86 15				
	2424.41 20	100 15				
4675.39	2521.8 3	49 13				
	2968.1 3	100 15				
4790.6	4790.4 ^a 19	100	E1 ^a		0.00196	

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult.	δ	α	Comments
4820.2	1067 ^h	100				
4851.9	896.8 [@] 4	100	(M1+E2) ^e	0.4 ^e 2	3.98×10^{-4} 11	B(E2)(W.u.)<4.9; B(M1)(W.u.)<0.01. δ : Other: +1.1 3 in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$.
4886.6	4886.4 ^a 13	100	D ^a			
4908.1	953 [§]	100 [§]				
4985.0	1029.9 [@]	100				
5048.4	1381.6 [@]	100				
5129.6	5129.4 ^a 7	100	E1 ^a		0.00207	
5222.3	1169 [§]	100 [§]				
5242.7	1039.2 [@]	100	E2		3.23×10^{-4}	Mult.: Q from $\gamma(\theta)$ in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$, assumed E2 band member.
5263.4	5263.2 ^a 8	100	E1 ^a		0.00211	
5265.82	2219.34 14	100				
5299.2	1344.1 [#] 4	100	(E2)			Mult.: from $\gamma(\theta)$ in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$.
5370.11	1881.67 5	100 6				
	2325.42 18	21 2				
5435.5	1332 ^c	100 ^c	Q			Mult.: from angular distribution of oriented nuclei (ADO) ratios in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ (2010Su05).
5465.3	5465.1 ^a 8	100	E1 ^a		0.00216	
5512.5	5512.3 ^a 10	100	E1 ^a		0.00217	
5539.7	1108.3 [#] 4	100 [#]	Q ^b		5.54×10^{-4}	Mult.: from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$. From $T_{1/2}$ considerations, M2 is more likely. However, assignment to a band structure in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$ suggests E2 character. Other: D in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
5552.5	1253.2 [#] 4	100	Q		2.30×10^{-4}	Mult.: Q from angular distribution of oriented nuclei (ADO) ratio in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.
5876.9	5876.6 ^a 7	100	E1 ^a		0.00227	
5989.7	5989.4 ^a 7	100	M1 ^a		1.66×10^{-3}	
6006.9	1155 [§]	100 [§]				
6160.1	1252 [§]	100 [§]				
6297.0	6296.7 ^a 14	100	D ^a			
6362.8	6362.5 ^a 8	100	D ^a			
6549.1	1641 [§]	100 [§]				
6572.2	1273 [#]	100	Q			Mult.: from Angular Distribution of Oriented nuclei (ADO) ratio in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ and level scheme.
6587.7	6587.4 ^a 8	100	M1 ^a			
6604.2	1305 [§]	100 [§]				
6636.6	6636.3 ^a 15	100	D ^a			
6702.5	6702.2 ^a 13	100	E1 ^a			
6716.8	1474 ^h	100	E2			Mult.: Q in $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ and $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$, assumed E2 from placement in band structure.
6779.7	1240 ^h	100	Q			Mult.: from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$.
6786.1	626 [§]	100 [§]				
7306.3	7305.9 ^a 8	100	M1 ^a			
7426.0	7425.6 ^a 8	100	E1 ^a			
7619.7	840 ^h	100	Q			Mult.: from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$.
7753.5	7753.0 ^a 10	100	E1 ^a			
7767.8	1051 ^h	100	E2			Mult.: Q from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$, E2 from assumed band structure.
8058.1	1272 [§]	100 [§]				
8245.7	626 ^h	100	Q			Mult.: from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$.
8283.7	8283.2 ^a 15	100	M1 ^a			

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult.	Comments
8878.5	8877.9 ^a 14	100	D ^a	
9423.7	1178 ^h	100	Q	Mult.: from R(DCO) in $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$.
9619.2	1561 [§]	100 [§]		
10269.7	846 ^h	100		
11336.2	1717 [§]	100 [§]		
13173	1837 [§]	100 [§]		

[†] From ^{72}As ε decay, unless otherwise stated.

[‡] From (n,n' γ).

[§] From $^{46}\text{Ti}(^{28}\text{Si}, 4p\gamma)$.

[#] From $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$.

[@] From $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$.

^a From $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$.

^b From (p,p' γ).

^c from $^{65}\text{Cu}(^7\text{Li}, 2n\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2p\gamma)$ (2010Su05).

^d From angular distribution and linear-polarization data in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$.

^e From angular distribution in $^{68}\text{Zn}(\alpha, 2n\gamma)$, $^{67}\text{Zn}(\alpha, n\gamma)$ and RUL.

^f From internal conversion data in (p,p' γ).

^h From $^{64}\text{Ni}(^{12}\text{C}, \alpha 2n\gamma)$.

ⁱ From $\gamma(0)$ in ^{70}As ε decay, cases of D+Q with large, non-zero values for δ have been assumed to be M1+E2 in character.

Adopted Levels, Gammas (continued)

^{70}Zn $2\beta^-$ Decay $2011\text{Be}39$

Parent ^{70}Zn : $E=0$; $J\pi=0+$; $T_{1/2}\geq 3.8\times 10^{18}$ y; $Q(\text{g.s.})=997.1$ 21; % $2\beta^-$ decay=100.

$^{70}\text{Zn}-T_{1/2}$: From 2011Be39 for $2\nu\beta\beta$ mode at 90% confidence level (C.L.). Other: 2.3×10^{17} from 2009Be27.

$^{70}\text{Zn}-Q(\beta^-)$: From 2012Wa38.

2011Be39, 2009Be27: Measured half-life for double β decay using ZnWO_4 crystal scintillators with a total mass of 984 g fixed in polystyrene light-guide and photomultiplier tubes. The detector installed in low background DAMA/R&D setup at the Gran Sasso National Lab of INFN. Measured $\beta(\gamma)$ events.

 ^{70}Ge Levels

E(level)	$J\pi$
0.0	$0+$

 ^{70}Ga β^- Decay

Parent ^{70}Ga : $E=0.0$; $J\pi=1+$; $T_{1/2}=21.14$ min 5; $Q(\text{g.s.})=1651.7$ 15; % β^- decay=99.59 5.

1977Sc10: produced from $^{69}\text{Ga}(\text{d},\text{p})$ and $^{71}\text{Ga}(\text{d},\text{t})$ reactions ($E_d = 10.4$ MeV); natural target; NaI(Tl), Ge(Li), magnetic spectrometer, electron spectrometer, plastic scintillator. Measured: $\text{I}\beta^-$, $E\gamma$, $\text{I}\gamma$, $T_{1/2}$ using delayed β -e coin.

1975Bu07: obtained from deuteron bombardment of natural Ga target; Ge(Li) detector. Measured: $E\gamma$, $\text{I}\gamma$, $T_{1/2}$.

1958Ke20: source from $^{69}\text{Ga}(\text{n},\gamma)$ reaction, using moderated neutrons; NaI(Tl) detector for γ -detection, plastic scintillator for β -detection. Measured $T_{1/2}$ of 1215 level with $\beta\gamma$ delayed coin.

1957Bu41: produced from $^{69}\text{Ga}(\text{n},\gamma)$ reaction in an enriched target; NaI(Tl) detector, plastic scintillator and β spectrometer. Measured: $E\gamma$, $\text{I}\gamma$, $\gamma\gamma(\theta)$, $\beta\gamma$ coin, $T_{1/2}$.

1958Al01: source from neutron capture in enriched target; β spectrometer used for β conversion electron coin measurements. Measured: $\text{I}\beta^-$, ce β^- coin, $T_{1/2}$ of 1215 level with β^- conversion electron coin.

2012Kr07: source neutron irradiation of natural Ga target; neutrons from the pneumatic transfer facility of the Oregon State University TRIGA reactor. Ge detectors used for γ -detection. Measured: $E\gamma$, $\text{I}\gamma$.

Other: 2015DuZZ.

 ^{70}Ge Levels

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}$	Comments
0.0	$0+$		
1039.513 10	$2+$		
1215.628 16	$0+$	2.9 ns 4	$T_{1/2}$: weighted average of 2.8 ns 8 (1958Ke20, using $\beta\gamma$ delayed-coincidence technique) and 3.0 ns 5 (1958Al01, using delayed β -e coincidences).

[†] From $E\gamma$.

[‡] From the Adopted Levels.

 β^- radiations

$E\beta^-$	E(level)	$\text{I}\beta^{-\dagger\ddagger}$	Log ft	Comments
(436.1 15)	1215.628	0.32 1	5.431 15	$E\beta^-$: Other: 440 20 from measurements of 1957Bu41.
(612.2 15)	1039.513	0.36 2	5.895 25	$\text{I}\beta^-$: Other: 0.305 7 in 2012Kr07.
				$E\beta^-$: Other: 610 20 from measurements of 1957Bu41.
				$\text{I}\beta^-$: Other: 0.375 7 in 2012Kr07.
(1651.7 15)	0.0	98.91 6	5.0925 18	$E\beta^-$: Other: 1650 10 from measurements of 1957Bu41.

[†] From 1977Sc10.

[‡] Absolute intensity per 100 decays.

^{70}Ga β^- Decay (continued)

$\gamma(^{70}\text{Ge})$

I γ normalization: Based on the following branching ratios of 1977Sc10 from β and γ counting in 4π geometry. β transitions: 98.91% 6 (g.s.), 0.36% 2 (1039), and 0.32% 1 (1215). ϵ transitions: 0.41% 6.

$E\gamma^\dagger$	E(level)	$I\gamma^\S@$	Mult.#	α	$I(\gamma+ce)@$	Comments
176.115 13	1215.628	0.29 1	E2	0.0893	0.32 1	ce(K)/($\gamma+ce$)=0.0724 10; ce(L)/($\gamma+ce$)=0.00827 12; ce(M)/($\gamma+ce$)=0.001225 18; ce(N)/($\gamma+ce$)=7.09 $\times 10^{-5}$ 10.
1039.513 10	1039.513	0.65 5	E2	3.23 $\times 10^{-4}$		
1215 ‡	1215.628		E0		4 $\times 10^{-3}$ 3	I($\gamma+ce$): from I($\gamma+ce$)(1215 γ)/I($\gamma+ce$)(176 γ)=1.4 $\times 10^{-2}$ 7 (1958A101). ce(K): from internal conversion electrons in coincidence with β^- (1958A101).

† From 2012Kr07, unless otherwise stated.

‡ From 1977Sc10.

§ Derived by evaluators from measured β -feedings and measured relative intensity, I(1039)/I(176) = 2.30 6 (assuming efficiency corrections applied), given in 1977Sc10.

From the Adopted Gammas.

@ Absolute intensity per 100 decays.

Decay Scheme

^{70}As ϵ Decay 2002Li41,1968De16

Parent ^{70}As : $E=0.0$; $J\pi=4+$; $T_{1/2}=52.6$ min 3; $Q(\text{g.s.})=6220$ 50; $\% \epsilon + \% \beta^+$ decay=100.

2002Li41: source was produced via $^{70}\text{Ge}(\text{p},\text{n})$, $E_{\text{p}}=16$ MeV. Compton-suppressed HPGe detector and a planar Ge used for γ -ray detection. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coin.

1992De54: mass separated source was produced in $^{56}\text{Fe}(^{16}\text{O},\text{pn})$. Seven Ge(Li) detectors used for γ -ray detection.

Measured $\gamma(0)$; deduced δ .

1968De16: source was produced via $^{70}\text{Ge}(\text{d},2\text{n})$; enriched target, chemical separation; Ge(Li) detectors used for γ -ray detection; measured $T_{1/2}$, $E\gamma$, $I\gamma$, $\gamma\gamma$ coin.

1963Bo14: source was produced via $^{70}\text{Ge}(\text{d},2\text{n})$; natural and enriched targets, chemical separation; NaI(Tl) detector and β spectrometer; measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coincidences, β^+ spectrum.

Others: 1967Vi06, 1969Hi01.

 ^{70}Ge Levels

$E(\text{level})^{\dagger}$	$J\pi^{\dagger}$	$E(\text{level})^{\ddagger}$	$J\pi^{\dagger}$	$E(\text{level})^{\ddagger}$	$J\pi^{\dagger}$
0.0	0+	2562.05 3	3-	3675.75 7	3+, 4+
1039.495 22	2+	2806.25 3	4+	4101.45 5	(3-)
1215.57 3	0+	3046.43 3	3+	4243.11 15	
1707.628 18	2+	3058.720 24	4+	4577.23 16	(3, 4+)
2153.17 3	4+	3294.76 8	3+, 4+	4675.41 21	(3, 4+)
2156.73 3	2+	3371.64 10	(3, 4)	5265.81 14	
2451.30 3	3+	3488.234 24	(3, 4+)	5370.07 5	
2534.93 4	2+	3570.51 7	(2, 3)-		

† From the Adopted Levels.

‡ From a least-squares fit to $E\gamma$'s by evaluators.

 β^+, ϵ Data

$E\epsilon$	$E(\text{level})$	$I\beta^{+\ddagger}$	$I\epsilon^{\ddagger}$	$\text{Log } ft$	$I(\epsilon+\beta^+)^{\dagger\ddagger}$
(850 50)	5370.07		0.84 6	5.13 7	0.84 6
(950 50)	5265.81		0.164 19	5.94 7	0.164 19
(1540 50)	4675.41	0.008 3	0.077 11	6.69 8	0.085 12
(1640 50)	4577.23	0.034 10	0.18 3	6.39 8	0.21 3
(1980 50)	4243.11	0.12 3	0.14 3	6.64 11	0.26 5
(2120 50)	4101.45	0.59 7	0.45 6	6.20 7	1.04 9
(2540 50)	3675.75	1.03 14	0.27 4	6.58 8	1.30 18
(2650 50)	3570.51	0.35 4	0.075 11	7.17 8	0.43 5
(2730 50)	3488.234	6.0 4	1.1 1	6.04 6	7.1 4
(2850 50)	3371.64	0.17 3	0.026 6	7.70 10	0.20 4
(2930 50)	3294.76	0.63 12	0.082 17	7.22 10	0.71 14
(3160 50)	3058.720	35.6 19	3.2 3	5.69 5	38.8 21
(3170 50)	3046.43	31.9 19	2.8 3	5.75 5	34.7 21
(3410 50)	2806.25	1.2 4	0.079 25	7.37 14	1.3 4
(3660 50)	2562.05	1.6 4	0.078 19	7.44 11	1.7 4
(3690 50)	2534.93	0.80 16	0.037 8	7.76 10	0.84 17
(3770 50)	2451.30	5.66 19	0.241 16	6.97 4	5.90 20
(4060 50)	2156.73	0.8 3	0.02 1	8.04 17	0.8 3
(4070 $\S$ 50)	2153.17	4.3 15	0.13 5	7.30 16	4.4 15

† From γ intensity imbalance.

‡ Absolute intensity per 100 decays.

$\S$ Existence of this branch is questionable.

 $\gamma(^{70}\text{Ge})$

$I\gamma$ normalization: from $\Sigma I(\gamma+\text{ce})$ to g.s.=100, assuming that there is no direct feeding to the g.s. because of large spin change.

$E\gamma^{\dagger}$	$E(\text{level})$	$I\gamma^{\dagger\text{d}}$	Mult.&	$\delta\&\text{c}$	α	Comments
176.04 4	1215.57	3.5 2	E2		0.0894	
239.90 10	3046.43	0.25 7				
252.46 4	3058.720	3.3 2	[M1+E2]		0.016 9	δ : 1.28 27 or -0.15 11 (1992De54).
294.60 16	2451.30	0.10 4				

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^{70}As ϵ Decay 2002Li41,1968De16 (continued) $\gamma(^{70}\text{Ge})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger d}$	Mult.&	$\delta\&c$	α	Comments
297.88 8	2451.30	0.66 10				
445.6 10	2153.17	0.17 8				$E\gamma$: The level scheme in 2002Li41 shows that 1707.6 keV level is populated by 449.15 γ . Level energy difference requires 445.6 γ decays into 1707.6 keV level.
450.4 $\frac{1}{2}$ 5	2156.73	0.16 $\frac{1}{2}$ 8	E2		0.00327	
492.09 5	1707.628	1.31 9	E2		0.00247	
496.74 $\frac{3}{2}$ 4	3058.720	3.1 2				
595.11 4	3046.43	22.9 13	[M1+E2]		0.00118 23	δ : 1.50 9 or -0.06 3 (1992De54).
607.34 4	3058.720	5.3 3	M1(+E2)		0.00112 21	δ : $\delta \geq 12$ or 0.19 8 (1992De54).
653.15 6	2806.25	0.60 7				
668.21 4	1707.628	26.9 16	M1+E2	-3.6 +11-6	9.80×10^{-4} 2	δ : -5.8 $\leq \delta \leq$ -0.7 (1992De54).
$^x685.50^a$ 12						
743.62 4	2451.30	27.0 19	M1(+E2)		5.78×10^{-4} 9	δ : -1.80 15 or -0.27 4 (1992De54).
760.2 $^{\oplus}$ 5	3294.76	0.30 15				
827.24 10	2534.93	0.45 5				
889.72 4	3046.43	3.2 2	M1+E2		0.00044 4	δ : -1.18 $\leq \delta \leq$ -0.50 (1992De54).
893.50 4	3046.43	2.3 1	M1+E2		0.00043 4	δ : 4 +9-2 or 0.38 +33-19 (1992De54).
901.95 5	3058.720	1.19 8				
905.61 2	3058.720	13.6 8	[M1+E2]		0.00042 4	δ : 1.42 16 or -0.20 5 (1992De54).
941.10 4	2156.73	2.1 1	E2		4.09×10^{-4}	
953.30 7	3488.234	0.53 5				
1036.99 $^{\#}$ 4	3488.234	3.0 2				
1039.49 4	1039.495	100 6	E2		3.23×10^{-4}	
1098.54 4	2806.25	5.1 3	E2		2.84×10^{-4}	
1113.60 4	2153.17	25.1 15	E2		2.77×10^{-4}	
1117.28 4	2156.73	3.4 2	E2(+M1)		0.00023 1	δ : -4.0 $\leq \delta \leq$ -0.7 (1992De54).
1196.66 $^{\#}$ 15	4243.11	0.32 6				
1218.57 11	3371.64	0.19 4				
1295.24 $\frac{3}{2}$ 6	4101.45	0.59 6				
1331.58 7	3488.234	0.47 4				
1335.28 10	3488.234	0.38 4				
1338.76 4	3046.43	11.0 7	M1+E2		0.00016 1	δ : $\delta \geq 26$ or 0.24 4 (1992De54).
1350.90 6	3058.720	0.57 6				
1411.86 4	2451.30	10.6 6	M1+E2	-2.2 +5-3	2.18×10^{-4} 4	δ : 4.8 9 or 0.48 5 (1992De54).
1417.24 $\frac{3}{2}$ 7	3570.51	0.50 5				
1495.43 5	2534.93	1.4 1	M1+E2	-0.75	2.15×10^{-4}	δ : $0.02 \leq \delta \leq 2.4$ (1992De54).
$^x1507.80^b$ 13		0.83 7				
1522.55 2	2562.05	5.3 4	E1+M2	-0.11 10	3.42×10^{-4}	
1523.2 $\frac{1}{2}$ 7	3675.75	1.1 $\frac{1}{2}$ 2				δ : 3.4 +14-7 or -0.58 10 (1992De54).
1539.29 $^{\#}$ 20	4101.45	0.18 5				
1587.17 12	3294.76	0.39 5				
1707.61 2	1707.628	21.3 6	E2		2.87×10^{-4}	
1780.52 2	3488.234	4.7 1				δ : $\delta \geq 11$ or 0.21 6 (1992De54).
1881.67 5	5370.07	0.84 5				
1944.21 16	4101.45	0.15 2				
1948.35 11	4101.45	0.35 3				
2006.87 3	3046.43	3.4 1	M1+E2			δ : -11 +3-6 or 0.15 4 (1992De54).
2019.16 2	3058.720	20.2 5	E2		4.02×10^{-4}	
$^x2095.69$ 14		0.07 1				
2156.65 6	2156.73	0.58 3				
2219.34 14	5265.81	0.20 2				
2255.16 11	3294.76	0.17 2				
2325.42 18	5370.07	0.18 2				$E\gamma$: Authors of 2002Li41 stated that the placement of the transition was confirmed but level spacing requires 2323.6 γ decays into 3046.4 keV level.
2331.59 24	3371.64	0.05 1				
2419.88 24	4577.23	0.12 2				
2424.41 20	4577.23	0.14 2				
2448.82 9	3488.234	0.36 2				δ : $\delta \geq 5$ or 0.33 13 (1992De54).
2521.8 3	4675.41	0.034 9				
2531.7 $^{\#}$ 2	3570.51	0.03 1				

Continued on next page (footnotes at end of table)

^{70}As ϵ Decay 2002Li41,1968De16 (continued)

$\gamma(^{70}\text{Ge})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger\d}$
2636.20 7	3675.75	0.48 2
^x 2781.57 ^e 25		0.14 2
2968.1 3	4675.41	0.07 1
^x 3123.59 17		0.14 1

[†] From 2002Li41, unless stated otherwise. Intensity is normalized to $I_{\gamma}(1039.5\gamma)=100$.

[‡] From coincidence data in 2002Li04.

[§] Placement by 2002Li41.

[#] New transition identified by 2002Li41.

[@] From 1968De16, not reported by 2002Li41.

[&] From Adopted Gammas. Values from 1992De54 are given as comments.

^a Authors of 2002Li14 stated that 685.50 γ is the double-escape peak of the 1707.61 keV γ -ray.

^b Authors of 2002Li14 stated that 1707.61 γ is the single-escape peak of the 2019.6 keV γ -ray.

^c If no value given it was assumed $\delta=1.00$ for E2/M1, $\delta=1.00$ for E3/M2 and $\delta=0.10$ for the other multipolarities.

^d For absolute intensity per 100 decays, multiply by 0.82 ^d.

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

^x γ ray not placed in level scheme.

$^{12}\text{C}(^{66}\text{Zn}, ^8\text{Be}\gamma)$ 2006Le31

$E(^{66}\text{Zn})=180$ MeV provided by Munich tandem accelerator. Natural carbon deposited on gadolinium that was evaporated on a tantalum foil backed by a copper layer used as a target. 2α particles and recoiling ^{12}C ions were detected in a Si detector. The γ rays were measured in coincidence with 2α particles using four NaI(Tl) detectors. A Ge detector was used to measure the γ -rays. Measured $T_{1/2}$ using Doppler-shift attenuation method (DSAM) and g factors using Transient Field technique.

 ^{70}Ge Levels

E(level) [†]	J π [‡]	$T_{1/2}$ [§]	Comments
0.0	0+		
1039	2+	1.32 ps 14	$g=+0.43$ 12 (2006Le31).
1215	0+		
1707	2+	1.94 ps 28	$g=+0.4$ 6 (2006Le31).
2153	4+	0.76 ps 14	
2156	2+		
2451	3+		
2535	2+		
2562	3-	0.55 ps 7	
2806	4+		
3059	4+		
3416	5-		

[†] From a least-squares fit to $E\gamma$'s by evaluators.

[‡] From the Adopted Levels.

[§] From Doppler-shift attenuation method (2006Le31).

 $\gamma(^{70}\text{Ge})$

$E\gamma$ [†]	E(level)	Comments
176	1215	$E\gamma$: deduced by the evaluators from the level scheme given in 2006Le31.
492	1707	
668	1707	
743	2451	
854	3416	
906	3059	
941	2156	
1039	1039	
1098	2806	
1113	2153	
1117	2156	
1263	3416	
1412	2451	
1495	2535	
1522	2562	
1707	1707	
2019	3059	
2156	2156	

[†] From 2006Le31, except where noted.

$^{46}\text{Ti}(^{28}\text{Si},4\text{p}\gamma)$ 2000Mu23

E=110 MeV. Measured γ , $\gamma\gamma(6)$, DCO. An array of eight Compton-suppressed HPGe detectors in conjunction with a recoil mass spectrometer.

 ^{70}Ge Levels

<u>E(level)[†]</u>	<u>$J\pi^{\ddagger}$</u>	<u>E(level)[†]</u>	<u>$J\pi^{\ddagger}$</u>	<u>E(level)[†]</u>	<u>$J\pi^{\ddagger}$</u>
0.0 [§]	0+	3752.0		5296.0	
1039.0 [§]	2+	3899.0		6004.0	
1214.0	0+	3953.0 [@]	7-	6158.0 [@]	(11-)
1707.0 [#]	2+	4052.0 [#]	(6+)	6547.1	
2152.0 [§]	4+	4201.0 [§]	8+	6601.1	
2561.0 [@]	3-	4296.0	7-	6784.0 [@]	(13-)
2805.0 [#]	4+	4429.0	8+	8056 [@]	(15-)
3058.0	4+	4849.0		9617 [@]	(17-)
3295.0 [§]	6+	4906.0 [@]	(9-)	11334 [@]	(19-)
3415.0 [@]	5-	5221.0 [#]	(8+)	13171 [@]	(21-)
3665.0 [@]	6-	5240.0 [§]	10+		

[†] From a least-squares fit to E γ 's, by evaluators.

[‡] Deduced from DCO measurements. The details of the measurements were not given in 2000Mu23.

[§] (A): Sequence based on g.s.

[#] (B): Sequence based on second 2+.

[@] (C): Sequence based on 3-.

 $\gamma(^{70}\text{Ge})$

<u>Eγ</u>	<u>E(level)</u>	<u>Eγ</u>	<u>E(level)</u>	<u>Eγ</u>	<u>E(level)</u>
175	1214.0	906	4201.0	1252	6158.0
234	3899.0	947	3752.0	1263	3415.0
250	3665.0	953	4906.0	1272	8056
288	3953.0	1001	4296.0	1305	6601.1
343	4296.0	1039	1039.0	1343	5296.0
357	3415.0		5240.0	1522	2561.0
484	3899.0	1098	2805.0	1561	9617
626	6784.0	1113	2152.0	1641	6547.1
658	3953.0	1134	4429.0	1717	11334
668	1707.0	1143	3295.0	1837	13171
854	3415.0	1155	6004.0	2019	3058.0
896	4849.0	1169	5221.0		
906	3058.0	1247	4052.0		

$^{64}\text{Ni}(^{12}\text{C}, \alpha 2n \gamma)$ 2016Ra08

2016Ra08: E(^{12}C)=55 MeV beam provided by the 15 UD Pelletron accelerator at the Inter-University Accelerator Centre, New Delhi. Target consisted of isotopically enriched ^{64}Ni with thickness $\approx 1.5 \text{ mg/cm}^2$ on a 7 mg/cm^2 Au backing. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\gamma\gamma(\theta)(\text{DCO})$ using the Gamma Detector Array (GDA) consisting of 12 Compton-suppressed n-type HPGe detectors.

 ^{70}Ge Levels

E(level) [†]	$J\pi^{\ddagger}$	E(level) [†]	$J\pi^{\ddagger}$	E(level) [†]	$J\pi^{\ddagger}$
0.0 §	0+	3668.0@ 14	(5+)	6714.5 § 20	12+
1039.2 § 8	2+	3751.8@ 13	6+	6778.0# 20	12+
1706.8@ 8	2+	4201.5 § 14	8+	7618.0# 22	14+
2152.1 § 11	4+	4429.0# 14	8+	7765.5 § 22	14+
2450.0@ 10	3+	4818.8@ 16	(8+)	8244.0# 24	16+
2805.0@ 11	4+	5240.5 § 17	10+	9422# 3	18+
3295.1 § 12	6+	5538.0# 17	10+	10268# 3	(20+)

[†] From least-squares fit to $E\gamma$, by evaluators, assuming $\Delta E\gamma=1 \text{ keV}$.

[‡] As given in 2016Ra08; J from R(DCO) and band assignments, while parity are assigned based on literature and systematics.

§ (A): g.s. band.

(B): Side band based on 8+.

@ (C): Band based on 2+.

 $\gamma(^{70}\text{Ge})$

R(DCO) defined as $I\gamma(50^\circ \text{ or } 144^\circ \text{ gated by } \gamma \text{ at } 98^\circ)/I\gamma(98^\circ \text{ gated by } \gamma \text{ at } 50^\circ \text{ or } 144^\circ)$. 2016Ra08 use only $\Delta J=2$ transitions as gating transitions where expected R(DCO) ratios are ≈ 1 for pure quadrupole transitions and 0.5 for pure dipole transitions.

$E\gamma$	E(level)	$I\gamma^\dagger$	Mult.	Comments
450	4201.5	1.5 3		
490	3295.1	0.8 2		
626	8244.0	8.9 11	Q	Mult.: R(DCO)=1.17 22 (2016Ra08).
653	2805.0	1.2 4		
667	1706.8	11.9 6	Q	Mult.: R(DCO)=0.94 7. 2016Ra08 state this is $\Delta J=0$, Q transition.
677	4429.0	1.0 3	(Q)	
743	2450.0	3.4 3	D	Mult.: R(DCO)=0.72 13 (2016Ra08).
840	7618.0	10.8 10	Q	Mult.: R(DCO)=1.09 18 (2016Ra08).
846	10268	2.2 8		
906	4201.5	51.1 12	Q	Mult.: R(DCO)=0.99 7 (2016Ra08).
947	3751.8	6.9 5	Q	Mult.: R(DCO)=1.01 3 (2016Ra08).
1039 [‡]	1039.2	183.4 [‡] 9	Q	Mult.: R(DCO)=1.01 5 (2016Ra08).
	5240.5	24.8 [‡] 9	Q	Mult.: R(DCO)=1.12 11 (2016Ra08).
1051	7765.5	11.7 14	Q	Mult.: R(DCO)=1.17 12 (2016Ra08).
1067	4818.8	3.3 5		
1098	2805.0	9.3 7	Q	Mult.: R(DCO)=1.19 10 (2016Ra08).
1109	5538.0	23.1 12	Q	Mult.: R(DCO)=0.98 12 (2016Ra08).
1113	2152.1	134.9 9	Q	Mult.: R(DCO)=1.05 6 (2016Ra08).
1134	4429.0	29.5 9	Q	Mult.: R(DCO)=1.01 9 (2016Ra08).
1143	3295.1	100		
1178	9422	4.3 9	Q	Mult.: R(DCO)=0.94 25 (2016Ra08).
1218	3668.0	1.5 4		
1240	6778.0	14.1 11	Q	Mult.: R(DCO)=1.08 15 (2016Ra08).
1411	2450.0	3.4 4		
1474	6714.5	14.7 11	Q	Mult.: R(DCO)=1.13 12 (2016Ra08).
1707	1706.8	4.7 5		

[†] Relative intensities normalized to $I\gamma(1143\gamma)=100$.

[‡] Multiply placed; intensity suitably divided.

⁶⁵Cu(⁷Li,2nγ), ⁶⁰Ni(¹²C,2pγ) 1977Ro28,2010Su05

1977Ro28: ⁶⁰Ni(¹²C, 2pγ), E(¹²C)=30–39 MeV; ⁶⁵Cu(⁷Ni, 2nγ), E(⁷Li)=16–19 MeV. Beams provided by ORNL EN tandem accelerator. Two Ge(Li) detectors used for γ-ray detection. Measured E_γ, I_γ, γγ coin (⁶⁰Ni(¹²C, 2pγ)), γ(θ), γγ(θ), T_{1/2} by DSAM.
 1978RoZS: ⁶⁴Cu(⁷Li,2nγ); in-beam measurement of linear polarization of γ rays using a Compton polarimeter.
 2010Su05: ⁶⁰Ni(¹²C,2pγ), E(¹²C)=45 MeV beam provided by the tandem accelerator at the Japan Atomic Energy Agency (JAEA). γ-rays were detected with an array of 15 HPGe detectors with BGO shields and three LOAX detectors without shields. The HPGe detectors were placed at angles of 47°, 72°, 90°, 105°, 144° and 147°. The LOAX detectors were placed at 36° and 108° with respect to the beam direction. Measured E_γ, I_γ, γγ, ADO ratios (Angular Distribution from Oriented nuclei). The γ ray energies in 2010Su05 are consistently =1 keV lower than those given in 1977Ro28 (and similarly those from other datasets). In order to combine the 2010Su05 E_γ values with the results of other measurements, the evaluators have added 1 keV to all E_γ values given in 2010Su05 and rounded to the nearest keV.

⁷⁰Ge Levels

Evaluators note: 6506.5 keV 11(–), 7132.5 keV 13(–) and 8404.5 keV 15(–) levels were omitted in the Adopted Levels since the level energies could not be reproduced by the least-squares fit. The energy differences obtained were up to 14 keV.

E(level) [†]	Jπ ^{&}	T _{1/2} ^a	Comments
0.0 #	0+		
1039.6 # 3	2+	>5 ps ^b	
1215.9 ‡ § 6	0+		
1708.2 3	2+	>7 ps ^c	Jπ: J=2 from γ(θ).
2153.6 # 4	4+ ^d	4 ps ^b 1	
2156.9 ‡ § 4	2+		
2452.1 4	3+		Jπ: J=1,2,3 from γ(θ).
2562.6 ‡ @ 4	3–	2.3 ps ^c 5	Jπ: J=1,2,3 from γ(θ).
2807.4 4	4+		Jπ: J=1–4 from γ(θ).
3059.6 § 3	4+	1.0 ps ^c 5	Jπ: J=1–4 from γ(θ).
3298.0 # 5	6+ ^d	2.6 ps ^c 6	
3417.1 @ 4	5– ^d	>14 ps ^c	
3667.6 5	6– ^d		
3754.0 5	(6)+		Jπ: J=2–6 from γ(θ).
3956.0 5	7–		Jπ: J=5,6,7 from γ(θ).
4104.3 ‡ § 6	6+		
4204.8 # 6	8+ ^d		
4300.2 @ 5	6–, 7–, 8–		Jπ: J=5–9 from γ(θ).
4432.7 6	8+		Jπ: J=4–8 from γ(θ). J=7–9 from yield function in 1977Ro28.
4852.8 6	8(–)		Jπ: J=6,8 from γ(θ).
5244.8 ‡ # 11	10+		
5300.1 6	9(–)		Jπ: Jπ=5,6–,7–,8– from γ(θ); J=6–8 from yield function in 1977Ro28.
5436.3 ‡ § 12	8+		
5541.0 7	9+		
5553.4 ‡ @ 6	9(–)		
6506.5 ‡ @ 12	11(–)		
6573.1 ‡ 12	11(–)		
6720.9 ‡ # 15	12+		
7132.5 ‡ @ 16	13(–)		
8404.5 ‡ @ 18	15(–)		

[†] From a least-squares fit to E_γ's by evaluators. ΔE_γ=1 keV, if not specified.

[‡] Level reported only in 2010Su05.

§ (A): Member of 0⁺ band in 2010Su05.

(B): Member of the g.s. band in 2010Su05.

@ (C): Member of band based on 3(–) in 2010Su05.

& From the Adopted Levels. Additional support from γ(θ) and linear polarization measurements are indicated.

^a From DSAM in 1977Ro28.

^b Corrected for precursor γ rays in 1977Ro28.

^c Not corrected for precursor γ rays in 1977Ro28.

^d 1978RoZS state Jπ consistent with γ(θ) of 1977Ro28 and their linear polarization results, however, no details are given.

⁶⁵Cu(⁷Li,2nγ),⁶⁰Ni(¹²C,2pγ) 1977Ro28,2010Su05 (continued)

γ(⁷⁰Ge)

ADO ratio are for the different combinations of detectors (2010Su05).

γ-ray coincidence intensity ratios (ADO ratios): I(γ1:47°,γ2:all)/I(γ1:105°,γ2:all)=ADO(1),

I(γ1:144°,γ2:all)/(γ1:105°,γ2:all)=ADO(2) and (γ1:147°)/(γ1:105°,γ2:all)=ADO(3). Expected ADO ratios are ≈1.3 for stretched quadrupole or ΔJ=0, dipole and 0.8 for stretched pure dipole transitions.

Eγ [†]	E(level)	Iγ [§]	Mult.&	δ [#]	Iγ [@]	Comments
176 [‡]	1215.9				2.65 20	
250 [‡]	4204.8				0.44 4	
250.4 4	3667.6	9.2 9	D+Q	+0.05 2	3.0 3	Mult.: other: D from ADO(1)=0.85 4, ADO(2)=0.69 4, ADO(3)=0.70 4 (2010Su05).
251.9 4	3059.6	0.5 2			2.9 2	
288.2 4	3956.0	6.4 6	D+Q	+0.13 1	2.65 22	Mult.: other: D from ADO(1)=0.97 5, ADO(2)=0.83 4, ADO(3)=0.84 4 (2010Su05).
295 [‡]	2452.1				0.05 1	
298 [‡]	2452.1				0.41 6	
344.1 4	4300.2	1.1 2	D(+Q)	+0.1 3	0.72 6	Mult.: other: ΔJ=0 D from ADO(1)=1.27 9, ADO(2)=1.39 11, ADO(3)=1.40 10 (2010Su05).
357.1 4	3417.1	3.3 7	D(+Q)	+0.00 4	1.48 12	Mult.: other: D from ADO(1)=0.87 5, ADO(2)=0.74 5, ADO(3)=0.82 5 (2010Su05).
405 [‡]	2562.6				0.17 2	
408 [‡]	2562.6				0.12 2	
449 [‡]	2156.9		D		0.35 4	Mult.: ΔJ = 0 dipole transition based on ADO(1)=1.28 20, ADO(2)=1.13 27, ADO(3)=1.40 23 (2010Su05).
451 [‡]	4204.8				0.16 1	
456 [‡]	3754.0				0.19 2	
492 [‡]	1708.2				0.86 7	
496.7 4	3059.6	0.3 1	D		2.7 2	Mult.: ADO(1)=0.91 5, ADO(2)=0.74 5, ADO(3)=0.83 5 (2010Su05).
539 [‡]	3956.0				0.09 2	
607.2 4	3059.6	0.8 2	D		4.8 4	Mult.: ADO(1)=1.01 5, ADO(2)=0.89 5, ADO(3)=0.94 5 (2010Su05).
626 [‡]	7132.5		Q		0.82 7	Mult.: ADO(1)=1.16 7, ADO(2)=1.30 8, ADO(3)=1.20 7 (2010Su05).
653 [‡]	2807.4		D		0.98 11	Mult.: ΔJ = 0 dipole transition based on ADO(1)=0.90 6, ADO(2)=0.86 7, ADO(3)=0.86 6 (2010Su05).
658.1 4	3956.0	1.2 2	D(+Q)	+0.02 5	0.97 9	Mult.: other: D from ADO(1)=0.78 5, ADO(2)=0.65 6, ADO(3)=0.65 5 (2010Su05).
668.1 4	1708.2	5.1 5	Q		26.8 23	Mult.: ΔJ = 0 quadrupole transition based on ADO(1) = 1.01 5, ADO(2)=0.84 4, ADO(3) =0.93 5 (2010Su05).
679	4432.7				0.12 2	
688 [‡]	4104.3				0.24 2	
743.8 4	2452.1	4.5 4	D(+Q)	+0.04 8	22.3 18	Mult.: other: D from ADO(1)=1.01 5, ADO(2)=0.85 4, ADO(3)=0.91 5 (2010Su05).
854 [‡]	2562.6				0.25 3	
854.6 4	3417.1	6.7 7	Q		2.76 22	Mult.: ADO(1)=1.25 7, ADO(2)=1.33 8, ADO(3)=1.30 8 (2010Su05).
883 [‡]	4300.2		Q		0.77 6	Mult.: ADO(1)=1.28 14, ADO(2)=1.15 16, ADO(3)=1.34 15 (2010Su05).
896.8 4	4852.8	1.2 2	D+Q	+1.1 3	1.16 10	Mult.: other: D from ADO(1)=0.69 7, ADO(2)=0.75 10, ADO(3)=0.86 9 (2010Su05).
902 [‡]	3059.6				1.47 12	
906.0 4	3059.6	1.6 3	D		7.5 7	Mult.: ΔJ = 0 dipole transition based on ADO(1)=1.22 6, ADO(2)=1.10 6, ADO(3)=1.14 6 (2010Su05).
906.6 4	4204.8	5.9 6	E2		8.2 7	Mult.: other: Q from ADO(1)=1.27 6, ADO(2)=1.17 6, ADO(3)=1.24 6 (2010Su05).
941 [‡]	2156.9				1.52 12	
946.7 4	3754.0	1.7 3	Q		1.04 9	Mult.: other: Q from ADO(1)=1.46 17, ADO(2)=1.67 23, ADO(3)=1.81 21 (2010Su05). Other: D+Q from 1977Ro28 based on δ=+0.38 8.
953 [‡]	6506.5		Q		1.02 9	Mult.: ADO(1) =1.25 8, ADO(2)=1.69 12, ADO(3)=1.45 10 in 2010Su05.

Continued on next page (footnotes at end of table)

$^{65}\text{Cu}(^7\text{Li},2n\gamma), ^{60}\text{Ni}(^{12}\text{C},2p\gamma)$ 1977Ro28,2010Su05 (continued) $\gamma(^{70}\text{Ge})$ (continued)

$E_{\gamma}^{\dagger}$	E(level)	$I_{\gamma}^{\S}$	Mult.&	$\delta^{\#}$	$I_{\gamma}^{\textcircled{a}}$	Comments
1002.4 4	4300.2	1.5 3	D+Q	+0.11 2	0.98 9	Mult.: other: D from ADO(1)=0.86 6, ADO(2)=0.90 8, ADO(3)=0.76 6 (2010Su05).
1039.6 4	1039.6	100	E2		100 10	
1040 $\ddagger$	5244.8		Q		5.8 6	Mult.: ADO(1) = 1.21 6, ADO(2)=1.16 6, ADO(3)=1.16 6 (2010Su05).
1045 $\ddagger$	4104.3				3.3 3	
1098.8 4	2807.4	4.2 4	Q		5.0 5	Mult.: ADO(1)=1.37 8, ADO(2)=1.29 8, ADO(3)=1.32 8 (2010Su05).
1108.3 4	5541.0	1.7 3	D		1.54 16	Mult.: ADO(1)=0.81 5, ADO(2)=0.57 5, ADO(3)=0.47 3 (2010Su05).
1114.0 4	2153.6	39 4	Q		35 3	Mult.: ADO(1) = 1.30 7, ADO(2)=1.16 6, ADO(3) =1.20 6 (2010Su05).
1117 $\ddagger$	2156.9				4.8 4	
1134.6 4	4432.7	5.4 5	Q		2.9 3	Mult.: ADO(1)=1.07 6, ADO(2)=1.13 7, ADO(3)=1.15 6 (2010Su05).
1144.5 4	3298.0	18.0 18	E2		9.4 9	Mult.: other: Q from ADO(1)=1.40 7, ADO(2)=1.53 8, ADO(3)=1.48 8 (2010Su05).
1253.2 $\ddagger$ 4	5553.4	0.4 1	Q		1.16 10	E γ : placement from 2010Su05. 1253 γ is placed from a 4551-keV, J=(8) level in 1977Ro28. Mult.: ADO(1)=1.21 7, ADO(2)=1.52 10, ADO(3)=1.35 8 (2010Su05).
1263.9 4	3417.1	8.1 8	E1(+M2)	+0.02 2	2.85 24	Mult.: other: D from ADO(1)=0.91 5, ADO(2)=0.89 5, ADO(3)=0.81 4 (2010Su05).
1272 $\ddagger$	8404.5				0.24 4	ADO(1)=1.39 8, ADO(2)=1.26 10, ADO(3)=1.17 8 for 1273 + 1273 unresolved doublet (2010Su05).
1273 $\ddagger$	6573.1		Q		0.42 4	Mult.: ADO(1)=1.39 8, ADO(2)=1.26 10, ADO(3)=1.17 8 for 1273 + 1273 unresolved doublet (2010Su05).
1295 $\ddagger$	4104.3		Q		0.49 4	Mult.: ADO(1)=1.27 12, ADO(2)=1.78 23, ADO(3)=1.28 14 (2010Su05).
1332 $\ddagger$	5436.3		Q		0.47 5	Mult.: ADO(1) =1.39 10, ADO(2)=1.91 15, ADO(3)=1.45 11 (2010Su05).
1344.1 4	5300.1	0.6 2	Q		0.88 8	Mult.: ADO(1)=1.25 20, ADO(2)=1.72 33, ADO(3)=1.89 25 (2010Su05).
1351 $\ddagger$	3059.6				0.47 4	
1412.6 4	2452.1	1.4 3	D+Q		10.6 9	Mult.: ADO(1)=1.19 6, ADO(2)=1.07 6, ADO(3)=1.06 5 (2010Su05).
1476 $\ddagger$	6720.9		Q		0.26 2	Mult.: ADO(1) =1.39 9, ADO(2)=1.90 14, ADO(3)=1.66 11 (2010Su05).
1523.1 4	2562.6	11 1	D(+Q)	+0.02 5	8.7 8	Mult.: other: D from ADO(1)=0.98 5, ADO(2)=0.99 5, ADO(3)=0.97 5 (2010Su05).
1708.3 4	1708.2	5.7 6	E2		16.4 13	
1948 $\ddagger$	4104.3				0.18 2	E γ : 1948 γ populates 2156.9 keV 2+ state according to level scheme. Placement of 1948 γ is questionable due to ΔJ .
2020.5 4	3059.6	2.2 4	Q		11.9 10	Mult.: ADO(1)=1.32 7, ADO(2)=1.34 7, ADO(3)=1.39 7 (2010Su05).
2156 $\ddagger$	2156.9				0.60 6	

 $\dagger$ From 1977Ro28, except where noted. $\ddagger$ From 2010Su05 with a 1 keV offset added by the evaluators. The results of 2010Su05 are consistently ≈ 1 keV lower than the E_{γ} values reported by 1977Ro28 (and similarly those from other datasets) suggesting a problem with the energy calibration in 2010Su05. $\Delta E=1$ keV assumed for least-squares fitting. $\S$ Relative photon intensity at $E(^7\text{Li})=18$ MeV with $I_{\gamma}(1040\gamma)=100$ (1977Ro28). $\#$ From $\gamma(\theta)$ in 1977Ro28. $\textcircled{a}$ From 2010Su05, normalized to $I_{\gamma}(1040\gamma)=100$. $\&$ From $\gamma(\theta)$ (1977Ro28) and linear polarization data (1978RoZS), except where noted.

$^{66}\text{Zn}(^6\text{Li},d)$ E=34 MeV 1980Ar14

1980Ar14: $^{66}\text{Zn}(^6\text{Li},d)$, E(^6Li)= 34 MeV by Los Alamos Van de Graaf accelerator. The deuterons were identified and measured by Q3D magnetic spectrometer with one meter long detector in the focal plane. Resolution (FWHM)=60 keV. Measured $\sigma(\theta)$. Results were compared with DWBA predictions assuming L = 0 and alpha cluster form factor.

 ^{70}Ge Levels

E(level)	L	S [†]
0.0	0	3.03
1210	0	0.14

[†] $\sigma(\theta)(\text{exp})/\sigma(\theta)(\text{DWBA})$.

 $^{68}\text{Zn}(\alpha,2n\gamma)$, $^{67}\text{Zn}(\alpha,n\gamma)$

1984Ef01: E=10,15 MeV $^{67}\text{Zn}(\alpha,n\gamma)$; E=45 MeV $^{61}\text{Ni}(^{12}\text{C},n2p\gamma)$; Ge(Li) detectors were used to measure γ s. Measured $T_{1/2}$ by DSAM and RDM.
 1982Cl02: E=47 MeV, $^{55}\text{Mn}(^{14}\text{N}, n2p\gamma)$; E=46 MeV, $^{56}\text{Fe}(^{16}\text{O}, 2p\gamma)$; Ge(Li) detectors were used to detect γ s. Measured E_γ , I_γ , $T_{1/2}$ by RDM.
 1979Ne09: E=23 MeV; in-beam measurement of absolute conversion coefficients using a mini-orange spectrometer with Si solid state detector.
 1978Cl05: E=16 and 22.5 MeV for $^{68}\text{Zn}(\alpha,2n\gamma)$ and $^{67}\text{Zn}(\alpha,n\gamma)$ reactions; measured yield functions for $E\alpha=13-21$ MeV, $\gamma(\theta)$ at seven angles from $30^\circ-148^\circ$, and linear polarization of γ at $E\alpha=16$ MeV. Ge(Li) detector and a "five-in-one" Ge(Li) detector used as a Compton polarimeter.
 1977Mo20: E=30 MeV; $T_{1/2}$ by DSAM; Ge(Li) detector.
 1976Mo15: E=24-40 MeV; measured yield functions of γ ; mean lifetime of levels from electronic timing at E=33 MeV; $\gamma\gamma$ coin at 31 MeV; $\gamma(\theta)$ at 31 MeV. Enriched target, Ge(Li) detector.
 Others: 1982AlZH, 1990Bo27.

 ^{70}Ge Levels

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}^{\S}$	Comments
0.0	0+		
1039.22 5	2+	1.3 ps 3	$J\pi$: E2 transition to 0+ g.s. $T_{1/2}$: weighted average of 1.3 ps 3 (1984Ef01) and 1.5 ps 10 (1977Mo20).
1214.5 10			
1707.3 6	2+	1.1 ps +10-4	$T_{1/2}$: Other: 4 ps +2-1 (1977Mo20).
2152.6 6	4+	0.8 ps 2	$J\pi$: E2 transition to 1039.2 level and yield function. $T_{1/2}$: weighted average of 0.6 ps 3 (1984Ef01) and 1.0 ps 3 (1977Mo20).
2450.9 6	3+	1.7 ps +10-3	$J\pi$: $\gamma(\theta)$ and the yield function of 744 γ . $T_{1/2}$: Other: 3 ps 3 (1977Mo20).
2534.2 10		0.6 ps 2	
2561.36 9	3-	0.4 ps 1	$J\pi$: $\gamma(\theta)$ and linear polarization measurement of 1522 γ (1978Cl05). $T_{1/2}$: unweighted average of 0.6 ps 1 (1984Ef01) and 0.3 ps 1 (1977Mo20).
2805.7 12	4+	0.6 ps 2	$J\pi$: 1098 γ E2 to 2+. $T_{1/2}$: Other: 4 ps +7-1 (1977Mo20).
3058.0 6	4+	1.4 ps 3	$J\pi$: from 2019 γ E2 to 2+. $T_{1/2}$: Other: 0.20 ps 10-3 (1977Mo20).
3296.5 6	6+	0.5 ps 1	$J\pi$: $\gamma(\theta)$ of 1144 γ E2 transition and yield function. $T_{1/2}$: weighted average of 0.5 ps 1 (1977Mo20) and 0.6 ps 2 (1984Ef01).
3415.8 6	5-	13.7 ps 10	$J\pi$: $\gamma(\theta)$ and yield function of 854 γ . $T_{1/2}$: from 1982Cl02. Others: 3 ps +4-2 (1977Mo20), 1.9 ps 9 (1984Ef01).
3666.2 6	6-	35 ps 3	$J\pi$: J=6 from $\gamma(\theta)$ of 250 γ (1976Mo15); parity from M1 transition to $J\pi=5-$ level at 3415.7. $T_{1/2}$: from 1982Cl02. Other: 40 ps 8 (1984Ef01).
3669.0? 12		1 ps 1	
3752.5 15	(6)+	1.6 ps 5	$J\pi$: $\gamma(\theta)$ of 947 γ suggests a 6+ assignment but the yield function does not confirm this. $T_{1/2}$: Other: > 3 ps (1977Mo20).
3954.5 6	7-	17.0 ps 10	$J\pi$: J=7 from $\gamma(\theta)$ of 288 γ and 658 γ (1976Mo15); parity from M1 transition to $J\pi=6-$ level at 3666.1 keV. $T_{1/2}$: weighted average of 17.5 ps 10 (1982Cl02) and 15 ps 2 (1984Ef01).
4202.8 12	8+	8 ps 2	$J\pi$: 906 γ E2 transition and yield function. $T_{1/2}$: Other: 7 ps +14-2 (1977Mo20).

Continued on next page (footnotes at end of table)

$^{68}\text{Zn}(\alpha, 2n\gamma), ^{67}\text{Zn}(\alpha, n\gamma)$ (continued) **^{70}Ge Levels (continued)**

E(level) [†]	J π [‡]	T _{1/2} [§]	Comments
4299.0 9	7+	3 ps 1	J π : J from $\gamma(0)$ of 344 γ and 1003 γ ; absence of a transition to the 5- level at 3415.7 may indicate a positive parity for this level.
4430.8 12	(8)+	0.4 ps 2	J π : 1134 γ E2 transition and yield function. T _{1/2} : Other: 0.8 ps 2 from 1977Mo20 which if corrected for the tail of the 1144 γ is expected to be less than the reported value.
4551.8 14	(8)	104 ps +70-35	J π : from 253 γ to 7+.
4851.0 12	(8-)	>3 ps	J π : J suggested by the $\gamma(0)$ of the 896 γ ; this is not confirmed by the yield function. T _{1/2} : from 1977Mo20.
4984.5 12			
5047.8 12			
5242.0 15			E(level): existence of this level established by coincidence intensity data.
5298.1 12			
5539.9 15	(10-)	5 ns 2	T _{1/2} : from 1976Mo15. J π : the T _{1/2} for this level suggests that the 1109 γ may be M2 with an assignment of J π =10-.

[†] From a least-squares fit to E γ 's by evaluators.[‡] From multiplicities of γ -rays deduced from $\gamma(0)$ and linear polarization measurements in 1978Cl05, unless otherwise stated.[§] From 1984Ef01 using DSAM, unless otherwise stated. **$\gamma(^{70}\text{Ge})$**

E(level)	E γ [†]	I γ [‡]	Mult.	$\delta^{\oplus}$	Comments
1039.22	1039.21 5	100	E2 [§]		δ : 0.00 2 (1978Cl05).
1214.5	175.25	100			
1707.3	668.14	100 4			
	1707.27	53 2	E2 [#]		
2152.6	1113.38	100 2	E2 [#]		δ : -0.1 2 (1976Mo15).
2450.9	743.56 7	100 6	M1 [§]		
	1411.7	46 8			
2534.2	1495.0	100 36			
2561.36	1522.12 7	100 3	E1+M2 [§]	-0.11 10	
2805.7	1098.3	100 9	E2 [#]		δ : -0.2 2 (1976Mo15).
3058.0	906.2	100			
	2019.0	28	E2 [#]		δ : +0.2 2 (1976Mo15). I γ : 906 γ and 2019 γ from 1976Mo15.
3296.5	1143.89 2	100 4	E2 [#]		δ : 0.0 2 (1976Mo15).
3415.8	357.72 5	59 4	E1+M2 [§]	-0.06 3	
	854.22	97 6	E2 [#]		δ : 0.02 +4-5 (1982Cl02).
	1263.09 6	100 6	E1(+M2) [§]	-0.05 5	
3666.2	250.46 5	100 4	M1(+E2) [§]		δ : 0.03 +2-5 (1982Cl02).
3669.0?	1218.1	100			I γ : very weak γ .
3752.5	946.8	100	E2 [#]		δ : -0.2 2 (1976Mo15).
3954.5	288.33 5	100	M1(+E2) [§]		δ : 0.01 +2-3 (1982Cl02).
	657.7	20			I γ : for 288 γ and 658 γ from 1976Mo15.
4202.8	906.22	100	E2 [#]		δ : -0.2 2 (1976Mo15).
4299.0	344.2	61			
	1002.6	100			I γ : for 344 γ and 1003 γ from 1976Mo15.
4430.8	1134.22	100 21	E2 [#]		δ : -0.1 2 (1976Mo15).
4551.8	252.8	100			
4851.0	896.4	100	(M1+E2) [#]	0.4 2	
4984.5	1029.9	100			
5047.8	1381.6	100			I γ : very weak γ . E γ : populates 3954.7 keV 7- level in 1978Cl05 (Figure 1). From the energy level differences this γ -ray should populate 3666.2 keV 6- level.
5242.0	1039.2	100			
5298.1	1343.5	100			I γ : very weak γ .
5539.9	1109.1	100	(M2)		I γ : very weak γ . Mult.: suggested by T _{1/2} of decaying state; $\gamma(0)$ could not be measured because of mixing with 1114 γ .

Footnotes continued on next page

⁶⁸Zn(α,2nγ), ⁶⁷Zn(α,nγ) (continued)

γ(⁷⁰Ge) (continued)

† From 1978C105 and 1979C1ZX; uncertainties given where available.

‡ Relative photon branching from each level at θ=55° from 1975EbZZ except where indicated otherwise.

§ From γ(θ) and linear polarization data (1978C105).

From γ(θ) and T_{1/2} of parent level (1976Mo15).

@ From 1978C105 and 1976Mo15.

⁶⁹Ga(p,γ) 1996Ne07

Partial cross sections for the reaction ⁶⁹Ga(p,γ) were measured and used to determine the partial radiative strength functions of ⁷⁰Ge. Target: 0.68 mg/cm², 99.7% enriched. γ-rays detected using one Ge(Li) detector. Measured E_γ; deduced E_{level}.

⁷⁰Ge Levels

<u>E(level)[†]</u>	<u>E(level)[†]</u>	<u>E(level)[†]</u>
0.0	2153	2535
1039	2157	2807
1216	2307	2945
1708	2452	

† Deduced from measured γ-rays, only E_{level} given in 1996Ne07.

⁶⁹Ga(d,n) 1975ArZH,1974ArZI

Target: J_π=3/2⁻. E_d = 11 MeV; measured σ(θ) to ground and 1216 states; comparison with DWBA.

⁷⁰Ge Levels

<u>E(level)</u>	<u>L</u>
0.0	1
1216	1

$^{69}\text{Ga}(^3\text{He},\text{d})$ 1975Ar29Target $J\pi=3/2^-$.1975Ar29: E=25 MeV by Orsay MP tandem accelerator, 99.75% enriched ^{69}Ga . Split-pole spectrometer with a resolution FWHM=18–21 keV was used. Measured $\sigma(\theta)$, $\theta(\text{lab})=5^\circ-41^\circ$; DWBA analysis.1975La05: E=22.5 MeV, FWHM=15 keV; measured $\sigma(\theta)$, $\theta(\text{lab})=8^\circ-55^\circ$; DWBA analysis. ^{70}Ge Levels

E(level) [†]	L [†]	(2J+1)C ² S [†]	Comments
0.0	1	2.0	
1040 3	1+3	0.96+0.96	
1216 3	1	0.87	
1709 3	1+3	0.39+0.48	
2157 3	1+3	0.81+0.66	
2307 3	1(+3)	0.13	(2J+1)C ² S: <0.03 for L=3.
2452 3	3(+1)	2.27	(2J+1)C ² S: <0.07 for L=1.
2535 3	1+3	0.16+0.62	
2563 3	4(+2)	1.31	(2J+1)C ² S: <0.09 for L=2.
2808 3	3	1.14	
2888 3	1(+3)	0.22	(2J+1)C ² S: <0.05 for L=3.
2941 3	1+3	0.37+2.71	
3053 3	3(+1)	11.7	(2J+1)C ² S: <0.25 for L=1.
3066? § 6			
3102? § 6			
3182 3	1+3	0.84+1.55	
3243 3	1+3	1.22+1.0	
3314 3	2(+4)	0.07	(2J+1)C ² S: <0.02 for L=4.
3335 3	1(+3)	0.59	(2J+1)C ² S: <0.14 for L=3.
3422 3	1+3	0.36+0.45	
3452 3			
3466? § 6			
3481 3	1+3	0.05+0.12	
3517? § 6			
3563? § 6			
3567 3	4(+2)	0.21	(2J+1)C ² S: <0.02 for L=2.
3592? § 6			
3628 3	1(+3)	0.49	(2J+1)C ² S: <0.12 for L=3.
3660? § 6			
3672? § 6			
3687 3	1+3	0.51+0.63	
3716? § 6			
3733 3	1+3	0.05+0.03	
3775 3	1+3	0.03+0.18	
3854 3	4+2(+0)	0.41+0.02	(2J+1)C ² S: <0.02 for L=0.
3888 3	1+3	0.82+1.52	
3903 3	1+3	0.31+0.26	
3964 3	4+2(+0)	0.74+0.04	(2J+1)C ² S: <0.02 for L=0.
3995 3			
4024 3			
4060 3	1+3	0.27+0.15	
4080 3	1+3	0.20+0.31	
4116? § 6			
4129 3	4+2+0	1.03+0.02 [‡]	(2J+1)C ² S: 0.02 for L=0.
4157 3	1+3	0.26+0.22	
4194? § 6			
4212 3			
4238 3	1+3	0.09+0.27	
4287 3	1+3	0.22+0.26	
4330 3	4+2(+0)	1.37+0.07	(2J+1)C ² S: <0.03 for L=0.
4352 3	4+2(+0)	0.80+0.04	(2J+1)C ² S: <0.03 for L=0.
4391 3	1+3	0.20+0.37	
4419 3	4+2	0.08+0.09	
4446 3			
4473 3	1+3	0.12+0.48	
4520 3	4+2	0.53+0.05	
4555 3			
4574 3			

Continued on next page (footnotes at end of table)

$^{69}\text{Ga}({}^3\text{He},d)$ 1975Ar29 (continued) **^{70}Ge Levels (continued)**

$E(\text{level})^\dagger$	$L^\dagger$	$(2J+1)C^2S^\dagger$	Comments
4613 3	1+3	0.12+0.48	
4642 3	4+2(+0)	0.40+0.04	(2J+1) C^2S : <0.02 for L=0.
4687 3	4+2(+0)	2.09+0.13	(2J+1) C^2S : <0.04 for L=0.
4736 3	(4+2+0)	(1.14)	(2J+1) C^2S : S=(0.13) for L=2 and S=(0.04) for L=0.
4768 3	4+2(+0)	0.56+0.06	(2J+1) C^2S : <0.03 for L=0.
4847 3	4+2(+0)	0.74+0.08	(2J+1) C^2S : <0.03 for L=0.
4877 3	4+2+0	1.03+0.03 ‡	(2J+1) C^2S : S=0.02 for L=0.
4905 3	(4+2+0)	(1.01)	(2J+1) C^2S : S=(0.11) for L=2 and S=(0.05) for L=0.
4943 3	4+2(+0)	0.47+0.05	(2J+1) C^2S : <0.03 for L=0.
4979 3	4+2(+0)	0.23+0.03	(2J+1) C^2S : <0.01 for L=0.
5008 3	4+2+0	1.43+0.04 ‡	(2J+1) C^2S : S=0.03 for L=0.
5048 3	4+2+0	1.79+0.02 ‡	(2J+1) C^2S : S=0.01 for L=0.
5078 3	1+3	0.08+0.02	
5102 3	1+3	0.12+0.02	
5145 3	(4+2+0)	(0.79)	(2J+1) C^2S : S=(0.09) for L=2 and S=(0.04) for L=0.

† From DWBA analysis of 1975Ar29, except where indicated otherwise.

‡ Spectroscopic factor calculated assuming g7/2 transfer.

§ Weakly excited level (1975La05).

 $^{69}\text{Ga}(\alpha,t)$ 1975Ar29

Target $J\pi=3/2^-$.

1975Ar29: E=39.35 MeV by Orsay MP tandem accelerator, 99.75% enriched ^{69}Ga . Split-pole spectrometer with a resolution FWHM=20 keV was used. Measured $\sigma(\theta)$, DWBA analysis.

 ^{70}Ge Levels

$E(\text{level})^\dagger$	$L^\ddagger$	$E(\text{level})^\dagger$	$L^\ddagger$	$E(\text{level})^\dagger$	$L^\ddagger$
0.0	(1)	2564 4	(4)	3631 4	(1)
1035 4	(1+3)	2806 4	(3)	3680 4	(1+3)
1215 4	(1)	2887 4	(4)	3851 4	(4)
1705 4	(1+3)	2946 4	(1+3)	3897 4	(1+3)
2152 4	(1+3)	3054 4	(3)	3967 4	(4)
2310 4	(1)	3193 4	(1+3)	4335 4	(4)
2449 4	(3)	3240 4	(1+3)	4688 4	(4)
2533 4	(1+3)	3337 4	(1)	5055 4	(4)

† A nominal uncertainty of 4 keV has been assigned by the authors based on comparison with level energies from $^{69}\text{Ga}({}^3\text{He},d)$.

‡ All values are tentative, being based on a comparison between experimental intensities observed at 9° and 21° to the beam direction and the values calculated using the $({}^3\text{He},d)$ data. The agreement is fairly good.

$^{70}\text{Ge}(\gamma, \gamma')$ 1995Ju01

$E_\gamma=4$ MeV. The scattered γ s were detected by a Ge spectrometer consisting of 4 Ge detectors placed at different scattering angles. Measured $\gamma(\theta)$.

 ^{70}Ge Levels

$E(\text{level})^\dagger$	$J\pi^\S$	Γ (MeV)	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV) ‡	Comments
0.0	0+			
3240.4 4	1	9.1 26	3.0 6	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV): 14 2 at 10 MeV. I_s : Integrated photon scattering cross section = 3.3 eVb 6.
3314.8 4	1	11 3	11 3	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV): 55 6 at 10 MeV. Γ (MeV): $\Gamma=\Gamma_0$. I_s : Integrated photon scattering cross section = 11.3 eVb 27.
3895.1 8	1	14 5	14 5	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV): 31 7 at 10 MeV. Γ (MeV): $\Gamma=\Gamma_0$. I_s : Integrated photon scattering cross section = 10.6 eVb 34.

† From observed ground state gamma-ray transitions.

‡ Values at 4 MeV.

§ Deduced from measured gamma-ray transition multipolarities.

 $\gamma(^{70}\text{Ge})$

$E_\gamma^\dagger$	$E(\text{level})$	Mult. ‡
3240.4	3240.4	D
3314.8	3314.8	D
3895.1	3895.1	D

† From 1995Ju01.

‡ From $\gamma(\theta)$ in 1995Ju01. Intensity ratios $W(90^\circ)/W(127^\circ)$ are presented in Figure 6 and are consistent with dipole character.

 $^{70}\text{Ge}(\text{pol } \gamma, \gamma')$ 1995Ju01

$E_\gamma=9-14$ MeV. The scattered γ s were detected by a Ge spectrometer consisting of 4 Ge detectors located at different scattering angles. Measured E_γ , $\gamma(\theta)$, $\gamma(\text{linear pol})$; deduced Γ .

 ^{70}Ge Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	Γ (MeV) §	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV)	Comments
0.0	0+			
4356.6 7	1(-)	67 11	67 11	$B(E1)\uparrow=0.0023$ 4. I_s : Integrated photon scattering cross section = 40.5 eVb 68.
4447.3 8	1-	111 20	61 11	$B(E1)\uparrow=0.0036$ 7. I_s : Integrated photon scattering cross section = 35.6 eVb 65.
4520.7 9	1-		<67	$B(E1)\uparrow<0.0005$. I_s : Integrated photon scattering cross section = 37.8 eVb 52.
4790.4 19	1(-)	28 16	28 16	I_s : Integrated photon scattering cross section = 13.9 eVb 82. $J\pi$: from 4790.4 γ E1 to 0+.
4886.4 13	1	40 10	40 10	I_s : Integrated photon scattering cross section = 19.2 eVb 46.
5129.4 7	1-	136 38	89 25	$B(E1)\uparrow=0.0029$ 8. I_s : Integrated photon scattering cross section = 38.8 eVb 11.
5263.2 8	1(-)	112 21	112 21	$B(E1)\uparrow=0.0022$ 4. I_s : Integrated photon scattering cross section = 46.6 eVb 88.
5465.1 10	1-	133 22	133 22	$B(E1)\uparrow=0.0023$ 4. I_s : Integrated photon scattering cross section = 51.2 eVb 85.
5512.3 10	1(-)	113 18	113 18	$B(E1)\uparrow=0.0019$ 3. I_s : Integrated photon scattering cross section = 43.0 eVb 67.
5876.6 7	1(-)	96 30	96 30	$B(E1)\uparrow=0.0014$ 4. I_s : Integrated photon scattering cross section = 32.0 eVb 99.
5989.4 7	1(+)	149 31	149 31	I_s : Integrated photon scattering cross section = 48.0 eVb 98.
6296.7 14	1	277 87	147 46	I_s : Integrated photon scattering cross section = 42.8 eVb 14.

Continued on next page (footnotes at end of table)

$^{70}\text{Ge}(\text{pol } \gamma, \gamma')$ 1995Ju01 (continued) **^{70}Ge Levels (continued)**

E(level) [†]	$J\pi^{\ddagger}$	Γ (MeV) [§]	$\Gamma_{\gamma 0}^2/\Gamma$ (MeV)	Comments
6362.5 8	1	133 28	133 28	Is: Integrated photon scattering cross section = 37.9 eVb 80.
6587.4 12	1(+)	333 62	136 25	Is: Integrated photon scattering cross section = 36.1 eVb 67.
6636.3 15	1	168 25	168 25	Is: Integrated photon scattering cross section = 44.1 eVb 66.
6702.2 13	1(-)	289 49	289 49	B(E1) $\uparrow$ =0.0027 5.
				Is: Integrated photon scattering cross section = 74.1 eVb 13.
7305.9 8	1(+)	249 60	249 60	Is: Integrated photon scattering cross section = 53.8 eVb 13.
7425.6 16	1(-)	316 60	316 60	B(E1) $\uparrow$ =0.0022 4.
				Is: Integrated photon scattering cross section = 66.0 eVb 13.
7753.0 10	1(-)	430 92	307 66	B(E1) $\uparrow$ =0.0026 6.
				Is: Integrated photon scattering cross section = 59.0 eVb 13.
8283.2 15	1(+)	307 86	307 86	Is: Integrated photon scattering cross section = 51.5 eVb 15.
8877.9 14	1	332 78	332 78	Is: Integrated photon scattering cross section = 48.5 eVb 12.

[†] From measured ground state gamma-ray transitions in 1995Ju01.[‡] From measured gamma-ray transition multipolarities.[§] $\Gamma=\Gamma_0$ when g.s. transition is assumed to be 100%. **$\gamma(^{70}\text{Ge})$**

$E\gamma^{\dagger}$	E(level)	Mult. [‡]	$E\gamma^{\dagger}$	E(level)	Mult. [‡]	$E\gamma^{\dagger}$	E(level)	Mult. [‡]
4356.6 7	4356.6	(E1)	5465.1 8	5465.1	E1	6636.3 15	6636.3	D
4447.3 8	4447.3	E1	5512.3 10	5512.3	(E1)	6702.2 13	6702.2	(E1)
4520.7 8	4520.7	E1	5876.6 7	5876.6	(E1)	7305.9 8	7305.9	(M1)
4790.4 19	4790.4	(E1)	5989.4 7	5989.4	(M1)	7425.6 8	7425.6	(E1)
4886.4 13	4886.4	D	6296.7 14	6296.7	D	7753.0 10	7753.0	(E1)
5129.4 7	5129.4	E1	6362.5 8	6362.5	D	8283.2 15	8283.2	(M1)
5263.2 8	5263.2	(E1)	6587.4 8	6587.4	(M1)	8877.9 14	8877.9	D

[†] From 1995Ju01.[‡] From $\gamma(\theta)$ and $\gamma(\text{linear pol})$ in 1995Ju01. Evaluators derive multipolarities from the authors given $J\pi$ values. Authors state that for definite $J\pi$ assignments, the analyzing power differed by at least three standard deviations from the value for the opposite parity. If the difference was at least two standard deviations or the value itself very close ($<\sigma/2$) to one or the other parity, the assignment was given as tentative. Specific values for $\gamma(\theta)$ or $\gamma(\text{linear pol})$ were not provided. **$^{70}\text{Ge}(\text{e}, \text{e}')$ 1975Kl10, 1990Kh03**1990Kh03: E=225 MeV; measured elastic scattering cross sections for $\theta(\text{lab})=30^\circ-82^\circ$; phase-shift analysis.1975Kl10: E=84–120 MeV; measured elastic and inelastic scattering cross sections for $\theta=92^\circ-140^\circ$ for momentum transfer from 0.65–1.14 fm⁻¹; DWBA analysis. **^{70}Ge Levels**

E(level) [†]	$J\pi^{\dagger}$	Comments
0.0	0+	R=4.07 fm 2 (1975Kl10), 4.055 fm 8 (1990Kh03); R is the rms value of the charge distribution.
1039.5	2+	B(E2) $\uparrow$ =0.169 10 (1975Kl10).
2562.0	3-	B(E3) $\uparrow$ =0.073 10 (1975Kl10).

[†] From the Adopted Levels.

$^{70}\text{Ge}(\text{n},\text{n}'\gamma)$ 1985DoZW,1987Do14

1987Do14: reactor fast neutrons, enriched target. An anti-Compton Ge(Li)-NaI(Tl) detector system was used to detect γ -rays. Measured $\gamma(\theta)$; sign convention for δ not given by authors.

1985DoZW: reactor fast neutrons, measured $E\gamma$, $I\gamma$, $T_{1/2}$ by DSAM.

1970Ch15: $E=0.5-2.55$ MeV; Ge(Li) detectors; measured $\sigma(\theta)$ for γ rays with pulsed beam TOF system; sign convention for δ not given by authors.

Others: 1969Ko34, 1969Li12, 1971Ko26, and 1988DoZU.

 ^{70}Ge Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$
0.0	0+		2805.8	4+		3334.6	0+ to 3+	
1039.3	2+		2887.4	0+		3371.5	(3,4)	0.3 ps 2
1215.3	0+		2944.4	2+		3417.8	5-	
1707.7	2+		3046.3	3+		3489.1	(3,4+)	
2153.6	4+		3059.0	4+		3581.3	4+	0.6 ps 2
2156.9	2+		3105.6	(0+)		3631.2	(2)+	0.5 ps 1
2306.2	0+		3180.4	2+	0.015 ps 6	3668.8	6-	
2451.2	3+		3293.6	3+,4+		3956	7-	
2535.0	2+	>0.4 ps	3297	6+				
2561.7	3-		3313.9	1-				

† From a least-squares fit to $E\gamma$ s by the evaluators.

‡ From the Adopted Levels.

§ From 1985DoZW by DSAM.

 $\gamma(^{70}\text{Ge})$

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\S$	Mult. ‡	$\delta^\#$	Comments
176.4	1215.3	11.6 3			
251.0	3668.8				
358.8	3417.8				
449.2	2156.9	0.20 2			
492.4	1707.7	0.10 2			
595.1	3046.3	0.7 3			
608.3	3059.0	0.20 2			
651.8	2805.8	0.20 4			
658.5	3956	0.2			
668.3	1707.7	10.6 2	D+Q		δ : -6 +3-10 or -0.6 5 from population parameter method using $\gamma(\theta)$ of 1709 γ to fix the excited state alignment and the $\gamma(\theta)$ of 668 γ to determine δ ; -7 4 or -0.75 25 from Wolfenstein-Hauser-Feshbach statistical model calculations. Sign of δ reversed from that given by 1970Ch15; -10 +5-10 (1987Do14) from $\gamma(\theta)$.
730.8	2887.4	0.20 2			
743.7	2451.2	2.9 3	D+Q	+3.5 9	
758.2	3293.6	0.10 5			
827.6	2535.0	1.6 2			
889.4	3046.3	0.20 2			
892.7	3046.3	0.6 1			
905.5	3059.0	0.7 1			
941.0	2156.9	2.5 2			
1039.3	1039.3	100 5			
1098.5	2805.8	1.6 2			
1114.3	2153.6	6.2 3			
1117.6	2156.9	3.0 5			
1179.5	2887.4	0.20 3			
1217.9	3371.5	0.3 1			
1236.7	2944.4	1.0 1			
1266.9	2306.2	1.1 2			
1319.8	2535.0	0.20 2			
1332.2	3489.1	0.20 2			
1338.6	3046.3	0.3 1			
1351.3	3059.0	0.10 2			
1397.9	3105.6	0.10 3			
1411.9	2451.2	1.3 1	D+Q	-2.2 +5-3	

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$^{70}\text{Ge}(\text{n},\text{n}'\gamma)$ 1985DoZW,1987Do14 (continued) **$\gamma(^{70}\text{Ge})$ (continued)**

$E\gamma^\dagger$	E(level)	$I\gamma^\S$	Mult. ‡	$\delta^\#$	$E\gamma^\dagger$	E(level)	$I\gamma^\S$
1427.6	3581.3	0.3 1			2019.7	3059.0	0.9 1
1495.4	2535.0	2.1 2	D+Q	-0.75	2066.3	3105.6	0.30 2
1522.4	2561.7	4.7 3	D+Q	-0.11 4	2141.1	3180.4	0.7 1
1585.2	3293.6	0.4 1			2156.9	2156.9	0.8 1
1707.7	1707.7	10.2 7			2274.6	3313.9	0.5 1
1781.4	3489.1	0.5 1			2295.3	3334.6	0.6 1
2007.0 [@]	3046.3	0.10 2			2591.9	3631.2	0.30 1

[†] From 1985DoZW.[‡] Deduced from the measured δ in 1987Do14.[§] Relative intensity (1985DoZW).[#] From 1987Do14, unless given otherwise, with all signs changed. $\delta(1522\gamma)$ with adopted value suggests the sign convention of these authors to be opposite to that of Krane-Steffen.[@] The authors' value of 2027.0 appears to be a misprint.

$^{70}\text{Ge}(\text{p},\text{p}'),(\text{pol } \text{p},\text{p}') \quad 1969\text{Hi01},1967\text{Br10}$

1993Mo05: polarized beam, E=22.3 MeV, coupled-channel calculations for one-, two-phonon states.

1969Hi01: E=7.02 and 10 MeV. Scattered protons were detected using photographic emulsions placed at the focal plane of a magnetic spectrograph. FWHM=6 and 10 keV; measured $\sigma(\theta)$ for $\theta=50^\circ$ and 90° ; Hauser-Feshbach analysis.

1967Br10: E=11-12 MeV, FWHM=12 keV; measured $\sigma(\theta)$.

1970Cu03: E=14.5 MeV, FWHM=70 keV; measured $\sigma(\theta)$, $\theta=20^\circ$ - 150° ; coupled-channel analysis.

1985Se05: E=11.5 MeV, incident beam polarized; measured $\sigma(\theta)$, $\theta=25^\circ$ - 165° ; and vector-analyzing power; coupled-channel analysis.

1986Ro08: E=22 MeV; measured $\sigma(\theta)$, DWBA and coupled-channel analysis. Reanalysis of data by 1992Ke07.

 ^{70}Ge Levels

$J\pi$ from 1969Hi01 based on a comparison with Hauser-Feshbach analysis are given in comments.

E(level) [†]	$L^\ddagger$	Comments
0.0		
1039 2	2	$J\pi=2+$. $\beta_2=0.25$ 2 (1992Ke07).
1215 2		$J\pi=0+$.
1707 2		$J\pi=2+$.
2156 3		$J\pi=4+$.
2160 3		$J\pi=2+$.
		E(level): the 2156 and 2160 levels form a doublet with an estimated separation of 3.4 keV 5 (1969Hi01).
2310 2		$J\pi=0+$.
2454 2		$J=(3)$.
2538 2		$J\pi=(1,2+)$.
2565 2	3	$J\pi=3-$; based on the large $\sigma(\text{p},\text{p}')$ at 10 MeV for the 2565-keV level which suggests that it is the one-phonon octupole level.
		$\beta_3=0.265$ 20 (1992Ke07).
2809 2	4	$J\pi=(4+)$.
2890 2	0	$J=0$.
2948 2		$J=(2,1)$.
3049 2		$J\pi=3+$.
3062 2	4	$J\pi=4+$.
		E(level): energy separation of 3049 and 3062 levels is 12.5 keV 3 (1969Hi01).
3109 2		$J=(0)$.
3182 2		
3195 2	4	E(level): energy separation of 3182 and 3195 levels is 13.2 keV 4 (1969Hi01).
3242 2	4	$J=1$.
3296 2	4	
3316 2	1	$J=1$.
		E(level): probable doublet with $J=1$ for one member.
3336 2		
3345 2		
3351 2		
3419 2	5	
3428 2		$J\pi=(5-)$ from coupled-channel fit of 1970Cu03.
3432 2	3	
3456 2	4	
3483 2		$J=(1,2)$.
3489 2	5	$J=3,4$.
3563 3	4	
3570 3		
3581 3	3+5	
3593 3		$J=3,4$.
3633 3	(0)	
3667 3		
3678 3		$J=3,4$.
3691 3		
3710 3	4	
3740 3		
3754 10	(6)	E(level): from 1986Ro08.
3777 3		
3783 3	2+3	
3850 3		
3857 3		
3871 3		
3891 3		
3904 3	(0)	$J=(1,2)$.

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$^{70}\text{Ge}(\text{p},\text{p}'),(\text{pol } \text{p},\text{p}')$ 1969Hi01,1967Br10 (continued) **^{70}Ge Levels (continued)**

E(level) [†]	$L^{\ddagger}$	Comments
3911 3		
3928 3		
3941 10	4	E(level): from 1986Ro08.
3959 10		
3976 3		
3990 3	(2)	
4003 3		
4037 3		
4054 3	4	
4062 3		
4097 3		J=(1,2).
4107 3	3	
4119 3		
4132 3		
4144 3		J=(1,2).
4153 3		
4166 3		
4176 10		
4196 10	8	
4219 10	4	
4227 10		
4242 10		
4261 10		
4282 10	4	
4299 10		
4334 10		
4357 10	4	
4365 10		
4378 10		
4392 10		
4409 10		
4421 10		
4448 10		
4475 10		
4520 10		
4534 10		
4546 10		
4557 10		
4578 10		
4606 10		
4621 10		
4641 10		
4677 10		
4689 10		
4707 10		
4716 10		
4727 10		

[†] The 3959 keV, 4176 keV and higher energy levels are from 1967Br10; the rest are from 1969Hi01 unless indicated otherwise.

[‡] From DWBA analysis (1986Ro08).

1965Mo01, 1966Va09, 1966Va11: $E(p)=5-7$ MeV; measured $\gamma(\theta)$, details not given.

§ From multipolarities deduced from internal conversion measurements in 1985Pa15, unless otherwise stated.

$$X(I, J, K) = B(E0, J(I) \text{ to } J(J)) / B(E2, J(I) \text{ to } J(K)) \text{ from 1985Pa15 are:}$$
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$^{70}\text{Ge}(\text{p,p}'\gamma)$ 1969Hi01,1985Pa15 (continued) $\gamma(^{70}\text{Ge})$ (continued)

E(level)	E γ	I $\gamma^{\S}$	Mult.	I($\gamma+\text{ce}$) [#]	Comments
1215.8	1215.8		E0 [†]	1.00 4	I($\gamma+\text{ce}$): experimental I(ce(K)) increased by 10% to include L-conversion as determined from 1969Ha61. K-conversion decay branch %=0.91 4.
1708.0	492.2 668.4 1708				
2153.0	1113.4				
2156.8	448.8 941	3@ 26@	E2 [‡] E2 [†]		
	1117.2 2156.8	63@ 8@	E2 [‡] E2 [‡]		
2307.1	599.1 1091.3	45 4	E2 [†] E0 [†]	0.007 11	I($\gamma+\text{ce}$): experimental I(ce(K)) increased by 10% to include L-conversion as determined from 1969Ha61. ce(K)(1091 γ)/ce(K)(1268 γ)=0.59 8 (1985Pa15). B(E2)(599 γ)/B(E2)(1268 γ)=35 5 (1985Pa15). I($\gamma+\text{ce}$): includes pair production. I(e ⁺ -)(2307 γ)/ce(K)(1268 γ)=1.6 5 (1985Pa15). ce(K)(2307 γ)/ce(K)(1268 γ)=0.35 10; this corresponds to ce(K)(2307 γ)/I(1268 γ)=6.5 $\times 10^{-5}$ 18 and I(e ⁺ -)(2307 γ)/I(1268 γ)=3.3 $\times 10^{-4}$ 9 (1986PaZR). ce(K)/pair conversion probability=0.20 8; which may be compared with a theoretical ratio=0.212 (1986Pa19,1986Pa23).
2451.6	294.8 298.6 743.6 1412				
2535.4	1319.6 1495.8				
2562.3	1522.7				
2806.7	653.7& 1098.7				
2887.1	730.3				
2945.3	1237.3				
3046.7	240 595.1 889.9 893.7 1338.7 2007.1				
3059.2	252.5 496.9 607.6 902.4 906.2 1351.2 2019.6				
3107.2	1399.2 2067.6				

[†] From internal conversion data (1985Pa15).[‡] Assumed by 1985Pa15.[§] Percent photon branching from each level (1985Pa15).[#] Percent branching from each level (1985Pa15).[@] Percent photon branching from each level calculated using the relative transition probabilities (1985Pa15).

& Placement of transition in the level scheme is uncertain.

$^{70}\text{Ge}(\text{d},\text{d}')$ 1967Kr01,1978Sz08

1967Kr01: $E_{\text{d}}=12$ MeV. Measured $\sigma(\theta)$ for $\theta(\text{lab})=30^\circ-165^\circ$; DWBA analysis.

1978Sz08: $E_{\text{d}}=16$ MeV polarized d provided by Notre Dame Van de Graaff. 84.6% enriched ^{70}Ge target. Scattered particles detected with a scattering chamber using four $\Delta\text{E-E}$ detectors. Measured $\sigma(\theta)$ and vector analyzing power; DWBA and coupled channel analysis.

1985Se05: $E_{\text{d}}=8$ and 16 MeV polarized d provided by Notre Dame Van de Graaff. 84.6% enriched ^{70}Ge target. The reaction products detected with a scattering chamber using four $\Delta\text{E-E}$ detectors. Measured $\sigma(\theta)$ and vector analyzing power; coupled channel analysis.

Other: 2004Ko64.

 ^{70}Ge Levels

E(level) [†]	Comments
0.0	
1040	
1210	
1710	$J\pi=(2+)$ from angular distribution (1967Kr01).
2160	$J\pi=(4+)$ from angular distribution and comparison with angular distribution data on ^{72}Ge (1967Kr01).
2580	$J\pi=(3-)$ from large yield and comparison with 2520 keV level of ^{72}Ge with $J\pi=3-$ (1967Kr01).
3063	$J\pi=4+$ assignment by other reaction studies confirmed by the $\sigma(\theta)$ data; but little could be concluded from the fit to the vector analyzing power (VAP) data (1978Sz08).
3430	$J\pi=4+$ shows better overall fit to the $\sigma(\theta)$ and VAP data; however, it is possible that the data have contributions from more than one level (1978Sz08).
3540	$J\pi=(4+)$ appears to be most consistent with $\sigma(\theta)$ and VAP data; because of the experimental uncertainties of the data on this weakly excited level, this assignment is tentative (1978Sz08).

[†] From 1967Kr01 up to 2580; remaining levels are from 1978Sz08.

 $^{70}\text{Ge}(\alpha,\alpha')$ 1987Sc31

1989Ro12: $E_{\alpha}=36$ MeV provided by Orsay tandem MP. 96.2% enriched ^{70}Ge . The split-pole magnetic spectrometer was used. Measured $\sigma(\theta)$; coupled channel analysis in the framework of harmonic and anharmonic vibrations and asymmetric rotor model and deduced deformation parameters.

1988Ba70: $E_{\alpha}=25$ MeV provided by Radial Ridge Cyclotron at University of Birmingham. 98.84% enriched ^{70}Ge target. FWHM=100–200 keV for the first 2+ and 3– levels, but was poorer for higher levels. Measured $\sigma(\theta)$; coupled channel analysis based on asymmetric rotor and vibrational model and deduced deformation parameters.

1987Sc31: $E_{\alpha}=31.5$ MeV provided by Van de Graaff at Heidelberg. The scattered α -particles were momentum analyzed with a Q3D spectrograph. Measured angular distribution of scattered α -particles. Deduced $\sigma(\theta)$; DWBA analysis with vibrational model form factors and deduced deformation parameters.

 ^{70}Ge Levels

E(level) [†]	$L^{\ddagger}$	Comments
0.0		
1040 10	2	
1214 10	0	
1707 10	2	
2153 10	2+4	
2555 10	3	
2800 10	3	
2942 10	(2)	
3063 10	4	
3130 10	(3)	E(level): this level is possibly the 3139 level in ^{74}Ge present as a 3.4% impurity in the ^{70}Ge target.
3185 10	2	
3200 10	(5)	
3323 10	1	
3427 10	5	
3440 10	3	
3575 10	4	
3637 10	0	
3679 10	4	
3777 10	3	
3870 10	3	

Continued on next page (footnotes at end of table)

$^{70}\text{Ge}(\alpha, \alpha')$ 1987Sc31 (continued) ^{70}Ge Levels (continued)

<u>E(level)[†]</u>	<u>L[‡]</u>	<u>E(level)[†]</u>	<u>L[‡]</u>	<u>E(level)[†]</u>	<u>L[‡]</u>
3908 § 10		4373 10	(3)	4893 10	3
3955 10	7	4418 10	4	4915 10	
3975 10	2	4455 10		4940 10	3
4005 10		4485 10	(3+5)	5010 10	(3)
4040 10	(4)	4532 10	(4)	5040 10	(3)
4092 10	3	4635 10	(4)	5088 10	(4)
4148 10	1	4657 § 10		5113 10	(3)
4268 10	5	4717 § 10		5155 10	(3)
4304 10	7	4775 10	(4)	5195 10	(4)
4336 10	(3+5)	4810 10	3	5227 10	(3)

[†] From 1987Sc31.[‡] From the angular distributions of scattered α -particles.§ $\sigma(\theta)$ smooth indicating a probable multiplet. **$^{70}\text{Ge}(^6\text{Li}, ^6\text{Li}')$ 1989Ja09**

1989Ja09: E(^6Li)=44 MeV provided by Orsay tandem MP Van de Graaff. 96.2% enriched ^{70}Ge target. A split-pole magnetic spectrometer used. Measured $\sigma(\theta)$, DWBA and coupled channel analysis.

2005Ba13: E(^6Li)=28 MeV provided by Sao Paulo Pelletron accelerator. self-supported $30\mu\text{g}/\text{cm}^2$ ^{70}Ge target. A split-pole magnetic spectrometer used. Elastically scattered ^6Li were monitored by a surface barrier detector. Measured angular distributions of scattered ^6Li , $\sigma(\theta)$, DWBA and coupled channel analysis.

 ^{70}Ge Levels

<u>E(level)[†]</u>	<u>L[§]</u>	<u>Comments</u>
0.0		
1038 ‡ 17		$\beta_2=0.180$ 20. Corresponding $\beta_2R=1.06$ 12.
1210 17		
1710 17		
2150 17		
2568 ‡ 17		$\beta_3=0.170$ 20. Corresponding $\beta_3R=1.00$ 11.
3058 17	4	
3176 17	2	
3314 17	4	
3430 17	4	
3573 17	3	

[†] From 1989Ja09.[‡] Deformation parameters based on a vibrational-model coupled-channel analysis.

§ From DWBA analysis (1989Ja09).

Coulomb Excitation

- 2013Gu23: E(⁷⁰Ge) at 196, 225 MeV provided by ESTU tandem accelerator at YALE. Targets: multilayer C or Mg in front, Gd or Fe in the middle, and Ta+Cu at the back. Total of three targets were used with thicknesses 0.42, 0.44, 0.45 mg/cm² for C; 0.5, 0.9 mg/cm² for Mg; 3.24, 3.34, 4.0 mg/cm² for Gd; 1.0, 1.1, 1.4 mg/cm² for Ta; and 3.51, 3.90, 4.49, 4.92, 5.40 mg/cm² for Cu. γ -rays were detected using four HPGe detectors. Charged particles were detected using silicon detectors. Measured: E γ , (particle) γ coin, $\sigma(\theta)$, precession angles. Deduced g factors by Transient Field technique.
- 2007Bo41: E(⁷⁰Ge) at 190,225 MeV beam provided by ESTU tandem accelerator at Yale. Target: multilayer consisting of 0.42 mg/cm² C deposited on successive layers of 5 mg/cm² Ti and 3.24 mg/cm² Ga evaporated onto 1.4 mg/cm² Ta backed by 3.5 mg/cm² of Cu. γ -rays were detected using four HPGe detectors. Charged particles were detected using silicon detectors. Measured: E γ , (particle) γ coin, $\sigma(\theta)$. Deduced g factors by Transient Field technique.
- 2003Su01: ⁷⁰Ge beam provided by tandem accelerator at JAERI. The beam was impinged on a thick natural Pb target. γ -rays were detected using Compton-suppressed 12 HPGe detectors. The scattered ⁷⁰Ge was detected with a position-sensitive detector. Measured: $\gamma(\theta)$. Deduced matrix elements for six low-lying states.
- 1987La20: ³⁴Si beam at 75 MeV provided by Australian National University 14 UD Pelletron accelerator and incident upon a multilayer target (natural Ge target backed with Fe and Cu, respectively). Four Ge detectors were used to detect γ -rays and backscattered beam ions were detected using annular surface-barrier surface counter. Measured: $\gamma(\theta)$; deduced g-factors using TF technique.
- 1983Uh01: E(¹⁶O)=37.0–52.5 MeV, E(¹⁸O)=31.5–57.0 MeV, FWHM=75–200 keV; measured $\sigma(\theta)$ for elastic and inelastic scattering from $\theta(\text{lab})=30^\circ$ – 175° ; DWBA analysis.
- 1980Le24: E(¹⁶O)=36–42 MeV; 98.4% enriched thick ⁷⁰Ge used as a target. One Ge(Li) detector used to detect γ -rays. Measured: E γ , I γ .
- 1980Le16: E(¹⁶O)=29.9 MeV, E(⁶Li)=10.5 MeV. The beams provided by the Universite de Montreal Tandem accelerator. The scattered particles were detected by four surface-barrier detectors. Measured: elastic and inelastic scattering at $\pm 157.5^\circ$ and $\pm 172.5^\circ$.
- 1977Fa07: E(¹⁶O)=36 MeV; measured $\gamma(\theta, \text{H}, \text{t})$ in polarized Gd at 80° K; Reanalysis of data to deduce g-factors from IMPAC measurements in 1969He11.
- 1974Hu01: E(¹⁶O)=33–38 MeV provided by Rutgers–Bell tandem accelerator. γ -rays were detected using NaI detectors. Backscattered particles were detected using an annular Si detector. Measured: $\gamma(\theta)$. Reanalysis of data to deduce g-factors from IMPAC measurements in 1969He11.
- 1969He11: E(¹⁶O)=33–38 MeV. Measured: $\gamma\gamma(\theta, \text{H})$; IMPAC.
- 1967Kr01: E(¹⁶O)=30–37.5 MeV. Measured σ .
- 1984Pa20: E(²⁸Si)=47.3–62.1 MeV provided by Oxford Folded tandem accelerator. γ -rays were detected using four NaI and one Ge(Li) detector. Measured: $\gamma(\theta, \text{H})$; deduced g-factors using Transient Field technique.
- 1972Si06: E(³⁵Cl)=60–83 MeV, and E(³²S)=75.7 MeV. Measured: $\sigma(\text{E}\gamma)$, E γ , γ yield ratios.
- 1969Si15: E α =5–11 MeV, FWHM=20–25 keV; E(¹⁶O)=25, 34–43 MeV, FWHM= 100 keV; measured Coulomb excitation probabilities.
- 1965Ro09: E α =6–9 MeV. Measured: E γ .
- 1962St02: E α =3–10 MeV. Measured: γ yield.

⁷⁰Ge Levels

E(level) [†]	J π [§]	T _{1/2} [#]	Comments
0.0	0+		
1039.5 5	2+	1.31 ps 2	B(E2) $\uparrow$ =0.179 3; g=+0.455 26. B(E2) $\uparrow$: from 1980Le16. Others: B(E2)=0.179 3 (1983Uh01); B(E2)=0.179 3; B(E2)=0.172 21 (1962St02). g: from weighted average of 0.44 4 (2013Gu23, using TF), 0.45 8 (2007Bo41, using TF), 0.370 89 (1987La20, using TF), 0.468 26 (1984Pa20, using TF) and 0.47 10 (1977Fa07, using IMPAC). Others: 0.38 8 (1977Fa07), 0.59 29 (1969He11); the same data reanalyzed by 1974Hu01 gave g=0.88 21; the same data reanalyzed by 1977Fa07 according to the latest understanding of the experiment and corrections give g=0.47 10 (this value is included in the weighted average). Q=+0.04 3 from multistep Coulomb excitation in 2003Su01; Q=+0.03 6 from multistep Coulomb excitation in 1980Le16 and correspond to considering ⁷⁰ Ge to be almost spherical; if it is considered as a moderately deformed oblate spheroid the same data give B(E2)=0.178 3 and Q=+0.09 6; Q=+0.003 100 (1969Si15).
1215.6 5	0+	4.8 ns 7	B(E2) $\uparrow$ =0.014 2. B(E2) $\uparrow$: Coulomb excitation from 1039.5 to 1215.6 level; weighted average of 0.0158 24 (1972Si06) and 0.012 3 (1980Le24). T _{1/2} : Deduced from B(E2).

Continued on next page (footnotes at end of table)

Coulomb Excitation (continued) ^{70}Ge Levels (continued)

E(level) [†]	J π [§]	T _{1/2} [#]	Comments
1708.2 5	2+	4.2 ps +26-14	B(E2) $\uparrow$ =0.0013 10; g=+0.66 37 (2013Gu23). g: weighted average of +0.39 37 and +1.03 44 for two targets and two beam energies in 2013Gu23 using TF. B(E2) $\uparrow$: for Coulomb excitation from g.s. to 1708.2 level (1980Le24). B(E2)(1040 to 1708)=0.050 19; B(E2)(1216 to 1708)=0.018 16 (1980Le24). T _{1/2} : from B(E2) for Coulomb excitation from 1039.5 to 1708.2 level with a branching fraction of 0.53 for the 669 transition from adopted γ 's. Other: 5.4 ps +53 - 18 in 1980Le24. Q: =-0.07 4 from multistep Coulomb Excitation in 2003Su01.
2153.6 5	4+	1.7 ps 4	Q=+0.22 5 (2003Su01); B(E2) $\uparrow$ =0.034 7; g=+0.42 20. g: weighted average of +0.21 63 and +0.22 36 for two targets and two beam energies (2013Gu23, using TF) and 0.5 2 (2007Bo41, using TF). B(E2) $\uparrow$: for Coulomb excitation from 1040 to 2154 level.
2157.5 $\frac{5}{2}$	2+		Q=+0.26 10 (2003Su01).
2562.5 5	3-		B(E3) $\uparrow$ =0.068; g=0.1 3 (2007Bo41). B(E3) $\uparrow$: from 1983Uh01; authors state that large uncertainties in data and possible defects in the first order DWBA do not allow a precise determination of B(E3). Other: 0.043 3 (1980Le24).

[†] From a least squares fit to E γ 's by the evaluators. $\frac{5}{2}$ From 2003Su01.[§] From Adopted Levels.[#] Deduced from reduced transition probabilities in 1980Le24, unless otherwise stated. $\gamma(^{70}\text{Ge})$

E(level)	E γ [‡]	I γ [†]	Mult. [§]	Comments
1039.5	1039.5 5	100	E2	
1215.6	176.1 5	100	E2	
1708.2	492.6 5	1.6 5	E2	Authors (1980Le24) stated that the energy and intensity of this transition taken from (p,p' γ) (1969Hi01).
	668.7 5	100	M1+E2	
	1708.2 5	57 11	E2	
2153.6	1114.1 5	100	E2	
2157.5	942.1			
2562.5	1523.0 5	100		

[†] Relative photon branching from each level (1980Le24). $\frac{5}{2}$ From 1980Le24, unless otherwise stated.[§] From Adopted Levels.

$^{72}\text{Ge}(\text{p},\text{t})$ 1977Gu12

1977Gu12: $E_p=26$ MeV provided by Orsay MP tandem accelerator. A split-pole spectrometer was used. FWHM=10 keV.

Measured $\sigma(\theta)$, $\theta(\text{lab})=5^\circ-60^\circ$; DWBA analysis.

1974Ba67: $E=20$ MeV, FWHM=30–40 keV; measured $\sigma(\theta)$, $\theta(\text{lab})=15^\circ-65^\circ$; DWBA analysis.

Others: 1982Be13, 1982Be45.

 ^{70}Ge Levels

$E(\text{level})^\dagger$	$L^\dagger$	$S^\#$	$E(\text{level})^\dagger$	$L^\dagger$	$S^\#$	$E(\text{level})^\dagger$	$L^\dagger$	$S^\#$
0.0	0	1.5	3412 3	5	0.6	4345 20	2	0.18
1037 3	2		3424 3	(2)	0.17	4357 20	2	0.14
1212 3	0	0.12	3455 3			4449 3	2	0.27
1708 3	2		3481 3			4472 3	4	0.26
2155 $\ddagger$ 3			3566 $\S$			4539 3	0	0.035
2311 3	0	0.018	3634 3	(2)	0.83	4629 3		
2538 3	2	0.29	3683 3	0	0.049	4712 20	(2)	0.12
2562 3	3	0.91	3740 3	0	0.007	4935 3	1	0.038
2806 3	4	0.1	3780 3	2	0.35	5024 3	2	0.18
2891 3	0	0.01	3868 3			5050 3	0	0.008
2947 3	2	0.22	3898 $\ddagger$ 3	(1)	0.008	5184 3	0	0.013
3054 3	4	0.89	3922 3	4	0.17	5290 3	0	0.033
3105 3	(0)	0.003	4028 3	4	0.49	5338 3	0	0.014
3176 3	2	0.6	4086 3	4	0.21	5403 3	0	0.014
3188 3	4	0.73	4180 3	2	0.55	5410 3		
3292 3			4226 3	2	0.13	5441 3	(2)	0.16
3308 3	(1)	0.012	4242 3	(4, 5)		5467 3	0	0.018
3329 $\ddagger$ 3			4264 20	2	0.061			
3340 $\ddagger$ 3			4332 20	0	0.046			

† From 1977Gu12.

$\ddagger$ Unresolved doublet.

$\S$ Mixed with tritons from (p,t) reactions on other Ge isotopes.

$\#$ $\sigma(\text{exp at peak})/\sigma(\text{DWBA})$; estimated uncertainty 20% in absolute values.

 $^{74}\text{Se}(\text{d},^6\text{Li})$ 1982Va08

Reaction products were momentum analyzed and identified with QMG/2 magnetic spectrograph and its focal plane detection system. Measured $\sigma(\theta)$, $\theta(\text{lab})=6^\circ-30^\circ$; DWBA analysis.

 ^{70}Ge Levels

$E(\text{level})$	L	$S^\dagger$
0.0	0	0.49
1037	2	0.20
1212	0	0.13

† $(2J+1)\sigma(\theta)(\text{exp})/\sigma(\theta)(\text{DWBA})$; estimated uncertainty 15%.

Adopted Levels, Gammas

Q(β⁻)=-2410 50; S(n)=9300 60; S(p)=4530 50; Q(α)=-3040 50 2012Wa38.
S(2n)=21590 50; S(2p)=11830 50 (2012Wa38).

⁷⁰As Levels

Cross Reference (XREF) Flags

A ⁷⁰Se β⁺ Decay
B ⁹Be(⁷⁸Rb,⁷⁰Asγ)
C ⁵¹V(²⁸Si,2αnγ),⁴⁶Ti(²⁸Si,3pnγ)

D ⁵⁵Mn(¹⁸O,3nγ)
E ⁵⁸Ni(¹⁴N,2pγ),⁵⁶Fe(¹⁶O,npγ)
F ⁷⁰Ge(p,nγ)

E(level) [†]	Jπ	XREF	T _{1/2} [‡]	Comments
0.0	4+	ABCDEF	52.6 min 3	%ε+%β ⁺ =100; Q=0.09 2; μ=+2.1061 2 (1980Ho02,2014StZZ). Jπ: J=4 from atomic-beam resonance method (1976He24); π from shell model agrees with μ. Possible configuration=((πf _{5/2})(vf _{5/2})). T _{1/2} : weighted average of 53.0 min 6 (1968De16), 52.5 min 3 (1968Bo40), and 52 min 1 (1952Ve09). μ,Q: from atomic beam resonance method. Values are from 2014StZZ, the original values of μ=+2.1054 2 and Q=0.094 from 1980Ho02 are uncorrected for diamagnetic shielding.
32.046 23	2+	ABCDEF	96 μs 3	Jπ: from 32.05γ E2 to 4+, 49.5γ from 1+.
81.54 3	1+	A F	<3 ns	Jπ: log ft=4.76 from 0+ parent.
166.734 24	3+	BCDEF	6.0 ns 5	T _{1/2} : from delayed coincidences in ⁵⁸ Ni(¹⁴ N,2pγ) (1987Ba39, 1991Ba43). Jπ: from 166.83γ M1 to 4+; 134.63γ M1(+E2) to 2+.
167.74 3	(2)+	A F	<3 ns	Jπ: no direct β ⁺ /ε feeding from 0+ parent; 160.89γ M1(+E2) from 1+.
234.74 3	1+	A F	<1 ns	Jπ: log ft=5.53 from 0+ parent; 202.66γ M1 to 2+.
325.66 3	2+	A F		Jπ: from 293.66γ M1 to 2+, 244.10γ M1 to 1+; no direct β ⁺ /ε feeding from 0+ parent.
328.65 3	1+	A F		Jπ: from 296.64γ M1 to 2+, 247.11γ M1(+E2) to 1+; log ft=6.2 from 0+ parent.
344.65 3	(0)+	A F	<1 ns	Jπ: from 263.13γ M1 to 1+, excitation function and comparison with Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
383.33 3	2-	F	<1 ns	Jπ: from 301.80γ E1 to 1+, γ(θ) in (p,nγ).
390.14 3	3+	CDEF	<1 ns	Jπ: from 390.15γ M1 to 4+, 223.42γ M1 to 3+, γ(θ) in (p,nγ).
425.33 5	(0)+	F		Jπ: from 343.81γ M1 to 1+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
458.16 3	1+	A F		Jπ: log ft=4.29 from 0+ parent.
485.324 22	4-	BCDEF	4.1 ns 4	T _{1/2} : weighted average of 4.5 ns 10 from ⁷⁰ Ge(p,nγ) (deduced from off-beam Iγ in 1979Te06) and 4.0 ns 4 from ⁵⁸ Ni(¹⁴ N,2pγ) (delayed coincidences) (1987Ba39, 1991Ba43). Jπ: J=4 from γ(θ) in (p,nγ); π from 318.60γ E1+M2 to 3+.
508.84 6	3+	F		Jπ: from 476.75γ M1 to 2+; 342.24γ M1 to 3+, γ(θ) in (p,nγ).
540.01 4	2+	F		Jπ: from 458.48γ M1 to 1+, γ(θ) in (p,nγ).
566.52 ^a 4	5(-)	BCDEF	<2 ns	Jπ: from 81.19γ D+Q to 4-; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ). T _{1/2} : from delayed γγ coincidence in ⁵⁸ Ni(¹⁴ N,2pγ). Other < 3 ns from ⁷⁰ Ge(p,nγ).
571.95 4	2+	F		Jπ: from 539.92γ M1+E2 to 2+, 490.35γ to 1+; γ(θ) in (p,nγ).
581.62 4	1+	A F		Jπ: log ft=5.08 from 0+ parent.
592.52 4	1+, 2+	F		Jπ: from 424.87γ M1 to 2+.
625.21 4	4+	F		Jπ: from 235.10γ M1(+E2) to 3+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
641.86 4	3+	F		Jπ: from 474.12γ M1 to 2(+); Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
683.97 7	(0)	F		Jπ: from 449.24γ to 1+; 358.32γ to 2+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
687.59 4	(3+, 4+)	F		Jπ: from 519.85γ to 2+, 520.82γ to 3+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
698.88 4	3-	F		Jπ: 315.53γ M1 to 2-, γ(θ) in (p,nγ).
721.90 4	(3)	F		Jπ: from 640.35γ to 1+; 689.88γ to 2+; 555.11γ to 3+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
772.30 3	3-	F		Jπ: from 388.96γ M1 to 2-; 286.96γ M1 to 4-.
778.96 4	(4-)	F		Jπ: from 293.63γ to 4-; 80.04γ to 3-; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
815.48 5	(3)	F		Jπ: from 783.35γ to 2+; Hauser-Feshbach analysis in ⁷⁰ Ge(p,nγ).
868.90 ^{&} 6	6(-)	BCDEF		Jπ: from 302.41γ (M1+E2) to 5(-); γ(θ) in (p,nγ).
887.61 ^b 20	7(-)	BCDE	4.5 ns 3	μ=0.75 5 (1991Ba43). μ: from perturbed angular distribution from an implanted source (1991Ba43). Jπ: from 321.1γ E2 to 5(-); based on excitation function and linear polarization measurements in ⁵⁸ Ni(¹⁴ N,2pγ). T _{1/2} : from delayed coincidences in ⁵⁸ Ni(¹⁴ N,2pγ) (1987Ba39, 1991Ba43).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{70}As Levels (continued)

E(level) [†]	J π	XREF	T _{1/2} [‡]	Comments
890.47 4	1+	A F	5.5 ns 10	J π : from log ft=5.64 from 0+ parent.
898.30 6	(5)	BCDEF		J π : from 331.74 γ to 5-; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
928.14 5	(2, 1)	F		J π : from 602.54 γ to 2+; 761.30 γ to 3+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
933.20 15		BC E		
938.96 5	4-	F		J π : from 372.39 γ M1+E2 to 5-, 555.66 γ to 2-; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
939.28 5	(2, 1)	F		J π : from 857.82 γ to 1+, 772.50 γ to 3+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
950.28 9	(0)	F		J π : from 621.63 γ to 1+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
966.86 9	(5)	F		J π : from 576.72 γ to 3+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
987.80 8	(0, 3)	F		J π : from 906.32 γ to 1+; 662.10 γ to 2+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
1003.62 5	1, 2	F		J π : from 578.20 γ to 0+; 678.03 γ to 2+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
1026.33 4	(1-, 2)	F		J π : from 944.85 γ to 1+; 254.01 γ to 3-; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
1045.85 9	6(-)	BCDEF		J π : from 479.35 γ (D+Q) to 5(-), (E2) 938 γ from 8(-).
1046.43 5	(1, 2)	F		J π : from 964.86 γ to 1+; 656.20 γ to 3+; Hauser-Feshbach analysis in $^{70}\text{Ge}(\text{p},\text{n}\gamma)$.
1115.08 7	(1, 2)	F		J π : from 656.80 γ to 1+, 789.43 γ to 2+.
1454.01 20	6+	BCDE		J π : D 556 γ to 7(-), 1454 γ to 4+.
1496.01 ^a 18	7(-)	D		J π : E2 930 γ to 5(-), band assignment.
1651.2 4	1+	A		J π : log ft=4.99 from 0+ parent.
1675.86 [#] 25	8(+)	BCDE	55 ps 20	J π : from 788.3 γ (E1+M2) to 7(-); J=8 from $\gamma(\theta)$ and excitation function in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$. T _{1/2} : from line-shape analysis in $^9\text{Be}(^{78}\text{Rb}, ^{70}\text{As}\gamma)$ Other: < 2 ns in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$.
1725.8 4		D		J π : 7(+) proposed in $^{55}\text{Mn}(^{18}\text{O}, 3\text{n}\gamma)$.
1752.0 [§] 3	9(+)	BCDE	59 ps 30	J π : from 76.1 γ D(+Q) to 8(+); J=9 from $\gamma(\theta)$ and excitation function in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$. T _{1/2} : from line-shape analysis in $^9\text{Be}(^{78}\text{Rb}, ^{70}\text{As}\gamma)$. Other: < 2 ns in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$. Configuration: (($\pi g_{9/2}$)($\nu g_{9/2}$)).
1765.5 3		D		
1806.8 4	7(-)	D		J π : E2 771.5 γ from 9(-).
1809.2 3		E		
1983.2 ^{&} 3	8(-)	D		J π : E2 1115 γ to 6(-), band assignment.
2282.1 ^b 3	9(-)	D		J π : E2 1394 γ to 7(-); band assignment.
2379.4 8	9(+)	D		J π : D+Q 703.5 γ to 8(+).
2467.2 4	9(+)	BCDE		J π : D+Q 791.5 γ to 8(+).
2579.0 ^a 3	9(-)	D		J π : E2 1082 γ to 7(-); band assignment.
2579.8 [#] 3	10(+)	BCDE	0.53 ps [@] 4	J π : E2 904 γ to 8(+). Other: J>9 from the slope of the excitation function in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$.
2691.0 4	9(+)	D		J π : D+Q 1015 γ to 8(+).
2732.7 [§] 3	11(+)	BCDE	0.527 ps 14	T _{1/2} : from DSAM in $^{55}\text{Mn}(^{18}\text{O}, 3\text{n}\gamma)$. Other: 0.76 ps 21 from DSAM in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, \text{n}\text{p}\gamma)$. J π : E2 981 γ to 9(+); band assignment.
2873.2 4	10(+)	D		J π : D+Q 1121 γ to 9(+).
3272.3 3	11(+)	CD		J π : 11(+) proposed in $^{55}\text{Mn}(^{18}\text{O}, 3\text{n}\gamma)$.
3300.6 ^{&} 5	10(-)	D		J π : E2 1317 γ to 8(-), band assignment.
3694.5 11	10(+)	D		J π : D+Q 1227 γ to 9(+).
3772.2 ^a 3	11(-)	D		J π : E2 1194 γ to 9(-); band assignment.
3792.2 [#] 4	12(+)	D	<0.31 ps [@]	J π : E2 1212 γ to 10(+); band assignment.
4076.0 [§] 7	13(+)	BCDE	0.069 ps [@] 7	T _{1/2} : other: <0.49 ps from effective lifetime from DSAM in $^{58}\text{Ni}(^{14}\text{N}, 2\text{p}\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, \text{n}\text{p}\gamma)$. J π : E2 1343 γ to 11(+), band assignment.
4114.3 5	(11-)	D		J π : 1833 γ to 9(-).
4206.5 ^{&} 3	12(-)	CD	<0.76 ps [@]	J π : E2 906 γ to 10(-); band assignment.
4604.5 3	13(-)	D		J π : E2 832 γ to 11(-).
4818.8 4	14(-)	D	<2.2 ps [@]	J π : E2 612 γ to 12(-).
5364.9? 6	14(-)	D		J π : D+Q 760 γ to 13(-), 1159 γ to 12(-).
5457.9 [§] 10	(15+)	D	<0.18 ps [@]	J π : 1382 γ to 13(+); band assignment.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{70}As Levels (continued)

E(level) [†]	J π	XREF	Comments
5498.4 5	15 (–)	D	J π : E2 894 γ to 13(–).
5884.1 7	15 (–)	D	J π : D+Q 1065 γ to 14(–).
6246.5 7	(16–)	D	J π : 1428 γ to (14–).

[†] From a least-squares fit to E γ , by evaluators.[‡] From delayed $\gamma(t)$ $^{70}\text{Ge}(p,n\gamma)$, except where noted.[§] (A): Based on 9+, 1752-keV level. Configuration= $\pi g_{9/2} \otimes \nu g_{9/2}$, $\alpha=1$.# (B): Based on 8+, 1676-keV level. Configuration= $\pi g_{9/2} \otimes \nu g_{9/2}$, $\alpha=0$.@ From DSAM in $^{55}\text{Mn}(^{18}\text{O},3n\gamma)$.

& (C): Negative parity band based on 6(–), 869-keV level.

a (D): Negative parity band based on 5(–), 567-keV level.

b (E): Negative parity band based on 7(–), 888-keV level.

 $\gamma(^{70}\text{As})$

E(level)	E γ [†]	I γ [†]	Mult.@	δ^a	α	Comments
32.046	32.05 [§] 3	100 [§]	E2		50.3	B(E2)(W.u.)=0.198 7. Mult.: from comparison with RUL and $\alpha(L)$ exp in β^+ decay in 1974Te04, no direct β^+ /EC-feeding observed. Other: Estimated from the transition probabilities deduced from measured half-life in 1979Te06.
81.54	49.51 [§] 3	100 [§]	(M1)&		0.643	B(M1)(W.u.)>0.037. Mult.: ce data indicate E1 or M1; M1 based on the decay pattern.
166.734	134.63 5	100 6	M1(+E2)&	–0.01 4	0.0404 8	B(M1)(W.u.)=0.00118 14.
	166.83 10	23.0 20	M1		0.0230	B(M1)(W.u.)=0.000143 19.
167.74	86.19 3	46.0 24	[M1+E2]		0.8 7	
	135.68 5	100 6				
234.74	153.18 3	12.0 9	[M1+E2]		0.09 7	
	202.66 3	100 7	M1		0.01392	B(M1)(W.u.)>0.0023.
325.66	90.96 8	3.7 6				
	158.89 9	5.1 6				
	244.10 3	100 6	M1		0.00869	
	293.66 5	20.3 15	M1		0.00550	
328.65	93.88 7	4.0 8				
	160.89 3	100 6	M1(+E2)	+0.05 ^b 28	0.026 11	
	247.11 3	40.0 25	M1(+E2)	–0.16 ^b 40	0.009 4	
	296.64 3	50 3	M1		0.00537	
344.65	109.84 6	3.5 7				
	263.13 3	100 6	M1		0.00721	B(M1)(W.u.)>0.0011.
	312.62 5	9.6 12	[E2]		0.01199	B(E2)(W.u.)>0.93.
383.33	148.57 3	17.0 9	[E1+M2]	+0.14 7	0.027 5	B(E1)(W.u.)>1.5 $\times 10^{-5}$. δ : measured δ results in B(M2) value which exceeds the RUL.
	215.51 15	2.0 4				
	301.80 3	100 5	E1		0.00290	B(E1)(W.u.)>1.1 $\times 10^{-5}$.
	351.29 4	10.8 8				
390.14	223.42 ^d 3	100 ^d 6	M1		0.01086	B(M1)(W.u.)>0.0015.
	390.15 4	33.1 19	M1		0.00277	B(M1)(W.u.)>9.1 $\times 10^{-5}$.
425.33	190.52 6	10.2 14				
	343.81 10	100 6	M1		0.00375	
458.16	113.50 4	7.0 9				
	129.49 17	1.0 2				E γ , I γ : from ^{70}Se β^+ decay.
	132.51 4	11.3 13				
	223.38 ^d 9	4 ^d 3				
	290.2 4	1.5 4				E γ , I γ : from ^{70}Se β^+ decay.
	376.64 4	29.0 22	M1		0.00302	
	426.11 3	100 8	M1		0.00225	
485.324	95.18 6	1.1 5	[E1]		0.0859	B(E1)(W.u.)=7 $\times 10^{-7}$ 3.

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{As})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult.@	δ^a	α	Comments
485.324	318.60 3	100 6	E1+M2	-0.041 20	0.00252 5	B(E1)(W.u.)= 1.60×10^{-6} 20; B(M2)(W.u.)=0.12 11. Mult.: from $\gamma(0)$ and $\gamma(\text{lin pol})$ in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$.
	485.31 3	86 6	E1 (+M2)	-0.004 15	8.24×10^{-4}	B(E1)(W.u.)= 3.9×10^{-7} 5.
508.84	342.24 10	43 3	M1		0.00379	
	476.75 6	100 7	M1		1.74×10^{-3}	
540.01	458.48 3	100	M1		0.00190	
566.52	81.19 3	100	D+Q	0.08 4		
571.95	404.15 8	20 3				
	490.35 10	19.4 20				
	539.92 3	100 7	M1+E2	+0.11 ^b 8	1.32×10^{-3} 3	
581.62	255.96 4	70 4	M1		0.00772	
	413.89 4	100 7	M1		0.00241	
	500.10 6	48 4				
	549.50 10	16 4				
592.52	263.93 14	9.0 25				
	357.81 7	19 5				
	424.87 51	31 8	M1		0.00227	
	560.46 4	100 8				
625.21	235.10 4	63 5	M1 (+E2)	<0.35	0.0108 13	δ : from $\alpha(K)_{\text{exp}}$ in $^{70}\text{Ge}(p, n\gamma)$ (1995Po03).
	458.41 8	18 8				
	625.17 7	100 11				
641.86	474.12 3	100	M1		1.76×10^{-3}	
683.97	358.32 9	54 10				
	449.24 10	100 10				
	516.1 4	<16				
687.59	297.51 6	8.0 25				
	519.85 12	26 18				
	520.82 5	100 19				
698.88	315.53 3	100	M1		0.00462	
721.90	554.04 15	10 6				
	555.11 8	36 7				
	640.35 6	73 8				
	689.88 5	100 12				
772.30	286.96 4	36.2 25	M1		0.00582	
	388.96 4	100 7	M1		0.00279	
778.96	80.04 6	2.4 8				
	293.66 5	100 6				
815.48	275.52 7	22 5				
	647.81 7	75 10				
	783.35 6	100 10				
868.90	302.41 5	100	(M1+E2)&	0.044 23	0.00513	
887.61	321.1 [‡] 3	100	E2		0.01093	B(E2)(W.u.)=2.13 15. Mult.: E2 from RUL. E2+M3 with $\delta = 0.04$ 3 in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, however, this results in an M3 component which exceeds RUL.
890.47	545.83 5	100 9				
	561.88 11	56 10				
	564.78 6	49 7				
	858.40 13	15 7				
898.30	29.8 ^e 2					E_{γ} : from $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$.
	331.74 5	100				
928.14	602.54 9	100 10				
	761.30 9	24 5				
	896.10 6	28 5				
933.20	34.7 [‡] 2	100 33				
	64.5 [‡] 2	100 33				
938.96	166.69 10	100 30				
	240.07 7	37 8				
	372.39 8	56 12	M1+E2		0.0048 18	
	555.66 8	56 19				
939.28	549.11 8	60 10				
	704.61 12	45 10				

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{As})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. @	δ^a	α	Comments
939.28	772.50 8	69 10				
	857.82 11	100 10				
950.28	621.63 9	100				
966.86	576.72 9	100				
987.80	662.10 10	100 50				
	906.32 12	29 3				
1003.62	578.20 7	100 16				
	659.02 6	100 20				
	675.02 25	88 24				
	678.03 13	56 24				
1026.33	254.01 4	100 9				
	327.37 10	68 9				
	944.85 6	76 12				
1045.85	479.35 9	100	(D+Q)	-2.9 3	0.00516 13	Mult., δ : D+Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$, in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$ multipolarity is given as E1+M2 with $\delta=-2.9$ 3. Evaluators note that this is a very large, non-zero value of δ for a level with no measured lifetime.
1046.43	656.20 20	14 9				
	878.75 9	86 12				
	964.86 6	100 12				
1115.08	656.80 20					
	789.43 7					
1454.01	408.2# 3	18# 4				
	566.4# 1	100# 8	D ^c			
	1454.2# 8	13# 6				
1496.01	626.9# 2	100# 10	D+Q ^c			
	929.6# 4	62# 19	E2 ^c		4.60×10 ⁻⁴	
1651.2	1323.7\$ 12	100\$ 25				
	1570.5\$ 9	83\$ 8				
	1618.8\$ 4	50\$ 8				
1675.86	221.8# 4	1.4# 5				
	743.0e 2	13.0 20				$E\gamma, I\gamma$: from $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$. Multipolarity for this transition was given D+Q in 1978Fi09 but this transition was not observed in 1991Ba43 or 2015Ha25 and thus, marked questionable by the evaluators. B(E1)(W.u.)=1.5×10 ⁻⁵ 6; B(M2)(W.u.)=0.03 +5-2.
	788.3# 2	100.0# 5	(E1+M2)&	0.017 13	2.70×10 ⁻⁴	
1725.8	271.8# 3	100#	D+Q ^c			
1752.0	76.1‡ 1	100‡	(M1(+E2))	0.01 3	0.191 4	B(M1)(W.u.)=0.7 4. Mult.: D(+Q) from $\gamma(0)$ in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$, M1(+E2) from assumed member of rotational band.
1765.5	312.0# 6	25# 8				
	719.5# 5	23# 10				
	896.4 6	100 19				
1806.8	919.0# 4	100	D+Q ^c			
1809.2	57.2‡ 2	100				
1983.2	938.4# 6	30# 9	(E2)		4.50×10 ⁻⁴	Mult.: Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$, $\Delta\pi=\text{no}$ from level scheme.
	1114.7# 4	100# 10	E2 ^c		3.02×10 ⁻⁴	
2282.1	1394.4# 3	100	E2 ^c		2.37×10 ⁻⁴	
2379.4	703.5# 8	100	D+Q ^c			
2467.2	741.5# 98	31# 14				
	791.5# 9	100# 30	D+Q ^c			
2579.0	596.3 3	100 30	M1+E2		0.00127 23	Mult.: D+Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$, $\Delta\pi=\text{no}$ from level scheme.
	771.5# 8	9# 3	E2 ^c		7.37×10 ⁻⁴	
	1081.9# 5	53# 15	E2 ^c		3.22×10 ⁻⁴	
2579.8	827.9# 3	61# 12	M1+E2		0.00056 6	Mult.: D+Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$, $\Delta\pi=\text{no}$ from level scheme.
	904.0# 4	100# 12	E2 ^c		4.93×10 ⁻⁴	B(E2)(W.u.)=64 12.

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{As})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult. @	α	Comments
2691.0	1015.1# 3	100	D+Q ^c		
2732.7	153.0# 3	4.3# 8			
	980.7# 3	100# 1	E2	4.04×10^{-4}	B(E2)(W.u.)=66.2 21. Mult.: E2 from RUL. E2+M3 with $\delta = -0.06$ 3 in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, however, this results in an M3 component which exceeds RUL.
2873.2	406.1# 4	10# 7			
	1121.1# 4	100# 25	D+Q ^c		
3272.3	693.2# 3	100# 22	D+Q ^c		
	805.1# 4	39# 11			
	1521.3 8	33 6			
3300.6	1317.0# 7	100	E2 ^c	2.41×10^{-4}	
3694.5	1227.3# 10	100	D+Q ^c		
3772.2	1194.0# 8	44# 11	E2 ^c	2.66×10^{-4}	
	1490.0# 3	100# 17	E2 ^c	2.44×10^{-4}	
3792.2	1058.9# 6	39# 14	D+Q ^c		
	1212.0# 6	100# 14	E2 ^c	2.60×10^{-4}	B(E2)(W.u.)>29.
4076.0	1343.3# 6	100	E2 ^c	2.39×10^{-4}	B(E2)(W.u.)=109 12.
4114.3	1832.8# 10	100			
4206.5	905.7# 6	100# 14	E2	4.90×10^{-4}	B(E2)(W.u.)>37. Mult.: Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$; M2 excluded by comparison to RUL.
	934.1# 8	8# 4	[E1]	1.91×10^{-4}	B(E1)(W.u.)> 2.7×10^{-5} .
	1474.0# 3	85# 14	E1	3.15×10^{-4}	Mult.: D from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$; $\Delta\pi=\text{yes}$ from level scheme.
4604.5	398.0# 1	25# 3	D+Q ^c		
	490.3# 4	22# 8			
	812.1# 3	12# 3	D		
	832.4# 3	100# 23	E2	6.05×10^{-4}	
4818.8	612.3# 3	100 11			Mult.: Q from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$; M2 excluded by comparison to RUL.
	743.2# 2	72# 11	(E1) ^c	3.06×10^{-4}	B(E1)(W.u.)>0.00018. Mult.: D from R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$; $\Delta\pi=\text{no}$ from level scheme. E γ : placement from $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$. A 743 γ is placed from the 1676-keV level in $^{51}\text{V}(^{28}\text{Si}, 2\alpha n\gamma)$, $^{46}\text{Ti}(^{28}\text{Si}, 3p n\gamma)$ and $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$.
5364.9?	759.9# ^e 6	100# 40	D+Q ^c		
	1159.2# ^e 8	80# 40	^c		
5457.9	1381.8# 8	100	[E2]	2.37×10^{-4}	B(E2)(W.u.)>36.
5498.4	893.9# 4	100	E2 ^c	5.06×10^{-4}	
5884.1	1065.3# 5	100	D+Q ^c		
6246.5	1427.7# 6	100			

[†] From $^{70}\text{Ge}(p, n\gamma)$, except where noted.[‡] From $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$.[§] From ^{70}Se β^+ decay.# From $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$.@ From $^{70}\text{Ge}(p, n\gamma)$, based on $\alpha(\text{K})\text{exp}$ and/or $\gamma(\theta)$, except where noted.& From $\gamma(\theta)$ and linear polarization in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$.a From $\gamma(\theta)$ in $^{58}\text{Ni}(^{14}\text{N}, 2p\gamma)$, $^{56}\text{Fe}(^{16}\text{O}, np\gamma)$, except where noted.b From $^{70}\text{Ge}(p, n\gamma)$, based on $\gamma(\theta)$.c From R(DCO) in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$. Stretched Q transitions are taken as E2 in character.

d Multiply placed; intensity suitably divided.

e Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas (continued)

 $^{70}_{33}\text{As}_{37}$

(E) Negative parity band based on 7(-), 888-keV level.

 $^{70}_{33}\text{As}_{37}$

Adopted Levels, Gammas (continued)

$^{70}\text{Se} \beta^+$ Decay 1974Te04

Parent ^{70}Se : $E=0.0$; $J\pi=0^+$; $T_{1/2}=41.1$ min 3; $Q(\text{g.s.})=2410$ 50; $\%\beta^+$ decay=100.

1974Te04: ^{70}Se source produced by $^{70}\text{Ge}(^3\text{He}, 3n)$ at $E=35$ MeV. Please see the paper for the details of the target and the chemical separation techniques used and the corrections for the contaminations. γ -rays were detected using one Compton suppressed Ge(Li) detector. The low energy γ -rays were measured using a LEPS detector. Measured: E_γ , I_γ , I_e , $\gamma\gamma$ coincidences.

1968Bo40: ^{70}Se source produced by $^{59}\text{Co}(^{14}\text{N}, 3n)$ at $E_{\text{beam}}=140$ MeV. γ -rays detected using a Ge(Li) detector. The decay of ^{70}Se and ^{70}As were detected using a GM counter.

 ^{70}As Levels

E(level)	$J\pi^\dagger$	E(level)	$J\pi^\dagger$	E(level)	$J\pi^\dagger$
0.0	4+	234.78 7	1+ ‡	458.21 5	1+ ‡
32.05 3	2+	325.67 7	2+	581.58 9	1+ ‡
81.56 4	1+ ‡	328.70 22	1+	890.57 13	1+ ‡
167.71 6	(2)+	344.75 9	(0)+	1650.95 94	1+ ‡

† From Adopted Levels.

‡ 1+ from log *ft*.

 β^+, ϵ Data

$E\epsilon$	E(level)	$I\beta^{+\ddagger}$	$I\epsilon^\ddagger$	Log <i>ft</i>	$I(\epsilon+\beta^+)^\dagger^\ddagger$
(760 50)	1650.95		0.81 11	4.99 9	0.81 11
(1520 50)	890.57	0.056 21	0.72 7	5.64 6	0.78 7
(1830 50)	581.58	1.6 3	3.9 4	5.08 6	5.5 4
(1950 50)	458.21	18.2 22	26.7 24	4.29 6	44.9 22
(2070 50)	344.75	0.5 6	0.5 6	6.1 6	1.0 12
(2080 50)	328.70	0.42 9	0.41 9	6.17 11	0.83 17
(2180 50)	234.78	2.70 23	1.95 21	5.53 6	4.65 25
(2330 50)	81.56	27.2 19	13.2 14	4.76 6	40.4 22

† From intensity balance of each of level in 1974Te04.

‡ Absolute intensity per 100 decays.

 $\gamma(^{70}\text{As})$

I_γ normalization: from the sum of intensities of γ 's feeding the 32 level and assuming that there is no direct feeding of g.s. ($\Delta J=4$) or 32 level ($\Delta J=2$).

E_γ	E(level)	$I_\gamma^\dagger^\S$	Mult. ‡	α	Comments
32.05 3	32.05	6.6 3	E2	50.3	$\alpha(\text{L})_{\text{exp}}=12$ (1974Te04).
$\times$ 39.59 5		1.4 2			
49.51 3	81.56	123 2	(M1)	0.643	K/L: 10 1 is consistent with E1 or M1 multipolarity (1974Te04). $\text{ce}(\text{L})(32\gamma)/\text{ce}(\text{K})(49\gamma)=1.15$.
86.25 9	167.71	2.7 2	[M1+E2]	0.8 7	
113.53 7	458.21	5.4 2			
129.49 17	458.21	1.0 2			
132.54 5	458.21	12.1 2			
135.63 5	167.71	9.0 2			
153.20 15	234.78	1.5 2	[M1+E2]	0.09 7	
160.79 10	328.70	2.7 2	M1(+E2)	0.08 6	
$\times$ 198.7 3		0.6 2			
202.73 6	234.78	16.8 2	M1	0.01390	
223.41 11	458.21	2.2 2			
244.14 9	325.67	9.8 3	M1	0.00869	
247.5 4	328.70	1.5 2	M1(+E2)	0.018 10	
255.86 8	581.58	6.3 2	M1	0.00773	
263.20 8	344.75	9.5 2	M1	0.00721	
290.2 4	458.21	1.5 4			
293.59 9	325.67	9.7 3	M1	0.00550	
297.1 4	328.70	1.5 3	M1	0.00535	
$\times$ 301.8 4		1.2 3			
312.64 26	344.75	0.8 2	[E2]	0.01199	

Continued on next page (footnotes at end of table)

⁷⁰Se β⁺ Decay 1974Te04 (continued)

γ(⁷⁰As) (continued)

E _γ	E(level)	I _γ ^{†§}	Mult. [‡]	α	E _γ	E(level)	I _γ ^{†§}
^x 343.85 15		2.3 2			549.69 22	581.58	1.0 1
376.65 8	458.21	32.4 3	M1	0.00302	561.56 22	890.57	0.6 1
413.91 8	581.58	7.2 2	M1	0.00241	564.86 21	890.57	0.6 1
426.15 8	458.21	100	M1	0.00225	858.71 28	890.57	0.4 1
^x 458.42 25		0.9 2			1323.7 12	1650.95	1.2 3
499.69 27	581.58	4.4 6			1570.5 9	1650.95	1.0 1
545.91 21	890.57	1.1 1			1618.8 4	1650.95	0.6 1

[†] Relative intensity with I_γ(426)=100.

[‡] From Adopted Gammas, unless otherwise stated.

[§] For absolute intensity per 100 decays, multiply by 0.291 6.

^x γ ray not placed in level scheme.

Decay Scheme

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

$^9\text{Be}(^{78}\text{Rb}, ^{70}\text{As}\gamma)$ 2014Mo26

2014Mo25: 101.6 MeV/nucleon beam of ^{78}Rb was produced through nuclear charge exchange from 150 MeV/nucleon ^{78}Kr primary beam impinging on a ^9Be target and using A1900 separator at NSCL-MSU cyclotron facility. Secondary ^9Be target was 376 mg/cm² thick. Measured $E\gamma$, $\gamma\gamma$ -coin, (^{70}As)- γ -coin; deduced $T_{1/2}$ of 8+ and 9+ states. γ rays were detected using SeGA array of 15 HPGe detectors. The residues were identified according to the TOF and the energy-loss in the focal plane of the S800 spectrometer.

 ^{70}As Levels

$E(\text{level})^\dagger$	$J\pi^\dagger$	$T_{1/2}^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\dagger$	$T_{1/2}^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\dagger$	$T_{1/2}^\ddagger$
0.0	4+		887.76	7(-)		1752.21	9(+)	59 ps 30
32.01	2+		898.27	(5)		2467.5		
166.74	3+		933.16			2579.9	(10+)	
485.32	4-		1045.87	6(+)		2732.9	11+	
566.52	5(-)		1454.3			4075.6	13+	
868.91	6(-)		1676.11	8(+)	55 ps 20			

† From the Adopted Levels.

‡ From line-shape analysis in $\gamma\gamma$ -coin (2014Mo26).

 $\gamma(^{70}\text{As})$

$E(\text{level})$	$E\gamma^\dagger$	$E(\text{level})$	$E\gamma^\dagger$	$E(\text{level})$	$E\gamma^\dagger$
166.74	134.63	933.16	34.7	1676.11	788.3
	166.83		64.5	1752.21	76.1
485.32	318.60	1045.87	479.35	2467.5	791.3
	485.31	1454.3	408.5	2579.9	827.7
566.52	81.19		566.5		903.8
868.91	302.41	1676.11	221.8	2732.9	980.7
898.27	331.74		743.0	4075.6	1342.7

† From the Adopted Gammas.

$^{51}\text{V}(^{28}\text{Si}, 2\alpha n\gamma), ^{46}\text{Ti}(^{28}\text{Si}, 3p n\gamma)$ 2000Mu21

2000Mu21: $^{51}\text{V}(^{28}\text{Si}, 2\alpha n\gamma)$ with $E(^{28}\text{Si})=125$ MeV, $^{46}\text{Ti}(^{28}\text{Si}, 3p n\gamma)$ with $E(^{28}\text{Si})=110$ MeV. γ -rays were detected using 12 Compton-suppressed HPGe detectors. Measured: γ , $\gamma\gamma$, $\gamma(\theta)$, DCO ratios.

Above ≈ 3 MeV there are significant differences between the results in this dataset and those in the $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$ dataset. The evaluators have chosen to adopt the results from the latter. Levels not included in the Adopted Levels dataset as proposed in this dataset are indicated.

 ^{70}As Levels

E(level) [†]	$J\pi^{\ddagger}$	Comments
0.0	4+	
33.0	2+	
167.0	3+	
390.0	(3, 4, 5+)	$J\pi$: 3+ in the Adopted Levels.
485.0	4-	
566.0	5(-)	
868.0@	6(-)	
887.0	7(-)	
898.0		
932.0		
1045.0		
1453.0		
1675.0#	8+	
1750.7§	9+	
1774.0@&	8-	
2466.1		
2578.2#	(10+)	
2732.0§	11+	
2888.0@&	(10-)	
3129.0&		
3271.2		
3344.0&		
3513.0&	(11-)	
3690.2#&	(12+)	
4022.0&		
4075.0§	13+	
4204.0@	(12-)	
4787&	(13-)	
4900.2#&	(14+)	
5591.0§&	15+	
5679@&	(14-)	
7205§&	(17+)	
8941§&	(19+)	

[†] From a least-squares fit to $E\gamma$, by evaluators.

[‡] From Table 1 of 2000Mu21. These values are somewhat different from the assignments made in Figure 2 of 2000Mu21. Significant differences with the $J\pi$ values given in the Adopted Levels are indicated in the comments.

§ (A): Band-1. Configuration= $((\pi [440]1/2+)(\nu [431]3/2+))$, $\alpha=1$.

(B): Band-2. Configuration= $((\pi [440]1/2+)(\nu [431]3/2+))$, $\alpha=0$.

@ (C): Band-3. Configuration= $((\pi [301]3/2-)(\nu [431]3/2+))$, $\alpha=0$.

& Level not observed in $^{55}\text{Mn}(^{18}\text{O}, 3n\gamma)$ and not included in the Adopted Levels.

 $\gamma(^{70}\text{As})$

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. [‡]	Comments
76	1750.7	50	D	Mult.: R(DCO)=0.56.
81	566.0	165		
95	485.0	3		
134	167.0	77		
154	2732.0	3		
167	167.0	16		
215	3344.0	3		
222	1675.0	8		
223	390.0	8		
302	868.0	26		

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$^{51}\text{V}(^{28}\text{Si},2\alpha n\gamma), ^{46}\text{Ti}(^{28}\text{Si},3pn\gamma)$ 2000Mu21 (continued) $\gamma(^{70}\text{As})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$	Mult. ‡	Comments
318	485.0	94		
321	887.0	130		
332	898.0	1		
397	3129.0	6		
408	1453.0	2		
479	1045.0	5		
485	485.0	74		
566	1453.0	4		
612	3344.0	8		
625	3513.0	6	D	Mult.: R(DCO)=0.52.
693	3271.2	4		
743	1675.0	10		
788	1675.0	100	D	Mult.: R(DCO)=0.60.
791	2466.1	2		
805	3271.2	5		
828	2578.2	6		
893	4022.0	13		
903	2578.2	16		
906	1774.0	15		
981	2732.0	47		
1112	3690.2	9		
1114	2888.0	14		
1210	4900.2	4		
1274	4787	5	Q	Mult.: R(DCO)=0.86.
1316	4204.0	5		
1343	4075.0	12	Q	Mult.: R(DCO)=0.93.
1475	5679	4		
1516	5591.0	9	Q	Mult.: R(DCO)=0.89.
1614	7205	7	Q	Mult.: R(DCO)=0.91.
1736	8941	2	Q	Mult.: R(DCO)=0.87.

 † From 2000Mu21. ‡ From R(DCO) ratios in 2000Mu21.

$^{55}\text{Mn}(^{18}\text{O},3\text{n}\gamma)$ 2015Ha25

2015Ha25: $^{55}\text{Mn}(^{18}\text{O},3\text{n}\gamma)$ with $E(^{18}\text{O})=50$ MeV. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin, $\gamma(\theta)$, DCO ratios using an array of 10 Compton-suppressed Ge detectors consisting of 3 Clover and 7 single-crystal detectors; deduced $T_{1/2}$ using Doppler shift attenuation method (DSAM).

 ^{70}As Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$T_{1/2}^\S$
0.0	4+		1752.23 ^{&} 24	9+		3695.0 11	10(+)	
32.05 3	2+		1765.8 4			3772.4 ^c 3	11-	
166.77 8	3+		1807.0 4	7-		3792.5 ^a 4	12+	<0.31 ps [#]
390.45 19	3+		1983.6 ^b 3	8-		4076.0 ^{&} 4	13+	0.069 ps 7
485.52 9	4-		2282.3 ^d 3	9-		4114.6 5	11-	
566.72 ^c 13	5-		2379.5 8	9(+)		4206.8 ^b 3	12-	<0.76 ps [@]
869.51 ^b 16	6-		2467.7 4	9(+)		4604.8 3	13-	
887.83 ^d 20	7-		2579.3 ^c 3	9-		4819.2 4	14-	<2.2 ps [@]
898.52 24	(5)		2580.0 ^a 3	10+	0.53 ps 4	5365.2? 6	(14-)	
1045.93 16	6-		2691.1 4	9(+)		5457.8 ^{&} 9	(15+)	<0.18 ps [#]
1454.21 21	6+		2733.0 ^{&} 3	11+	0.527 ps 14	5498.7 5	15-	
1496.51 ^c 23	7-		2873.6 4	10(+)		5884.5 6	15(-)	
1676.03 ^a 22	8+		3273.1 4	11(+)		6246.9 7	(16-)	
1726.0 4	7(+)		3300.9 ^b 5	10-				

[†] From a least-squares fit to $E\gamma$, by the evaluators.

[‡] As given in 2015Ha25. Authors state that J^π assignments for low-lying states taken from 1997Po03, while other J^π assignments based on decay patterns and multipolarities determined through DCO measurements.

[§] From Doppler shift attenuation method using coin. data at $\gamma(35^\circ)$ and $\gamma(145^\circ)$ by gating on transitions below the transition of interest. The quoted values are the weighted averages of the $T_{1/2}$ at $\gamma(35^\circ)$ and $\gamma(145^\circ)$ and were corrected for both direct and side feedings.

[#] Effective lifetime, not corrected for feedings. The weighted average of the $T_{1/2}$ at $\gamma(35^\circ)$ and $\gamma(145^\circ)$.

[@] Effective lifetime, not corrected for feedings. The $T_{1/2}$ measured at $\gamma(145^\circ)$ only.

[&] (A): Based on 1752.23 keV 9+. Conf = $\pi g_{9/2} \otimes v g_{9/2}$, $\alpha=1$.

^a (B): Conf = $\pi g_{9/2} \otimes v g_{9/2}$, $\alpha=0$.

^b (C): Negative parity band based 869.51 keV 6- state.

^c (D): Negative parity band based 566.72 keV 5- state.

^d (E): Negative parity band based 887.83keV 7- state.

 $\gamma(^{70}\text{As})$

The R_{DCO} were measured by gating on stretched E2 transitions, unless otherwise stated. Based on the symmetry of the Ge array used, the expected R_{DCO} for stretched E2 transitions and for $\Delta J=0$ transitions were ≈ 1 , for $\Delta J=1$ transitions were ≈ 0.5 (if the δ is small).

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\dagger$	Mult. [‡]	Comments
32.05 3	32.05			$E\gamma$: from the Adopted Gammas.
76.2 1	1752.23	64 [§] 10		
81.2 1	566.72	148 [§] 12		
95.0 2	485.52	3.8 [§] 6		
134.7 2	166.77	87 [§] 4		
153.0 3	2733.0	2.0 [§] 4		
166.8 1	166.77	22.1 [§] 11		
221.8 4	1676.03	1.4 4		
223.4 4	390.45	2.4 8		
271.8 3	1726.0	2.4 3	D+Q	Mult.: $R_{\text{DCO}} = 0.49$ 10 (2015Ha25).
302.8 1	869.51	31 2	D+Q	Mult.: $R_{\text{DCO}} = 1.47$ 31. Obtained by gating on the 788.2 γ E1 transition, assuming $\delta = 0$ (2015Ha25).
312.0 6	1765.8	1.3 4		
318.9 2	485.52	90 9	D	Mult.: $R_{\text{DCO}} = 0.65$ 14 (2015Ha25).
321.1 2	887.83	113 11	Q	Mult.: $R_{\text{DCO}} = 1.16$ 18 (2015Ha25).
331.8 2	898.52	2.0 9		
398.0 1	4604.8	3.2 4	D+Q	Mult.: $R_{\text{DCO}} = 0.46$ 9 (2015Ha25).
406.1 4	2873.6	0.6 4		
408.2 3	1454.21	1.8 4		
479.2 1	1045.93	11.3 4	D+Q	Mult.: $R_{\text{DCO}} = 0.87$ 10 (2015Ha25).
485.5 1	485.52	72 4	D	Mult.: $R_{\text{DCO}} = 0.87$ 2 (2015Ha25).
490.3 4	4604.8	2.8 10		

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$^{55}\text{Mn}(^{18}\text{O},3n\gamma)$ 2015Ha25 (continued) $\gamma(^{70}\text{As})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. ‡	Comments
566.4 1	1454.21	9.9 8	D	Mult.: $R_{\text{DCO}} = 0.48$ 5 (2015Ha25).
596.3 3	2579.3	11 3	D+Q	Mult.: $R_{\text{DCO}} = 0.55$ 18 (2015Ha25).
612.3 3	4819.2	10 2	Q	Mult.: $R_{\text{DCO}} = 0.92$ 11 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (612 γ):I γ (743 γ)=58 6: 42 6.
626.9 2	1496.51	9.4 9	D+Q	Mult.: $R_{\text{DCO}} = 0.88$ 14. Obtained by gating on the 318.9 γ E1 transition, assuming $\delta = 0$ (2015Ha25).
693.2 3	3273.1	9 2	D+Q	Mult.: $R_{\text{DCO}} = 0.27$ 6 (2015Ha25).
703.5 8	2379.5	1.6 5	D+Q	Mult.: $R_{\text{DCO}} = 1.24$ 29. Obtained by gating on the 788.2 γ E1 transition, assuming $\delta = 0$ (2015Ha25).
719.5 5	1765.8	1.2 5		
741.5 8	2467.7	2.2 10		
743.2 2	4819.2	7.1 10	D	Mult.: $R_{\text{DCO}} = 0.56$ 3 (2015Ha25).
759.9 6	5365.2?	2.2 9	D+Q	Mult.: $R_{\text{DCO}} = 0.18$ 7 (2015Ha25).
771.5 8	2579.3	1.0 3	Q	Mult.: $R_{\text{DCO}} = 1.02$ 22 (2015Ha25).
788.2 1	1676.03	100 3	D	Mult.: $R_{\text{DCO}} = 0.44$ 1 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (788 γ):I γ (221 γ)=98.6 4: 1.4 4.
791.5 9	2467.7	7 2	D+Q	Mult.: $R_{\text{DCO}} = 0.52$ 6. Obtained by gating on the 788.2 γ E1 transition, assuming $\delta = 0$ (2015Ha25).
805.1 4	3273.1	3.5 10		
812.1 3	4604.8	1.6 4	D	Mult.: $R_{\text{DCO}} = 0.47$ 6 (2015Ha25).
827.9 3	2580.0	13 2	D+Q	Mult.: $R_{\text{DCO}} = 1.21$ 34. Obtained by gating on the 788.2 γ E1 transition, assuming $\delta = 0$ (2015Ha25).
832.4 3	4604.8	13 3	Q	Mult.: $R_{\text{DCO}} = 1.10$ 10 (2015Ha25).
893.9 4	5498.7	9 2	Q	Mult.: $R_{\text{DCO}} = 0.87$ 10 (2015Ha25).
896.4 6	1765.8	5.2 10		
904.0 4	2580.0	20 5	Q	Mult.: $R_{\text{DCO}} = 0.80$ 17 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (905 γ):I γ (828 γ)=62 7: 38 7.
905.7 6	4206.8	7 2	Q	Mult.: $R_{\text{DCO}} = 1.27$ 18 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (906 γ):I γ (934 γ):I γ (1474 γ)=52 7: 4 2: 44 7.
919.0 4	1807.0	5.0 10	D+Q	Mult.: $R_{\text{DCO}} = 0.81$ 8 (2015Ha25).
929.6 4	1496.51	5.8 18	Q	Mult.: $R_{\text{DCO}} = 0.91$ 31.
934.1 8	4206.8	0.6 3		
938.4 6	1983.6	4.7 14	Q	Mult.: $R_{\text{DCO}} = 0.83$ 22 (2015Ha25).
980.7 3	2733.0	47 4	Q	Mult.: $R_{\text{DCO}} = 0.95$ 14 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (981 γ):I γ (153 γ)=95.9 8: 4.1 8.
1015.1 3	2691.1	6.0 12	D+Q	Mult.: $R_{\text{DCO}} = 0.35$ 10 (2015Ha25).
1058.9 6	3792.5	4.6 14	D+Q	Mult.: $R_{\text{DCO}} = 0.68$ 14 (2015Ha25).
1065.3 5	5884.5	2.5 8	D+Q	Mult.: $R_{\text{DCO}} = 0.64$ 18 (2015Ha25).
1081.9 5	2579.3	5.8 16	Q	Mult.: $R_{\text{DCO}} = 1.62$ 28 (2015Ha25).
1114.7 4	1983.6	15.6 15	Q	Mult.: $R_{\text{DCO}} = 0.84$ 20 (2015Ha25).
1121.1 4	2873.6	6.1 15	D+Q	Mult.: $R_{\text{DCO}} = 0.30$ 10 (2015Ha25).
1159.2 8	5365.2?	1.8 9		
1194.0 8	3772.4	4.0 10	Q	Mult.: $R_{\text{DCO}} = 0.88$ 23 (2015Ha25).
1212.0 6	3792.5	12 4	Q	Mult.: $R_{\text{DCO}} = 0.85$ 16 (2015Ha25).
				I γ : 2015Ha25 gives branching ratio of I γ (1212 γ):I γ (1059 γ)=72 10: 28 10.
1227.3 10	3695.0	4.3 10	D+Q	Mult.: $R_{\text{DCO}} = 0.50$ 12 (2015Ha25).
1317.0 7	3300.9	7.4 15	Q	Mult.: $R_{\text{DCO}} = 1.26$ 26 (2015Ha25).
1343.3 6	4076.0	19 2	Q	Mult.: $R_{\text{DCO}} = 0.96$ 5 (2015Ha25).
1381.8 8	5457.8	3.9 15		
1394.4 3	2282.3	15 2	Q	Mult.: $R_{\text{DCO}} = 0.88$ 10 (2015Ha25).
1427.7 6	6246.9	1.9 9		
1454.2 8	1454.21	1.3 6		
1474.0 3	4206.8	6.2 9	D	Mult.: $R_{\text{DCO}} = 0.55$ 4 (2015Ha25).
1490.0 3	3772.4	9.0 15	Q	Mult.: $R_{\text{DCO}} = 0.80$ 15 (2015Ha25).
1521.3 8	3273.1	3.0 5		
1832.8 10	4114.6	1.3 6		

† From $\gamma\gamma$ -coin. data (projected from matrices at 90°) in 2015Ha25, unless otherwise stated. Intensities were normalized to I(788.2 γ) = 100.

‡ From R(DCO) measurements (2015Ha25).

§ Determined using $\gamma(35^\circ)$ singles spectrum and corrected for angular distribution effects.

⁵⁸Ni(¹⁴N,2pγ), ⁵⁶Fe(¹⁶O,npγ) 1991Ba43,1978Fi09

1991Ba43: ⁵⁸Ni(¹⁴N,2pγ) at E(¹⁴N)=46 MeV, and ⁵⁶Fe(¹⁶O,npγ) at E(¹⁶O)= 46–64 MeV. γ-rays were detected using Ge(Li) and intrinsic Ge detectors. Na(Tl) detector was used for delayed coincidences. Measured: Eγ, Iγ, γ(θ), γ(θ,H), γγ coin, excitation functions, δ, linear polarization and T_{1/2} (from delayed coincidences).
 1978Fi09: ⁶⁹Ga(α,3nγ) at E(α)=30–50 MeV; ⁶⁰Ni(¹²C,np) at E(¹²C) = 50 MeV; ⁶³Cu(¹⁰B,2np) at E(¹⁰B)=40 MeV; ⁷⁰Ge(α,3npγ), energy was not specified for this reaction. Measured: Eγ, Iγ, γγ-coincidences, σ(E,Eγ,θ,t), γ(θ).
 Deduced: T_{1/2} (from time correlation between beam bursts and γ-emission).
 1987Be39: ⁵⁶Fe(¹⁶O,pnγ) with E(¹⁶O)=52 MeV. γ-rays were detected by a planer Ge detector and a NaI(Tl) detector. Measured: T_{1/2} by delayed coincidences.
 1997Ga26: ⁵⁸Ni(¹⁶O,3pnγ) at E(¹⁶O)=70 MeV. γ-rays were measured using 10 Compton-suppressed Ge detectors. Measured: γγ. Deduced: T_{1/2} for 2733 level and 4075 level using Doppler shift attenuation method. All transitions from levels below the 9+ level are not Doppler shifted.

⁷⁰As Levels

E(level) [†]	Jπ [§]	T _{1/2} [#]	Comments
0.0	4+		Jπ: From Adopted Levels.
32.10 9	2+		Jπ: From Adopted Levels.
166.80 12	3+	6.0 ns 5	
390.2 3			
485.50 17	4–	4.0 ns 4	T _{1/2} : weighted average of 4.2 ns 4 (1991Ba43) and 3.3 ns 7 (1978Fi09).
566.80 19	5(–)	<2 ns	
868.9 3	6(–)		
888.0 3	7(–)	4.5 ns 3	g=0.107 7 (1991Ba43). T _{1/2} : weighted average of 4.4 ns 1 (1978Fi09) and 5.3 ns 3 (1987Be39,1991Ba43). g: From perturbed γ(θ).
898.6 [‡] 3			
933.3 [‡] 3			
1045.9 3	6(+)		
1454.5 4			
1676.3 3	8+	<2 ns	
1752.4 3	9+	<2 ns	
1809.6 [‡] 4			
2467.6 9			
2580.1 6	(10+)		Jπ: J>9 from the slope of the excitation function for 828γ (1991Ba43).
2733.1 6	11+	0.76 ps 21	T _{1/2} : from DSAM in 1997Ga26.
4075.8 11		<0.49 ps	T _{1/2} : from DSAM in 1997Ga26. Upper limit from effective lifetime of 0.42 ps 7, not corrected for sidefeeding.

[†] From a least-squares fit to Eγ, by evaluators.

[‡] Observed by 1978Fi09 only.

[§] From multipolarity of γs deduced using γ(θ) and linear polarization in 1991Ba43, unless otherwise stated.

[#] From delayed γγ coin (1987Be39,1991Ba43), unless otherwise stated. Both of the references discuss the same work; however, the later values which are slightly different are considered to supersede the former data.

γ(⁷⁰As)

Eγ [†]	E(level)	Iγ [§]	Mult. ^a	δ&	Comments
29.8 [‡] 2	898.6	10 3			
32.1 1	32.10	<1.5			
34.7 [‡] 2	933.3	3 1			
57.2 [‡] 2	1809.6	4 2			
64.5 [‡] 2	933.3	3 1			
76.1 1	1752.4	62.8 25	D(+Q)	0.01 3	Mult.: Other: ΔJ=1 transition from γ(θ) (1978Fi09).
81.3 1	566.80	158 8	D+Q	0.08 4	Mult.: Other: ΔJ=1 transition from γ(θ) (1978Fi09).
95.3 3	485.50	3.8 [#] 7			
134.7 1	166.80	84 3	D(+Q)	–0.01 4	Mult.: Other: ΔJ=1 transition from γ(θ) (1978Fi09).
166.8 3	166.80	21 [#] 6			
221.8 5	1676.3	7.9 9			
223.4 5	390.2	8.8 [#] 9			
302.8 5	868.9	34.8 20	(M1+E2) [@]	0.044 23	
318.7 3	485.50	103 10	E1+M2 [@]	–0.041 20	
321.1 3	888.0	112 10	E2+M3 [@]	0.04 3	Mult.: Other: Stretched Q from γ(θ) (1978Fi09).
331.7 [‡] 2	898.6	2 1			
408.5 5	1454.5	2.8 [#]			

Continued on next page (footnotes at end of table)

$^{58}\text{Ni}(^{14}\text{N},2\text{p}\gamma), ^{56}\text{Fe}(^{16}\text{O},\text{np}\gamma)$ 1991Ba43,1978Fi09 (continued) $\gamma(^{70}\text{As})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\S}$	Mult. ^a	$\delta\&$	Comments
479.1 2	1045.9	15.3 9	(E1+M2) [@]	-2.9 3	
485.5 2	485.50	79 4	E1(+M2) [@]	-0.004 15	
566.5 5	1454.5	5.8 10			
743.0 [‡] 2	1676.3	13 2	D+Q		Mult.: $\Delta J=1$ transition from $\gamma(0)$ (1978Fi09).
788.3 2	1676.3	100	(E1+M2) [@]	0.017 13	
791.3 9	2467.6	15.0 [#] 7			
827.7 7	2580.1	15.1 [#] 9			
903.8 9	2580.1	18.3 [#] 9			
980.7 5	2733.1	34 3	(E2+M3) [@]	-0.06 3	
1342.7 9	4075.8	19 [#] 2			

[†] From 1991Ba43, unless otherwise stated.[‡] Observed by 1978Fi09 only.[§] Relative photon intensity from $^{56}\text{Fe}(^{16}\text{O},\text{np}\gamma)$ at $E(^{16}\text{O})=64$ MeV (1991Ba43).[#] From $\gamma\gamma$ coin data (1991Ba43).[@] From $\gamma(0)$ and linear polarization data (1991Ba43).[&] From $\gamma(0)$ (1991Ba43); sign convention not specified by authors.^a From $\gamma(0)$ (1991Ba43), unless otherwise stated. **$^{70}\text{Ge}(\text{p},\text{n}\gamma)$ 1995Po03**

1995Po03: ^{70}As produced by $^{70}\text{Ge}(\text{p},\text{n}\gamma)$ at $E(\text{p}) = 7.59\text{--}8.7$ MeV. γ -rays were detected using Compton suppressed 20% high purity Ge and 25% high purity coaxial Ge detectors. Internal conversion electrons are detected using a superconducting magnet coupled with a Si(Li) spectrometer. Measured $E\gamma$, ce, $\gamma\gamma$, $\gamma(0)$.

1979Te06: ^{70}As produced by $^{70}\text{Ge}(\text{p},\text{n}\gamma)$ at $E(\text{p}) = 6.5\text{--}14$ MeV. γ -rays were detected using Ge(Li) detectors. Low energy γ -rays were detected using a planer intrinsic Ge detector. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coincidence, $\gamma(0)$, $\sigma(E(\text{p}),E\gamma)$; deduced $T_{1/2}$.

 ^{70}As Levels

$E(\text{level})^{\dagger}$	$J\pi^{\S}$	$T_{1/2}^{\ddagger}$	Comments
0.0	4+		$J\pi$: From Adopted Levels.
32.05 3	2+	96 μs 3	$J\pi$: From 235.10 γ M1 from 1+.
81.52 3	1+	<3 ns	
166.73 3	3+		
167.73 4	2+	<3 ns	
234.73 4	1+	<1 ns	
325.65 4	2+		
328.64 4	1+		
344.64 4	0+	<1 ns	
383.32 3	2-	<1 ns	
390.14 3	3+	<1 ns	
425.32 6	0+		
458.15 4	1+		
485.322 24	4-	4.5 ns 10	
508.84 6	3+		
540.00 4	2+		
566.52 4	5(-)	<3 ns	
571.95 4	2+		
581.61 4	1+		
592.52 5	1+, 2+		
625.21 4	4+		
641.85 5	3+		
683.97 7	(0)		
687.59 4	3(+), 4(+)		
698.87 4	3-		
721.89 5	(3)		
772.29 4	3-		
778.94 4	(4)		

Continued on next page (footnotes at end of table)

$^{70}\text{Ge}(\text{p},\text{n}\gamma)$ 1995Po03 (continued) **^{70}As Levels (continued)**

$E(\text{level})^\dagger$	$J\pi^\S$	$T_{1/2}^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\S$
815.48 5	(3) #	5.5 ns 10	966.86 9	(5) #
868.93 6	6(-) #		987.79 8	(0,3) #
890.46 5	1+		1003.61 6	1,2 #
898.26 6	(5) #		1026.32 5	1,2 #
928.13 5	2,1 #		1045.87 10	6(+) #
938.95 5	4(-)		1046.42 6	1,2
939.28 5	2,1 #		1115.07 8	(1,2) #
950.28 10	(0) #			

 † From a least-squares fit to $E\gamma$, by evaluators. ‡ From off-beam $\gamma(t)$ in 1979Te06. § From gamma multipolarities measured in 1995Po03, unless otherwise stated.# From Hauser-Feshbach analysis and γ decay pattern in 1995Po03. **$\gamma(^{70}\text{As})$**

$E\gamma^\dagger$	$E(\text{level})$	$I\gamma^\dagger$	Mult. ‡	$\delta^\S$	α	Comments
32.05 10	32.05	15.8 13				
49.45 3	81.52	189 11	D		0.645	Mult.: from $A_2 = -0.052$ 49, $A_4 = -0.036$ 51 and $\delta=+0.12$ 31 from $\gamma(0)$ for 1+ to 2+ cascade in 1995Po03.
80.04 6	778.94	0.69 21				
81.19 3	566.52	9.8 5	D+Q			Mult.: from $A_2 = -0.413$ 104, $A_4 = -0.003$ 103 and $\delta=-0.08$ 4 from $\gamma(0)$ for 5- to 4- cascade in 1995Po03.
86.19 3	167.73	40.5 21	D+Q			Mult.: from $A_2 = -0.186$ 64, $A_4 = -0.012$ 50 and $\delta = +0.03$ 3 from $\gamma(0)$ for 2+ to 1+ cascade in 1995Po03.
90.96 8	325.65	1.3 2				
93.88 7	328.64	0.98 18				
95.18 6	485.322	0.27 12				
109.84 6	344.64	0.91 17				
113.50 4	458.15	1.61 19				
132.51 4	458.15	2.6 3				
134.63 5	166.73	100 6	(M1 (+E2))		0.15 11	$\alpha(\text{K})\text{exp}(134.63\gamma+135.68)=0.033$ 5.
135.68 5	167.73	88 5				$\alpha(\text{K})\text{exp}(134.63\gamma+135.68\gamma)=0.033$ 5.
148.57 3	383.32	11.2 6	D+Q	+0.14 7	0.034 4	Mult.: from $\gamma(0)$, $A_2 = -0.051$ 235, $A_4 = 0.027$ 185 in 1995Po03.
153.18 3	234.73	7.2 5	D+Q			Mult: from $A_2 = -0.126$ 106, $A_4 = -0.278$ 115 and $\delta=+0.28$ +52-25 from $\gamma(0)$ for 1+ to 1+ cascade in 1995Po03.
158.89 9	325.65	1.77 19				
160.89 3	328.64	24.5 13	M1 (+E2)	+0.05 28	0.026 11	$\alpha(\text{K})\text{exp}=0.029$ 6. Mult.: Other: $A_2 = -0.091$ 59, $A_4 = -0.086$ 62.
166.69 10	938.95	2.7 8				
166.83 10	166.73	23 2	M1		0.0230	$\alpha(\text{K})\text{exp}=0.0217$ 18.
190.52 6	425.32	1.84 24				
202.66 3	234.73	60 4	M1		0.01392	$\alpha(\text{K})\text{exp}=0.0119$ 8. Mult.: Other: $A_2 = 0.142$ 58, $A_4 = 0.124$ 46 and $\delta=-0.01$ 27 from $\gamma(0)$ for 1+ to 2+ cascade in 1995Po03.
215.51 15	383.32	1.31 25				
223.38 # 9	458.15	0.9 # 6				
223.42 # 3	390.14	32.0 # 17	M1		0.01086	$\alpha(\text{K})\text{exp}=0.0092$ 8. Mult.: Other: $A_2 = 0.131$ 106, $A_4 = -0.116$ 115 and $\delta = -0.21$ 8 from $\gamma(0)$ for 3+ to 3+ cascade in 1995Po03.
235.10 4	625.21	5.2 4	M1 (+E2)	<0.35	0.0108 13	$\alpha(\text{K})\text{exp}=0.0097$ 13. Mult.: Other: $A_2 = -0.328$ 135 and $A_4 = -0.180$ 137 in 1995Po03. δ : from $\alpha(\text{K})\text{exp}$.

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$^{70}\text{Ge}(\text{p},\text{n}\gamma)$ 1995Po03 (continued) $\gamma(^{70}\text{As})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$	Mult. [‡]	$\delta^{\S}$	α	Comments
240.07 7	938.95	1.0 2				
244.10 3	325.65	35 2	M1		0.00869	$\alpha(\text{K})_{\text{exp}}=0.0079$ 6. Mult.: Other: $A_2 = -0.179$ 69, $A_4 = -0.003$ 70 and $\delta = +0.03$ 3 from $\gamma(\theta)$ in 1995Po03.
247.11 3	328.64	9.8 6	M1 (+E2)	-0.16 40	0.009 4	$\alpha(\text{K})_{\text{exp}}=0.0138$ 11. Mult.: Other: $A_2 = -0.229$ 165, $A_4 = -0.264$ 174. δ : Other: 0.77 11 from $\alpha(\text{K})_{\text{exp}}$.
254.01 4	1026.32	3.4 3				
255.96 4	581.61	8.5 5	M1		0.00772	$\alpha(\text{K})_{\text{exp}}=0.0068$ 8.
263.13 3	344.64	26.0 14	M1		0.00721	$\alpha(\text{K})_{\text{exp}}=0.0065$ 5.
263.93 14	592.52	0.91 25				
275.52 7	815.48	1.18 25				
286.96 4	772.29	5.9 4	M1		0.00582	$\alpha(\text{K})_{\text{exp}}=0.0049$ 7. Mult.: Other: $A_2 = -0.169$ 173, $A_4 = 0.076$ 172 and $\delta = +0.07$ 11 from $\gamma(\theta)$ for 3- to 4- cascade in 1995Po03.
293.63 5	325.65	7.1 5	M1			$\alpha(\text{K})_{\text{exp}}=0.0050$ 4. Mult.: Other: $A_2 = 0.304$ 90, $A_4 = 0.024$ 75 and $\delta = +0.15$ 4 from $\gamma(\theta)$ for 2+ to 2+ cascade in 1995Po03.
293.63 3	778.94	28.3 15				
296.64 3	328.64	12.3 7	M1		0.00537	$\alpha(\text{K})_{\text{exp}}=0.0051$ 5. Mult.: Other: $A_2 = 0.040$ 87, $A_4 = -0.043$ 67 and $\delta = -0.19$ 24 from $\gamma(\theta)$ in 1995Po03.
297.51 6	687.59	0.78 24				
301.80 3	383.32	66 3	E1		0.00290	$\alpha(\text{K})_{\text{exp}}=0.00240$ 16. Mult.: Other: $A_2 = -0.165$ 53, $A_4 = 0.010$ 54 and $\delta = +0.03$ 3 from $\gamma(\theta)$ for 2- to 1+ cascade in 1995Po03.
302.41 5	868.93	1.1 4			0.009 5	
312.62 5	344.64	2.5 3				
315.53 3	698.87	24.2 13	M1		0.00462	$\alpha(\text{K})_{\text{exp}}=0.0040$ 3. Mult.: Other: $A_2 = -0.301$ 99, $A_4 = -0.061$ 76 and $\delta = +0.01$ 3 from $\gamma(\theta)$ for 3- to 2- cascade in 1995Po03.
318.60 3	485.322	25.2 14	E1		0.00250	$\alpha(\text{K})_{\text{exp}}=0.00207$ 19. Mult.: Other: $A_2 = -0.285$ 49, $A_4 = -0.047$ 38 and $\delta = +0.013$ 14 from $\gamma(\theta)$ for 4- to 3+ cascade in 1995Po03.
327.37 10	1026.32	2.3 3				
331.74 5	898.26	1.5 3				
342.24 10	508.84	7.8 5	M1		0.00379	$\alpha(\text{K})_{\text{exp}}=0.0036$ 5.
343.81 10	425.32	18.1 10	M1		0.00375	$\alpha(\text{K})_{\text{exp}}=0.0034$ 4.
351.29 4	383.32	7.1 5				
357.81 7	592.52	1.9 5				
358.32 9	683.97	2.7 5				
372.39 8	938.95	1.5 3	M1+E2	<1.7	0.0044 13	$\alpha(\text{K})_{\text{exp}}=0.0039$ 12. δ : from $\alpha(\text{K})_{\text{exp}}$.
376.64 4	458.15	6.7 5	M1		0.00302	$\alpha(\text{K})_{\text{exp}}=0.0030$ 4.
388.96 4	772.29	16.3 11	M1		0.00279	$\alpha(\text{K})_{\text{exp}}=0.0026$ 4.
390.15 4	390.14	10.6 6	M1		0.00277	$\alpha(\text{K})_{\text{exp}}=0.0030$ 7.
404.15 8	571.95	4.0 6				
413.89 4	581.61	12.2 8	M1		0.00241	$\alpha(\text{K})_{\text{exp}}=0.0024$ 3. Mult.: Other: $A_2 = -0.252$ 98, $A_4 = -0.267$ 104 and $\delta = +0.05$ 34 from $\gamma(\theta)$ in 1995Po03.
424.87 51	592.52	3.1 8	M1		0.00227	$\alpha(\text{K})_{\text{exp}}=0.0019$ 3.
426.11 3	458.15	23.1 17	M1		0.00225	$\alpha(\text{K})_{\text{exp}}=0.0022$ 3.
449.24 10	683.97	5.0 5				
458.41 8	625.21	1.5 6				
458.48 3	540.00	31.4 17	M1		0.00190	$\alpha(\text{K})_{\text{exp}}=0.00154$ 18. Mult.: Other: $A_2 = -0.400$ 104, $A_4 = -0.005$ 103 and $\delta = -0.17$ +12-19 from $\gamma(\theta)$ in 1995Po03.
^x 464.81 6						

Continued on next page (footnotes at end of table)

$^{70}\text{Ge}(\text{p},\text{n}\gamma)$ 1995Po03 (continued) $\gamma(^{70}\text{As})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$	Mult. ‡	$\delta^\S$	α	Comments
474.12 3	641.85	16.5 10	M1		1.76×10^{-3}	$\alpha(\text{K})_{\text{exp}}=0.0016$ 3. Mult.: Other: $A_2 = -0.237$ 186, $A_4 = -0.090$ 188 and $\delta = +0.03$ 5 from $\gamma(\theta)$ for 3+ to 2+ cascade in 1995Po03.
476.75 6	508.84	18.0 12	M1		1.74×10^{-3}	$\alpha(\text{K})_{\text{exp}}=0.00168$ 25. Mult.: Other: $A_2 = -0.271$ 133, $A_4 = 0.116$ 99 and $\delta = -0.05$ 4 from $\gamma(\theta)$ in 1995Po03.
479.35 9	1045.87	0.9 4				
485.31 3	485.322	21.6 13	E1		8.24×10^{-4}	$\alpha(\text{K})_{\text{exp}}=0.00078$ 14.
490.35 10	571.95	3.9 4				
500.10 6	581.61	5.8 5				
516.1 4	683.97	0.2 6				
519.85 12	687.59	2.5 17				$\alpha(\text{K})_{\text{exp}}(519.85\gamma+520.82\gamma)=0.0018$ 3.
520.82 5	687.59	9.8 18				$\alpha(\text{K})_{\text{exp}}(519.85\gamma+520.82\gamma)=0.0018$ 3.
539.92 3	571.95	20.1 14	M1+E2	+0.11 8	1.32×10^{-3} 3	$\alpha(\text{K})_{\text{exp}}=0.00130$ 14. Mult.: Other: $A_2 = 0.284$ 64, $A_4 = -0.056$ 71 in 1995Po03.
545.83 5	890.46	6.1 5				
549.11 8	939.28	2.5 4				
549.50 10	581.61	2.0 4				
554.04 15	721.89	0.8 4				
555.11 8	721.89	2.8 5				
555.66 8	938.95	1.5 5				
560.46 4	592.52	10.1 8				
561.88 11	890.46	3.4 6				
564.78 6	890.46	3.0 4				
576.72 9	966.86	0.9 3				
578.20 7	1003.61	2.5 4				
^x 597.05 6						
602.54 9	928.13	7.9 8				
621.63 9	950.28	3.8 4				
625.17 7	625.21	8.3 9				
640.35 6	721.89	5.6 6				
647.81 7	815.48	4.0 5				
656.20 20	1046.42	0.5 3				
656.80 20	1115.07					
659.02 6	1003.61	2.5 5				
662.10 10	987.79	1.3 6				
675.02 25	1003.61	2.2 6				
678.03 13	1003.61	1.4 6				
689.88 5	721.89	7.7 9				
^x 692.18 5						
704.61 12	939.28	1.9 4				
761.30 9	928.13	1.9 4				
^x 762.15 6						
772.50 8	939.28	2.9 4				
783.35 6	815.48	5.3 5				
789.43 7	1115.07					
^x 818.78 9						
^x 848.81 7						
857.82 11	939.28	4.2 4				
858.40 13	890.46	0.9 4				
878.75 9	1046.42	3.0 4				
896.10 6	928.13	2.2 4				
906.32 12	987.79	3.8 4				
944.85 6	1026.32	2.6 4				
964.86 6	1046.42	3.5 4				
^x 1033.53 6						

 † From data taken at 8.23 MeV proton energy. Relative photon intensity normalized to 134.63 γ (1995Po03). ‡ From $\alpha(\text{K})_{\text{exp}}$ in 1995Po03, unless otherwise stated. § From $\gamma(\theta)$ in 1995Po03, unless otherwise stated.

Multiply placed; intensity suitably divided.

^x γ ray not placed in level scheme.

Adopted Levels, Gammas

Q(β⁻)=-10504 15; S(n)=13566.5 22; S(p)=6110 30; Q(α)=-2748 3 2012Wa38.
S(2n)=23883.1 17, S(2p)=9529.0 25 (2012Wa38).

⁷⁰Se Levels

Cross Reference (XREF) Flags

A ⁷⁰Br ε Decay (79.1 ms)
B ⁷⁰Br ε Decay (2.2 s)
C ⁹Be(⁷⁰Se,⁷⁰Se'γ)
D ⁴⁰Ca(⁴⁰Ca,2α2pγ)

E ⁴⁰Ca(³⁶Ar,α2pγ),⁵⁸Ni(¹⁴N,pnγ)
F ⁵⁸Ni(¹⁴N,pnγ),⁶⁰Ni(¹²C,2nγ)
G Coulomb Excitation

E(level) [†]	Jπ	XREF	T _{1/2} [‡]	Comments
0.0 [@]	0+	ABCDEFGF	41.1 min 3	%ε+%β ⁺ =100. T _{1/2} : from 1974Te04.
944.52 [@] 5	2+	BCDEFG	2.23 ps 14	Q=+ (2007Hu03). T _{1/2} : from weighted average of 2.27 ps 26 (2014Ni09) and 2.22 ps 14 (2008Lj01) using recoil distance Doppler shift method. Others: 1.0 ps 2 from recoil distance Doppler shift method (1986He17) and 1.1 ps 3 (1975GuYV). Jπ: from 944.51γ E2 to 0+.
1599.9 ^{&} 3	2+	BCDEF	3.3 ps § 9	Q: from nuclear reorientation effect in Coulomb excitation (2007Hu03). T _{1/2} : Other: < 5.2 ps effective half-life from recoil distance Doppler shift method (2014Ni09). Jπ: from 1600.1γ E2 to 0+.
2010.3 3	(0+)	EF		Jπ: (0+) from 1065.8γ Q to 2+ in 1981Ah03. Authors tentatively assigned (0+) for this level based on isotropic angular distribution. Other: (0+) in 1980Wa19, based on the isotropic angular distribution.
2038.8 [@] 5	4+	BCDEF	0.97 ps 7	T _{1/2} : Others: < 3.3 ps, effective half-life from recoil distance Doppler shift method (2014Ni09) and 1.0 ps (1986He17) using recoil distance Doppler shift method deduced from singles data and 2.3 ps 6 (1975GuYV). Jπ: from 1094.4γ E2 to 2+; assumed E2 cascade member.
2382.5 ^{&} 4	4+	B DEF	<12 ps #	Jπ: from 782.6γ E2 to 2+; 1438.1γ E2 to 2+; assumed E2 cascade member.
2518.6 6	3(-)	CDEF	<1.7 ps	T _{1/2} : upper limit from effective half-life of 1.29 ps 40 from recoil distance Doppler shift method (2014Ni09). Other: 4.2 ps 6 using recoil distance Doppler shift method (1986He17) using singles data. Jπ: from 1574.1γ D to 2+; 868.8γ from 5-.
2553.1 10		E		Jπ: (4+) proposed in ⁴⁰ Ca(³⁶ Ar,α2pγ), ⁵⁸ Ni(¹⁴ N,pnγ).
3003.2 [@] 5	6+	B DEF	1.32 ps 21	T _{1/2} : other: 2.7 ps 6 from recoil distance Doppler shift method, deduced using singles (1986He17). Jπ: from 964.39γ E2 to 4+; assumed E2 cascade member.
3139.6 3		F		
3218.4 ^{&} 6	(6+)	D		Jπ: from 835.9γ to 4+; assumed E2 cascade member.
3356.4 11		E		
3387.4 5	5-	DEF	6.1 ps § 17	Jπ: from 528γ E2 from 7-, 1348.6γ to 4+.
3524.1 6	(5-)	DEF	<9 ps #	Jπ: from 1005.5γ (E2) to 3(-); 1485.2γ (E1) to 4+. Other: (4) in 1981Ah03.
3644 10		B DE		Jπ: (6+) proposed in ⁴⁰ Ca(³⁶ Ar,α2pγ), ⁵⁸ Ni(¹⁴ N,pnγ).
3788.9 6	(6-)	DEF		Jπ: J from D+Q 264.8γ to (5-), π from systematics in 1980Wa19. Other: (5) in 1981Ah03.
3915.4 ^b 5	7-	B DEF	<15 ps #	Jπ: from 912.2γ E1 to 6+, 691.5γ from 8+.
4037.6 [@] 5	8+	B DEF	<4 ps #	Jπ: from 1034.4γ E2 to 6+; assumed E2 cascade member.
4187.4 ^{&} 8	(8+)	D		Jπ: from 969.0γ to (6+); assumed E2 cascade member.
4324.5 9		E		
4410.7 6		DE		
4607.0 ^a 6	8+	B DE		Jπ: (8,9+) from R(DCO) in ⁴⁰ Ca(³⁶ Ar,α2pγ), ⁵⁸ Ni(¹⁴ N,pnγ), 1603.7γ to 6+.
4896.7 ^c 6	(9-)	DE		Jπ: from 981.3γ to 7-; 468.0γ to (8-); assumed E2 cascade member.
4955.0 12		B E		Jπ: (9) from 348.0γ to 8+ suggested in ε decay (2000Pi15) but the placement of the γ transition is uncertain.
5205.8 [@] 5	(10+)	B DE		Jπ: from 1168.12γ to 8+; assumed E2 cascade member.
5209.1 ^b 6	(9-)	DE		Jπ: from 1293.6γ to 7-; assumed E2 cascade member.
5308.1 ^{&} 10	(10+)	D		Jπ: from 1120γ to (8+); assumed E2 cascade member.
5693.2 ^a 6	(10+)	B DE		Jπ: from 1086.2γ to 8+; assumed E2 cascade member.
5805.5 ^c 6	(11-)	DE		Jπ: from 908.7γ to (9-); assumed E2 cascade member.
6017.0 15		B E		
6490.0 ^b 6	(11-)	DE		Jπ: from 1280.9γ to (9-); assumed E2 cascade member.
6510.2 [@] 5	(12+)	DE		Jπ: from 1304.45γ to (10+); assumed E2 cascade member.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

⁷⁰Se Levels (continued)

E(level) [†]	J π	XREF	T _{1/2} [‡]	Comments
6602& 5	(12+)	D		J π : from 1294 γ to (10+); assumed E2 cascade member.
6873.0 ^c 6	(13-)	DE		J π : from 1967.5 γ to (11-); assumed E2 cascade member.
6956.9 ^a 6	(12+)	DE		J π : from 1263.6 γ to (10+); assumed E2 cascade member.
7305.8 9	(13-)	E	1.6 ns 2	T _{1/2} : quoted by 1989My01; generalized centroid-shift method. J π : from 796.5 γ to 12+; 348.0 γ to (12+); proposed based on Weisskopf estimates in 1989My01.
7554.0 ^b 7	(13-)	D		J π : from 1064.0 γ to (11-); assumed E2 cascade member.
7940.8@ 5	(14+)	DE		J π : from 1430.6 γ to 12+; assumed E2 cascade member.
8017.7 ^c 7	(15-)	D		J π : from 1144.7 γ to (13-); assumed E2 cascade member.
8029& 5	(14+)	D		J π : from 1427.2 γ to (12+); assumed E2 cascade member.
8316.3 ^a 6	(14+)	D		J π : from 1359.4 γ to (12+); assumed E2 cascade member.
8349.5 13		E		
8771.8 ^b 8	(15-)	D		J π : from 1217.8 γ to (13-); assumed E2 cascade member.
9430.3 ^a 6	(16+)	D		J π : from 1114.0 γ to (14+); assumed E2 cascade member.
9496.2@ 6	(16+)	DE		J π : from 1555.3 γ to (14+); assumed E2 cascade member.
9624.1 ^c 7	(17-)	D		J π : from 1606.4 γ to (15-); assumed E2 cascade member.
10084.1 ^b 8	(17-)	D		J π : from 1312.3 γ to (15-); assumed E2 cascade member.
10646.2 ^a 6	(18+)	D		J π : from 1215.9 γ to 16+; assumed E2 cascade member.
11120.5 9		D		
11268.5@ 11	(18+)	D		J π : from 1772.3 γ to (16+); assumed E2 cascade member.
11532.2 ^c 10	(19-)	D		J π : from 1908.1 γ to (17-); assumed E2 cascade member.
11778.5 ^b 12	(19-)	D		J π : from 1694.4 γ to (17-); assumed E2 cascade member.
12267.7 ^a 7	(20+)	D		J π : from 1621.5 γ to (18+); assumed E2 cascade member.
13160.5@ 15	(20+)	D		J π : from 1892 γ to (18+); assumed E2 cascade member.
13181.4 ^c 11	(21-)	D		J π : from 1649.2 γ to (19-); assumed E2 cascade member.
13727.0 ^b 14	(21-)	D		J π : from 1948.4 γ to (19-); assumed E2 cascade member.
14257.7 ^a 11	(22+)	D		J π : from 1990.0 γ to (20+); assumed E2 cascade member.
15251 ^c 3	(23-)	D		J π : from 2070 γ to (21-); assumed E2 cascade member.
15806 ^b 7	(23-)	D		J π : from 2079 γ to (21-); assumed E2 cascade member.
16490 ^a 3	(24+)	D		J π : from 2232 γ to (22+); assumed E2 cascade member.
17870 ^c 4	(25-)	D		J π : from 2618 γ to (23-); assumed E2 cascade member.
17966 ^b 7	(25-)	D		J π : from 2160 γ to (23-); assumed E2 cascade member.
19218 ^a 5	(26+)	D		J π : from 2728 γ to (24+); assumed E2 cascade member.
20246 ^b 8	(27-)	D		J π : from 2280 γ to (25-); assumed E2 cascade member.

[†] From a least-squares fit to E γ 's, by evaluators. $\Delta E\gamma=1$ keV is assumed when no uncertainty is available.

[‡] From recoil distance Doppler shift method (2008Lj01), unless otherwise noted.

[§] From recoil distance Doppler shift method (1986He17), using singles data.

Effective lifetime from recoil distance method, not corrected for the side feedings (1986He17).

@ (A): g.s. yrast band.

& (B): Band based on 1600, 2+.

^a (C): Band based on 4607, 8+.

^b (D): Band based on 3915, 7-.

^c (E): Band based on 4896, (9-).

$\gamma(^{70}\text{Se})$

E(level)	E γ [†]	I γ [†]	Mult.@	δ^c	α	Comments
944.52	944.51 5	100	E2		4.82×10^{-4}	B(E2)(W.u.)=19.7 13.
1599.9	655.1 5	100 21	M1+E2&	-1.0 +1-2	$0.00109 4$	B(E2)(W.u.)=33 14; B(M1)(W.u.)=0.009 4. δ : Other: 1.4 +2.3-0.6 (1980Wa19).
	1600.1 7	25 5	E2		2.79×10^{-4}	B(E2)(W.u.)=0.19 8. Mult.: Q from $\gamma(0)$ in ⁵⁸ Ni(¹⁴ N,pn γ), ⁶⁰ Ni(¹² C,2n γ); M2 excluded by comparison to RUL.
2010.3	1065.8# 3	100#	(E2)		3.63×10^{-4}	
2038.8	438.9 5	0.8 7	[E2]		0.00415	B(E2)(W.u.)=17 15.
	1094.4 1	100 3	E2		3.41×10^{-4}	B(E2)(W.u.)=21.5 18.
2382.5	782.6 3	100 12	E2 ^a		7.71×10^{-4}	B(E2)(W.u.)>5.2.
	1438.1 7	80 50	E2 ^a		2.54×10^{-4}	B(E2)(W.u.)>0.20.
2518.6	1574.1 9	100	D			δ : $\delta=-0.26 15$ (1981Ah03); 0.0 (1980Wa19).
2553.1	1608.6 [‡]	100 [§]				

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Se})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\dagger}$	Mult.@	α	Comments
3003.2	620.7 9	3 1	[E2]	1.45×10^{-3}	B(E2)(W.u.)=8 3.
	964.39 5	100 4	E2	4.58×10^{-4}	B(E2)(W.u.)=29 5.
3139.6	2195.0# 3	100#			
3218.4	215 5	11 7			
	835.9 4	100 11			
3356.4	973.9 $\frac{1}{2}$	100 $\frac{1}{2}$			
3387.4	868.8 4	57 9	[E2]	5.91×10^{-4}	B(E2)(W.u.)=4.0 14.
	1348.6 4	100 12	E1 (+M2) ^b		δ : +0.12 with large error (1981Ah03); 0.0 (1980Wa19).
3524.1	1005.5 7	22 7	(E2) ^a	4.15×10^{-4}	B(E2)(W.u.)>0.64.
					Mult., δ : D+Q, -0.06 +9-2 (1981Ah03).
	1485.2 5	100 13	(E1) ^b	3.29×10^{-4}	B(E1)(W.u.)>1.1 $\times 10^{-5}$.
3644	1261 10	100			
3788.9	264.8 3	100	D+Q		Mult., δ : D+Q, 0.0< δ <3.7 (1980Wa19). Other: Q (1981Ah03).
3915.4	126.6 3	5.7 20			
	528.0 2	28.7 20	E2 ^a	0.00233	B(E2)(W.u.)>11.
	912.2 1	100 4	E1	2.17×10^{-4}	B(E1)(W.u.)>2.6 $\times 10^{-5}$.
					Mult., δ : E1+M2 with $\delta=-0.15$ 5 (1981Ah03), however, this results in an M2 strength which exceeds the RUL.
4037.6	1034.4 1	100	E2	3.89×10^{-4}	B(E2)(W.u.)>7.0.
					Mult.: Q from R(DCO) in $^{58}\text{Ni}(^{14}\text{N},\text{pn}\gamma)$, $^{60}\text{Ni}(^{12}\text{C},2\text{n}\gamma)$; M2 excluded by comparison to RUL.
4187.4	969.0 6	100			
4324.5	937.0 $\frac{1}{2}$				
	1321.3 $\frac{1}{2}$				
4410.7	495.3 3	100			
4607.0	569 2	18 8			
	691.5 6	56 8			
	1603.7 6	100 12			
4896.7	486.0 3	29 9			
	981.3 2	100 7			
4955.0	348.0 $\frac{1}{2}$ d	100 $\frac{1}{2}$			
5205.8	1168.12 8	100			
5209.1	1293.6 3	100			
5308.1	1120.7 6	100			
5693.2	1086.2 2	100 7			
	1655.4 9	41 6			
5805.5	908.7 2	100			
6017.0	1062.0 $\frac{1}{2}$	100 $\frac{1}{2}$			
6490.0	1280.9 2	100			
6510.2	1304.45 9	100			
6602	1294 5	100			
6873.0	1067.5 2	100			
6956.9	1263.6 3	100 10			
	1750.9 9	37 5			
7305.8	348.0 $\frac{1}{2}$ d				
	796.5 $\frac{1}{2}$				
7554.0	1064.0 3	100			
7940.8	1430.6 1	100			
8017.7	1144.7 2	100			
8029	1427.2 9	100			
8316.3	1359.4 3	100 8			
	1806.0 6	36 5			
8349.5	1043.7 $\frac{1}{2}$	100 $\frac{1}{2}$			
8771.8	1217.8 3	100			
9430.3	1114.0 3	100 10			
	1489.4 3	63 7			
9496.2	1555.3 3	100			
9624.1	1606.4 3	100			
10084.1	1312.3 3	100			
10646.2	1215.9 2	100			
11120.5	1624.3 6	100			
11268.5	1772.3 9	100			
11532.2	1908.1 7	100			

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Adopted Levels, Gammas (continued) $\gamma(^{70}\text{Se})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$
11778.5	1694.4 9	100	14257.7	1990.0 9	100	17966	2160 2	100
12267.7	1621.5 3	100	15251	2070 3	100	19218	2728 4	100
13160.5	1892 1	100	15806	2079 7	100	20246	2280 4	100
13181.4	1649.2 4	100	16490	2232 3	100			
13727.0	1948.4 6	100	17870	2618 2	100			

† From $^{40}\text{Ca}(^{40}\text{Ca}, 2\alpha 2p\gamma)$, unless otherwise noted.

‡ From $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p\gamma)$.

§ From $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p\gamma)$.

$^\#$ From $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$.

$^\@$ From $\gamma(\theta)$, R_{DCO} and γ -deexcitation pattern in $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$ (1981Ah03) or $\gamma(\theta)$ and linear polarization measurements in $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$ (1980Wa19), unless otherwise stated.

$^\&$ D+Q from $\gamma(\theta)$ in $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$; $\Delta\pi$ = no from level scheme.

$^\text{a}$ Q from $\gamma(\theta)$ in $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$; M2 excluded by comparison to RUL.

$^\text{b}$ D+Q (or D) from $\gamma(\theta)$ in $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$, $^{60}\text{Ni}(^{12}\text{C}, 2n\gamma)$; $\Delta\pi$ = yes from level scheme.

$^\text{c}$ From $\gamma(\theta)$ in $^{58}\text{Ni}(^{14}\text{N}, p\gamma)$ (1981Ah03).

$^\text{d}$ Multiply placed.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(E) Band based on
4896, (9-)

Adopted Levels, Gammas (continued)

^{70}Br ϵ Decay (79.1 ms)

Parent ^{70}Br : $E=0.0$; $J\pi=0+$; $T_{1/2}=79.1$ ms 8; $Q(g.s.)=10504$ 15; $\% \epsilon + \% \beta^+$ decay=100.

Please see the theory papers 2002To19, 2002Ha27 for G–T transition calculations.

The decay of ^{70}Br into levels in ^{70}Se has not been studied. Although a large g.s to g.s superallowed decay is expected, 2002Ha27 calculates that 325 1+ states should be fed with a total of 1.6% the β –decay strength.

 ^{70}Se Levels

E(level)	$J\pi$	Comments
0.0	0+	E(level): g.s to g.s superallowed branch expected to be $\approx 99\%$ (2002Ha27).

 ^{70}Br ϵ Decay (2.2 s) 2000Pi15,2001DoZZ

Parent ^{70}Br : $E=2292.3$ 8; $J\pi=9+$; $T_{1/2}=2.2$ s 2; $Q(g.s.)=10504$ 15; $\% \epsilon + \% \beta^+$ decay=100.

2000Pi15: $^{40}\text{Ca}(^{32}\text{S},\text{pn})$, $E(^{32}\text{S})=110$ MeV. γ –rays were measured using OSIRIS spectrometer. Measured γ , $\gamma\gamma$.

2001DoZZ: $^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn})$, $E(^{36}\text{Ar})=169$ MeV. GSI–mass separator and tape collector, 13 Ge detectors and a plastic scintillator. Measured $E\gamma$, $\beta\gamma\gamma$.

2002Ro25, 2002Ro16: $^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn})$, $E(^{36}\text{Ar})=169$ MeV. ISOLDE mass–separator, tape collector, Euroball–Cluster and Clovers, total absorption spectrometer consists of one NaI, two Si detectors and one Ge detector. Measured $\beta\gamma\gamma$, $\beta\gamma\gamma(t)$. Deduced $T_{1/2}$.

With a decay energy of 10.6 MeV and the highest observed level at 6.0 MeV, the decay scheme is most likely incomplete.

 ^{70}Se Levels

E(level) [†]	$J\pi^{\ddagger}$	Comments
0.0	0+	
944.6	2+	
1600.6	2+	
2037.9	4+	
2382.6	4+	
3001.6	6+	
3647	(6+)	
3913.9	7–	
4035.5	8+	
4604.8	8+	2002Ro25 report a 958 γ depopulating this level, but no final level was given. As there is no corresponding final level in the Adopted Levels, the 958 γ is not adopted here.
4952.8	(9)	$J\pi$: from 348.0 γ to 8+ suggested in ϵ decay (2000Pi15) but the placement of the γ is uncertain.
5204.3	(10+)	
5691.7	(10+)	
6014.8		

[†] From a least–squares fit to $E\gamma$'s, by the evaluators.

[‡] From Adopted Levels.

 β^+, ϵ Data

$E\epsilon$	E(level)	$I\beta^+$	$I\epsilon$	Log ft	$I(\epsilon+\beta^+)$	Comments
(7105 15)	5691.7	1.2 2	0.013 4	5.52 16	1.2 [†] 2	
(8192 15)	4604.8	74	0.45	4.1	74 [†]	$I(\epsilon+\beta^+)$: $I(\gamma+\text{ce})=I(\gamma+\text{ce})(690.2\gamma) + (\Sigma I(\gamma+\text{ce})(\text{to g.s.}))=75 + 18-33$ (2000Pi15).

[†] Reported in 2001DoZZ.

⁷⁰Br ε Decay (2.2 s) 2000Pi15,2001DoZZ (continued)

 $\gamma(^{70}\text{Se})$

No absolute normalization is provided since decay scheme is incomplete.

$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$	$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$	$E\gamma^\dagger$	E(level)	$I\gamma^\dagger$
348.0 [§]	4952.8	<10	911.7	3913.9	63 15	1062.0 [§]	6014.8	<5
569.0	4604.8	33 11	944.6	944.6	100 13	1093.3	2037.9	96 11
656 [‡]	1600.6		958 [‡]	4604.8		1168.8 [§]	5204.3	<7
690.2	4604.8	42 14	963.7	3001.6	92 10	1604 [‡]	4604.8	
782 [‡]	2382.6		1033.6	4035.5	33 15	1656.2 [§]	5691.7	<5

[†] From 2000Pi15, unless otherwise noted.

[‡] From 2002Ro25 in coin with 569 γ , not given in 2000Pi15.

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

Decay Scheme

Intensities: relative I_γ

$^9\text{Be}(^{70}\text{Se}, ^{70}\text{Se}'\gamma)$ 2014Ni09

2014Ni09: ^{70}Se beam from fragmentation of 150 MeV/nucleon ^{78}Kr beam on a ^9Be target, followed by separation using A1900 fragment separator at NSCL-MSU facility. Measured $E\gamma$, $I\gamma$, $T_{1/2}$ by RDDS technique using the TRIPLEX device (TRIPLEX) placed at the target position of S800 spectrograph. Calibration of distances was done using known lifetime of 4.2 ps 2 for first 2+ state in ^{62}Zn , which was strongly populated in the reaction used. Gamma rays were detected gated on recoil particles using SeGA array of 15 segmented HPGe detectors.

 ^{70}Se Levels

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}^{\S}$	Comments
0.0	0+		
945	2+	2.27 ps 26	
1600	2+	<5.2 ps #	$T_{1/2}$: Upper limit from effective $T_{1/2}$ of 4.66 ps 51 (2014Ni09).
2038	4+	<3.3 ps #	$T_{1/2}$: Upper limit from effective $T_{1/2}$ of 3.04 ps 26 (2014Ni09).
2519	3(-)	<1.7 ps #	$T_{1/2}$: Upper limit from effective $T_{1/2}$ of 1.29 ps 40 (2014Ni09).

[†] From $E\gamma$.

[‡] From the Adopted Levels.

[§] From Recoil-distance Doppler Shift (RDDS) method (2014Ni09).

Effective half-life from recoil-distance Doppler Shift (RDDS) method (2014Ni09), not corrected for side feeding. Therefore true lifetime can be shorter than this value. The quoted value should be considered as an upper limit.

 $\gamma(^{70}\text{Se})$

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}$
655	1600	7.1 10
945	945	100
1093	2038	30.5 16
1574	2519	16.5 13

[†] From 2014Ni09.

 $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p\gamma), ^{58}\text{Ni}(^{14}\text{N}, pn\gamma)$ 1986He17, 1989My01, 2008Lj01

1986He17: $^{58}\text{Ni}(^{14}\text{N}, pn)$ with $E(^{14}\text{N})=39$ MeV. Beam was provided by FN tandem accelerator at Universitat Koln. A 67.8% enriched 0.9 $\mu\text{g}/\text{cm}^2$ Ni target. 20 μm thick Ta stopper. γ -rays were measured using 3 Ge detectors. Neutrons were detected using a circular 4-segment NE213 detector. Measured $E\gamma$, $I\gamma$, γn coin, $T_{1/2}$ by recoil-distance Doppler shift method. $^{40}\text{Ca}(^{20}\text{Ar}, \alpha 2p\gamma)$ with $E(^{40}\text{Ar})=115$ MeV. Beam was provided by VICKSI accelerator at Berlin. A 350 $\mu\text{g}/\text{cm}^2$ Ca target with 96.9% ^{40}Ca on a thin 0.8 μm Al foil was used. 20 μm thick Ta foil used as a stopper. γ -rays were measured using three Ge(Li) detectors. Measured: $E\gamma$, $I\gamma$ and $T_{1/2}$ by recoil-distance Doppler shift method.

Authors adopted average $T_{1/2}$ from two experiments.

1989My01: $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p)$ with $E(^{36}\text{Ar})=145$ MeV. Beam was provided by VICKSI accelerator at Berlin. A 99.96% enriched 1 mg/cm^2 Ca target on a thin 50 mg/cm^2 Bi was used. γ -rays were measured using ORIS spectrometer which consisted of 12 BGO shielded Ge(Li) detectors. Measured: $E\gamma$, $I\gamma$, $\gamma\gamma$ coin, DCO ratios (not given in the publication).

Other: 1988MyZZ.

2008Lj01: $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p)$ with $E(^{36}\text{Ar})=136$ MeV. Beam was provided by accelerator at Legnaro. 0.5 mg/cm^2 enriched ^{40}Ca target on a 2.0 mg/cm^2 gold foil was used. 10 mg/cm^2 thick gold stopper. γ -rays were measured using GASP array of 38 Ge detectors. Cologne plunger was used to measure level lifetimes. Events with at least two prompt γ -rays detected in coincidence were recorded. Measured $E\gamma$ and $T_{1/2}$ using recoil-distance Doppler shift method.

2003LiZW: $^{40}\text{Ca}(^{36}\text{Ar}, \alpha 2p)$, $E(^{36}\text{Ar})=104$ MeV. ATLAS facility at ANL. Gammasphere and FMA were used. Measured $E\gamma$.

 ^{70}Se Levels

E(level) [†]	$J\pi^{\&}$	$T_{1/2}^{\S}$	Comments
0.0 [‡]	0+		
944.7 [‡]	2+	2.22 ps 14	$T_{1/2}$: Other: 1.0 ps 2 from recoil distance Doppler shift method (deduced using singles data) in 1986He17.
1600.9	2+	3.3 ps # 9	
2011.4	(0+)		E(level): seen by 1986He17 only. J^{π} adopted in 1986He17 based on literature.
2038.0 [‡]	4+	0.97 ps 7	$T_{1/2}$: Other: 1.0 ps 2 from recoil distance Doppler shift method (deduced using singles data) in 1986He17.

Continued on next page (footnotes at end of table)

$^{40}\text{Ca}(^{36}\text{Ar},\alpha 2p\gamma), ^{58}\text{Ni}(^{14}\text{N},pn\gamma)$ 1986He17,1989My01,2008Lj01 (continued) ^{70}Se Levels (continued)

E(level) [†]	J π ^{&}	T _{1/2} [§]	Comments
2382.4	4+	<12 ps [@]	
2516.8	3-	4.2 ps [#] 6	
2553.3	(4+)		
3001.7 $\frac{1}{2}^{\pm}$	6+	1.32 ps 21	T _{1/2} : Other: 2.7 ps 6 from recoil distance Doppler shift method, (deduced using singles data) in 1986He17.
3356.3	(6+)		
3386.0	5(-)	6.1 ps [#] 17	
3522.0	5-	<9 ps [@]	
3645.5	(6+)		
3786.0	6-		
3913.4	7-	<15 ps [@]	
4035.0 $\frac{1}{2}^{\pm}$	8+	<4 ps [@]	
4323.0	(7-)		
4408.5	(7,8-)		
4603.8	(8,9+)		
4895.2	(9)		
4951.8	(9)		
5203.9 $\frac{1}{2}^{\pm}$	10+		
5207.5	(8,9-)		
5691.3	(10+)		
5805.1	(11-)		
6013.8			
6487.6	(10,11-)		
6507.0 $\frac{1}{2}^{\pm}$	12+		
6874.4	(13-)		
6955.5	(12+)		
7303.5	(13-)	1.6 ns 2	T _{1/2} : quoted by 1989My01; generalized centroid-shift method. J π : proposed based on Weisskopf estimates in 1989My01.
7938.4 $\frac{1}{2}^{\pm}$	(14+)		
8347.2	(14,15-)		
9493.4 $\frac{1}{2}^{\pm}$	(16+)		

[†] From a least-squares fit to E γ 's, by evaluators, unless indicated otherwise.

$\frac{1}{2}^{\pm}$ Yrast band.

[§] From recoil distance Doppler shift method (RDDS) in 2008Lj01, except where noted. Side feeding contributions in 2008Lj01 were eliminated in the analysis using coincidences.

[#] From recoil distance Doppler shift method in 1986He17, using singles data.

[@] Effective lifetime from recoil distance Doppler shift method in 1986He17, using singles data, not corrected for side feedings.

[&] From DCO ratios observed in 1989My01 (DCOs are not given in the publication), unless stated otherwise.

 $\gamma(^{70}\text{Se})$

E γ [†]	E(level)	I γ [‡]	Comments
127.3	3913.4		
264.0	3786.0		
348.0 [§]	4951.8		
	7303.5		
486.7	4895.2		
495.1	4408.5		
527.3	3913.4	2.7 13	
569.0	4603.8		
619.3	3001.7		
656.1	1600.9	8.1 21	
690.2	4603.8		
781.5	2382.4	7.1 14	
796.5	7303.5		
869.3	3386.0		
909.9	5805.1		
911.7	3913.4	19 4	
937.0	4323.0		
944.6	944.7	100	

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$^{40}\text{Ca}(^{36}\text{Ar},\alpha 2p\gamma), ^{58}\text{Ni}(^{14}\text{N},pn\gamma)$ 1986He17,1989My01,2008Lj01 (continued) $\gamma(^{70}\text{Se})$ (continued)

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Comments
963.7	3001.7	21.2 15	
973.9	3356.3		
981.8	4895.2		
1005.1	3522.0	3.3 9	
1033.6	4035.0		
1043.7	8347.2		
1062.0	6013.8		
1066.7	2011.4	14 4	$E\gamma$: seen by 1986He17 only.
1069.3	6874.4		
1087.4	5691.3		
1093.3	2038.0	51 3	
1168.8	5203.9		
1263.1	3645.5		
1264.2	6955.5		
1280.1	6487.6		
1294.1	5207.5		
1303.1	6507.0		
1321.3	4323.0		
1348	3386.0	14.8 16	
1431.4	7938.4		
1437.9	2382.4	7.3 16	
1484	3522.0	3.4 8	
1555.0	9493.4		
1572	2516.8	13.5 22	
1600.9	1600.9	6.3 13	
1608.6	2553.3		
1656.2	5691.3		

 † From 1989My01. ‡ Relative intensity from $^{58}\text{Ni}(^{14}\text{N},pn\gamma)$ at $E(^{14}\text{N})=39$ MeV (1986He17) unless indicated otherwise; see 1986He17 for intensities from the $^{40}\text{Ca}(^{36}\text{Ar},\alpha 2p\gamma)$ reaction at $E(^{36}\text{Ar})=115$ MeV. $I\gamma$ and DCO ratios not given in 1989My01. § Multiply placed. **$^{40}\text{Ca}(^{40}\text{Ca},2\alpha 2p\gamma)$ 2002Ra42**

2002Ra42: $E(^{40}\text{Ca})=185$ MeV. 99.96% enriched self-supporting ^{40}Ca target with a thickness of 0.9 mg/cm². γ -rays detected using Euroball III comprised of 15 Cluster and 26 Clover detectors. Charged particles detected with the silicon ball ISIS consisting of 40 ΔE - E telescopes. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, $\gamma\gamma\gamma$ and $\gamma(0)$. Multipolarities could not be deduced because $\gamma(0)$ found to be nearly isotropic within statistical uncertainties. J^π based on literature, systematics and γ -coincidences. Additional experimental details provided in 2002RaZU.

 ^{70}Se Levels

$E(\text{level})^\dagger$	$J\pi^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\ddagger$	$E(\text{level})^\dagger$	$J\pi^\ddagger$
0.0 §	0+	4410.8 3	(8-)	8017.8 ^a 4	(15-)
944.52 § 5	2+	4607.0 [@] 3	(8+)	8029 [#] 5	(14+)
1600.02 [#] 11	2+	4896.84 ^a 24	(9-)	8316.3 [@] 3	(14+)
2038.93 § 11	4+	5205.86 § 17	10+	8771.9 ^{&} 6	(15-)
2382.6 [#] 3	4+	5209.1 ^{&} 3	(9-)	9430.3 [@] 3	(16+)
2518.7 4	3-	5308.2 [#] 10	(10+)	9496.3 § 4	(16+)
3003.32 § 12	6+	5693.2 [@] 3	(10+)	9624.2 ^a 5	(17-)
3218.5 [#] 5	(6+)	5805.5 ^a 3	(11-)	10084.2 ^{&} 7	(17-)
3387.52 22	5-	6490.1 ^{&} 4	(11-)	10646.2 [@] 4	(18+)
3524.1 3	5-	6510.32 § 19	12+	11120.6 7	(18+)
3644 10	(6+)	6602 [#] 5	(12+)	11268.6 § 10	(18+)
3788.9 3	6-	6873.1 ^a 4	(13-)	11532.3 ^a 9	(19-)
3915.53 ^{&} 15	7-	6956.9 [@] 4	(12+)	11778.6 ^{&} 11	(19-)
4037.73 § 16	8+	7554.1 ^{&} 5	(13-)	12267.8 [@] 5	(20+)
4187.5 [#] 8	(8+)	7940.94 § 22	(14+)	13160.6 § 14	(20+)

Continued on next page (footnotes at end of table)

⁴⁰Ca(⁴⁰Ca,2 α 2p γ) 2002Ra42 (continued)

⁷⁰Se Levels (continued)

E(level) [†]	J π [‡]	E(level) [†]	J π [‡]	E(level) [†]	J π [‡]
13181.5 ^a 10	(21-)	15806 ^{&} 7	(23-)	19218 [@] 5	(26+)
13727.0 ^{&} 13	(21-)	16490 [@] 3	(24+)	20246 ^{&} 8	(27-)
14257.8 [@] 10	(22+)	17870 ^a 4	(25-)		
15252 ^a 3	(23-)	17966 ^{&} 7	(25-)		

[†] From a least-squares fit to E γ 's, by evaluators.

[‡] From 2002Ra42, based on literature, systematics and γ -coincidences.

[§] (A): g.s. yrast band.

[#] (B): Band based on 1600, 2+.

[@] (C): Band based on 4607, (8+).

[&] (D): Band based on 3915, 7-.

^a (E): Band based on 4896, (9-).

 $\gamma(^{70}\text{Se})$

E γ [†]	E(level)	I γ [†]	E γ [†]	E(level)	I γ [†]	E γ [†]	E(level)	I γ [†]
126.6 3	3915.53	1.7 6	1086.2 2	5693.2	10.6 7	1600.1 7	1600.02	1.1 2
215 5	3218.5	0.5 3	1094.4 1	2038.93	89 3	1603.7 6	4607.0	5.0 6
264.8 3	3788.9	5.4 5	1114.0 3	9430.3	6.3 6	1606.4 3	9624.2	5.0 4
438.9 5	2038.93	0.7 6	1120.7 6	5308.2	2.9 6	1621.5 3	12267.8	5.5 5
486.0 3	4896.84	2.9 9	1144.7 2	8017.8	5.7 4	1624.3 6	11120.6	2.4 4
495.3 3	4410.8	5.1 9	1168.12 8	5205.86	29.5 5	1649.2 4	13181.5	2.6 3
528.0 2	3915.53	8.6 6	1215.9 2	10646.2	9.1 17	1655.4 9	5693.2	4.3 6
569 2	4607.0	0.9 4	1217.8 3	8771.9	9.7 6	1694.4 9	11778.6	3.7 3
620.7 9	3003.32	2.2 4	1261 10	3644	0.5 2	1750.9 9	6956.9	2.3 3
655.5 1	1600.02	4.4 9	1263.6 3	6956.9	6.3 6	1772.3 9	11268.6	2.3 3
691.5 6	4607.0	2.8 4	1280.9 2	6490.1	10.3 6	1806.0 6	8316.3	2.4 3
782.6 3	2382.6	7.2 8	1293.6 3	5209.1	15.0 8	1892 1	13160.6	0.6 2
835.9 4	3218.5	4.6 5	1294 5	6602	1.1 6	1908.1 7	11532.3	3.6 3
868.8 4	3387.52	4.1 6	1304.45 9	6510.32	26.3 9	1948.4 6	13727.0	1.1 3
908.7 2	5805.5	13.9 7	1312.3 3	10084.2	6.9 5	1990.0 9	14257.8	1.9 3
912.2 1	3915.53	30 1	1348.6 4	3387.52	7.2 8	2070 3	15252	1.5 2
944.51 5	944.52	100.0 6	1359.4 3	8316.3	6.7 5	2079 7	15806	0.9 3
964.39 5	3003.32	71 3	1427.2 9	8029	1.1 6	2160 2	17966	0.6 2
969.0 6	4187.5	4.0 2	1430.6 1	7940.94	18.6 8	2232 3	16490	0.5 3
981.3 2	4896.84	10.1 7	1438.1 7	2382.6	6 3	2280 4	20246	0.5 3
1005.5 7	3524.1	1.4 4	1485.2 5	3524.1	6.3 8	2618 2	17870	0.6 4
1034.4 1	4037.73	45 1	1489.4 3	9430.3	4.0 4	2728 4	19218	0.4 2
1064.0 3	7554.1	9.6 6	1555.3 3	9496.3	5.8 4			
1067.5 2	6873.1	11.7 6	1574.1 9	2518.7	4 1			

[†] From 2002RaZU.

⁵⁸Ni(¹⁴N,pnγ), ⁶⁰Ni(¹²C,2nγ) 1981Ah03,1980Wa19

1981Ah03: ⁵⁸Ni(¹⁴N,pnγ) with E(¹⁴N)=38 MeV. The beam provided by ORNL EN Tandem. 58 mg/cm² thick ⁵⁸Ni target. γ-rays were measured using two Ge(Li) and one Na(I) detectors. Measured Eγ, Iγ, γγ coin, γ(θ), γγ(θ). Deduced DCO and mixing ratio.
 1980Wa19: ⁶⁰Ni(¹²C,2nγ) with E(¹²C)=34 MeV. More than 99% enriched 3-5 mg/cm² thick ⁶⁰Ni target. Measured Eγ, γγ coin, γ(θ), and γn coincidences, linear polarization. Deduced multipolarity and mixing ratio.
 1975GuYV: E=36 MeV, ⁵⁸Ni(¹⁴N,pnγ), T_{1/2} by plunger technique.
 1974No08: ⁵⁸Ni(¹⁴N,pnγ) with E(¹⁴N)=36 MeV. 99.89% enriched 2.55 mg/cm² thick ⁵⁸Ni target. Measured Eγ, γγ coincidences.

⁷⁰Se Levels

E(level) [†]	Jπ [‡]	T _{1/2} [§]	Comments
0.0#	0+		
945.4# 2	2+	1.1 ps 3	Jπ: 2+ from 945.4γ E2 to 0+.
1601.4@ 2	2+		Jπ: 2(+) from 1601.4γ Q to 0+; 656.0γ D+Q to 2+.
2011.2 4	(0+)		Jπ: from 1065.8γ Q to 2+. γ(θ) in both 1980Wa19 and 1981Ah03 is isotropic.
2039.6# 4	4+	2.3 ps 6	Jπ: from 1094γ E2 to 2+.
2384.4@ 3	4+		Jπ: from 782.9γ Q to 2(+) ; 1439γ Q to 2+.
2519.2 4	3-		Jπ: from 1573γ D to 2+.
3004.1# 5	6+		Jπ: from 964.6γ E2 to 4+.
3140.4 4			E(level): based on deexciting 2195γ (1981Ah03). Transition not seen by 1980Wa19.
3388.7 5	5-		Jπ: from 1349.0γ D(+Q) to 4+.
3525.2 4	(5-)		Jπ: as proposed in 1980Wa19. Other: (4) in 1980Wa19.
3789.8 5	(6-)		Jπ: from 1980Wa19. Other: (5) in 1981Ah03.
3916.1 5	7-		Jπ: from 912.1γ E1 to 6+.
4038.9# 6	8+		Jπ: from 1034.8γ Q to 6+.

[†] From a least-squares fit to Eγ's, by evaluators.

[‡] From 1981Ah03 based on γ(θ), R_{DCO} and γ-deexcitation pattern. Additional support for Jπ assignments as determined in this dataset are indicated in the comments.

[§] From 1975GuYV.

(A): Yrast band.

@ (B): Kπ=2+ γ vibrational band.

γ(⁷⁰Se)

Eγ	E(level)	Iγ [‡]	Mult. [†]	δ [§]	Comments
264.6 3	3789.8	8.8	D+Q#		Mult.,δ: from γ(θ) in 1980Wa19 which gives mult=D+Q, 0.0<δ<3.7 (1980Wa19). 1981Ah03 give E2 for the transition multipolarity, however, this does not agree with their measured A ₂ and A ₄ values and their assignment as Jπ=(5) to (4) transition. Mult.: A ₂ =-0.14 5, A ₄ =0.0 5 (1980Wa19); A ₂ =-0.28 6, A ₄ =0.09 7 (1981Ah03).
527.3 3	3916.1	2.2	Q		Mult.: A ₂ =+0.24 10, A ₄ =-0.12 13 (1981Ah03). Iγ: other: Iγ(527γ):Iγ(912γ)= <10 :>90 (1980Wa19).
656.0 3	1601.4	5.0	D+Q	-1.0 +1-2	δ: Other: 1.4 +2.3-0.6 (1980Wa19). Mult.: A ₂ =-0.25 7, A ₄ =0.04 12 (1980Wa19); A ₂ =-0.23 5, A ₄ =0.02 7 (1981Ah03).
782.9 3	2384.4	7.7	Q		Iγ: other: Iγ(656γ):Iγ(1600γ)=52 2:48 2 (1980Wa19). Mult.: A ₂ =0.20 5, A ₄ =-0.07 6 (1980Wa19); A ₂ =0.30 10, A ₄ =-0.20 9 (1981Ah03).
912.1 3	3916.1	22.4	E1#		Iγ: other: Iγ(783γ):Iγ(1439γ)=63 4:37 4 (1980Wa19). δ: -0.15 5 (1981Ah03). Mult.: A ₂ =-0.28 3, A ₄ =-0.08 5, POL=+0.16 4 (1980Wa19); A ₂ =-0.226 31, A ₄ =0.071 34 (1981Ah03).
945.4 3	945.4	100	E2#		Mult.: A ₂ =0.154 7, A ₄ =-0.036 8, POL=+0.27 7 (1980Wa19); A ₂ =0.172 16, A ₄ =-0.077 20 (1981Ah03).
964.6 3	3004.1	33.3	E2#		Mult.: A ₂ =0.15 4, A ₄ =-0.08 5, POL=+0.62 30 (1980Wa19); A ₂ =0.181 18, A ₄ =0.040 22 (1981Ah03).
1005.9 3	3525.2	6.7	(Q)		Mult.,δ: Q in 1980Wa19; D(+Q), δ= -0.06 +9-2 (1981Ah03). A ₂ =0.41 15, A ₄ =-0.03 12 (1980Wa19); A ₂ =-0.164 25, A ₄ =0.069 31 (1981Ah03).
1034.8 3	4038.9	11.1	Q		Iγ: other: Iγ(1006γ):Iγ(1485γ)=18 3:83 3 (1980Wa19). Mult.: from R(DCO) in 1981Ah03.

Continued on next page (footnotes at end of table)

$^{58}\text{Ni}(^{14}\text{N,pn}\gamma), ^{60}\text{Ni}(^{12}\text{C,2n}\gamma)$ 1981Ah03,1980Wa19 (continued) $\gamma(^{70}\text{Se})$ (continued)

$E\gamma$	E(level)	$I\gamma^{\ddagger}$	Mult. [†]	Comments
1065.8 3	2011.2	4.2	Q	Mult.: $A_2=0.00$ 4, $A_4=0.01$ 5 (1980Wa19); $A_2=-0.04$ 10, $A_4=0.21$ 11 (1981Ah03).
1094.2 3	2039.6	59.7	E2 [#]	Mult.: $A_2=0.21$ 2, $A_4=-0.06$ 2, POL=+0.47 13 (1980Wa19); $A_2=0.218$ 19, $A_4=0.083$ 22 (1981Ah03).
1349.0 3	3388.7	17.2	D(+Q)	δ : +0.12 with large error (1981Ah03); 0.0 (1980Wa19). Mult.: $A_2=-0.052$ 28, $A_4=-0.092$ 34 (1981Ah03); $A_2=-0.20$ 7, $A_4=0.01$ 8 (1980Wa19).
1439.0 3	2384.4	7.7	Q	Mult.: $A_2=0.25$ 8, $A_4=-0.06$ 10 (1980Wa19); $A_2=0.19$ 6, $A_4=-0.17$ 8 (1981Ah03).
1485.6 3	3525.2	11.2	D	Mult.: From $\gamma(\theta)$ in 1980Wa19. $A_2=-0.25$ 7, $A_4=-0.10$ 8 (1980Wa19).
1573.8 3	2519.2	7.6	D	δ : -0.26 15 (1981Ah03); 0.0 (1980Wa19). Mult.: $A_2=-0.295$, $A_4=0.03$ 5 (1980Wa19); $A_2=-0.36$ 5, $A_4=-0.054$ 54 (1981Ah03).
1601.4 3	1601.4	7.0	Q	Mult.: $A_2=0.25$ 8, $A_4=-0.05$ 9 (1980Wa19); $A_2=0.18$ 6, $A_4=-0.11$ 7 (1981Ah03).
2195.0 3	3140.4	<1		$E\gamma$: Not seen by 1980Wa19.

[†] From $\gamma(\theta)$ and R_{DCO} in 1981Ah03, unless otherwise noted.

[‡] From 1981Ah03. Authors make only a general statement that uncertainties range from 5% to 20% depending on the strength of the transitions. 1980Wa19 provide only relative branchings from levels, which are indicated in the comments.

[§] From $\gamma(\theta)$ in 1981Ah03.

[#] From $\gamma(\theta)$ and linear polarization measurements in 1980Wa19.

Coulomb Excitation 2007Hu03

2007Hu03: A ^{70}Se beam at an energy of 206 MeV (and with an average intensity of about 10^4 ions/s) was produced by spallation reaction using ZrO_2 target and 1.4 GeV protons from CERN PS Booster. 2.0 mg/cm² ^{104}Pd target was used to populate the 945-keV level in ^{70}Se . Gamma rays were detected with a highly-segmented MINIBALL array of HPGe detectors. This array consisted of eight triple cluster detectors with each crystal six-fold segmented thus making a total of 144 individual elements. The scattered beam and recoiling target particles were detected in a double-sided silicon CD detector. Deduced spectroscopic quadrupole moment of the first 2+ state in ^{70}Se using nuclear reorientation effect. Computer code GOSIA used to analyze the multiple Coulomb excitation yields.

 ^{70}Se Levels

$E(\text{level})^{\ddagger}$	$J\pi^{\ddagger}$	Comments
0.0	0+	
945	2+	Q=+ (2007Hu03). Diagonal E2 matrix element=-0.5 is required for agreement of the current measurement with earlier measured lifetime $\tau=1.5$ ps 3 at 1 σ level. This value implies prolate shape.

[†] From $E\gamma$.

[‡] From Adopted Levels.

 $\gamma(^{70}\text{Se})$

$E\gamma^{\ddagger}$	E(level)
945	945

[†] From 2007Hu03.

Adopted Levels, Gammas

Q(β^-)=-10480 SY; S(n)=13390 40; S(p)=2280 15; Q(α)=-1825 SY 2012Wa38.
 $\Delta Q(\beta^-)$ =200; $\Delta Q(\alpha)$ = 16 (2012Wa38).
 S(2n)=29130 310; S(2p)=7109 15 (2012Wa38).
 1978Al23: $^{58}\text{Ni}(^{14}\text{N},2n)$ with $E(^{14}\text{N})=44$ MeV; plastic scintillation detector used to detect β rays; measured $T_{1/2}$.
 1981Vo04: from 600 MeV proton-irradiated Nb powder target; on-line mass separator; 4π β -detector; measured $T_{1/2} = 2.2$ s 2 (from $\beta(t)$). Authors compared their measurement with literature value (1978Al23) and suggested isomerism might exist.
 1988Bu12: $^{58}\text{Ni}(^{14}\text{N},2n)$ with $E(^{14}\text{N})=42.5$ MeV; rapid-transport target system with β -ray range telescope; measured $T_{1/2}$.
 2002Lo13: fragmentation of ^{78}Kr beam at 73 MeV/nucleon using LISE/SISSI-ALPHA spectrometer at GANIL and identified through ΔE and TOF measurements. A four-element Si telescope (ΔE detector, position sensitive detector, double-sided Si strip detector as the implantation device and a Si(Li) detector as a veto for lighter ions). Measured $T_{1/2}$ from time correlation between ion implantation and β events in the silicon strip detector. Large $\Delta T_{1/2}$ due to the low production rate of ^{70}Br .
 2014Ro14: produced by fragmentation of a ^{78}Kr beam on a natural Ni target with $E(^{78}\text{Kr})=70$ MeV/nucleon. Separated using the LISE3 spectrometer and identified using ΔE -TOF measurements. A silicon telescope was used. Measured $T_{1/2}$ from time correlation between ion implantation and β events in the silicon strip detector.
 1999Bo28: using $^{58}\text{Ni}(^{16}\text{O},p3n\gamma)$ reaction, the gamma rays and level scheme were assigned to ^{70}Br , but in the erratum the authors have retracted the assignment to ^{70}Br .

^{70}Br Levels

Cross Reference (XREF) Flags

A ^{70}Kr ε Decay
 B $^9\text{Be}(^{71}\text{Br},^{70}\text{Br}\gamma)$
 C $^{40}\text{Ca}(^{36}\text{Ar},\alpha p n\gamma),(^{32}\text{S},p n\gamma)$

E(level) [†]	J π [‡]	XREF	$T_{1/2}$ [§]	Comments
0.0	0+	ABC	79.1 ms 8	% ε +% β^+ =100. $T_{1/2}$: weighted average of 80.2 ms 8 (1978Al23, from $\beta(t)$) and 78.5 ms 6 (1988Bu12, from $\beta(t)$). Other: 79 ms 36 (2002Lo13) and 70 ms 19 (2014Ro14). $J\pi$: super allowed ε to 0+ ^{70}Se .
933.6 3	2+	BC	2.74 ps 40	$J\pi$: 933.6 γ E2 to 0+.
1336.4 4	(3+)	BC	22 ps 10	$J\pi$: 402.6 γ D to 2+, 666 γ from 4+.
1657.0 5	(5+)	BC	374 ps 83	$J\pi$: 320.7 γ E2 to (3+). $T_{1/2}$: from lineshape analysis of 321 γ using forward angle data in 2014Ni09.
1760.4 7		C		$J\pi$: (3+) in 2002Je07.
2002.3 4	4+	C		$J\pi$: 1068.8 γ E2 to 2+.
2292.3 [#] 8	9+	C	2.2 s 2	% ε +% β^+ =100. E(level): 2.23 MeV 9 deduced from decay energy of isomer and estimated Q value of ^{70}Br (2004Ka38). $T_{1/2}$: from $\beta(t)$ in 1981Vo04. Other: 2.2 s 3 preliminary value given in 2002Ro25. % ε +% β^+ : IT decay has not been observed. $J\pi$: Allowed ε decay to 8+, systematics.
2350.9 5	(5+)	C		$J\pi$: 348.6 γ D to 4+.
2677.0 6	(6+)	C		$J\pi$: 326.1 γ D to (5+).
2683.0 7	7+	C		$J\pi$: 1026.0 γ E2 to 5+, 390.7 γ to 9+.
3027.3 ^{&} 8	(8+)	C		$J\pi$: 344.4 γ D to 7+, 734.8 γ to 9+.
3098.5 [@] 9	(10+)	C		$J\pi$: 806.2 γ D+Q to 9+.
3547.2 [#] 8	11+	C		$J\pi$: 1254.8 γ E2 to 9+.
3681.1 8	(8+)	C		$J\pi$: 765.0 γ E2 from (10+).
4446.2 ^{&} 9	(10+)	C		$J\pi$: 765 γ E2 to (8+).
4531.2 [@] 10	(12+)	C		$J\pi$: 1432.6 γ to (10+); assumed E2 cascade member.
4884.8 [#] 9	(13+)	C		$J\pi$: 1337.6 γ to 11+; assumed E2 cascade member.
5443.3 ^{&} 10	(12+)	C		$J\pi$: 997.1 γ to (10+); assumed E2 cascade member.
6050.9 [@] 11	(14+)	C		$J\pi$: 1519.7 γ to (12+); assumed E2 cascade member.
6487.4 [#] 10	(15+)	C		$J\pi$: 1602.6 γ to (13+); assumed E2 cascade member.
6787.9 ^{&} 11	(14+)	C		$J\pi$: 1344.6 γ to (12+); assumed E2 cascade member.
7659.1 13		C		$J\pi$: (16+) in 2002Je07.
7712.4 [@] 12	(16+)	C		$J\pi$: 1661.5 γ to (14+); assumed E2 cascade member.
8069.8 [#] 11	(17+)	C		$J\pi$: 1582.4 γ to (15+); assumed E2 cascade member.
8430.7 ^{&} 13	(16+)	C		$J\pi$: 1642.8 γ to (14+); assumed E2 cascade member.
9470.4 13		C		$J\pi$: (18+) in 2002Je07.
9507.4 [@] 14	(18+)	C		$J\pi$: 1795.0 γ to (16+); assumed E2 cascade member.
9782.0 [#] 12	(19+)	C		$J\pi$: 1712.2 γ to (17+); assuming E2 cascade member.
11667.1 [#] 14	(21+)	C		$J\pi$: 1885.0 γ to (19+); assumed E2 cascade member.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{70}Br Levels (continued)

E(level) [†]	J π [‡]	XREF	Comments
13786.0 [#] 15	(23+)	C	J π : 2118.9 γ to (21+); assumed E2 cascade member.
16157.7 [#] 19	(25+)	C	J π : 2371.7 γ to (23+); assumed E2 cascade member.
18662.8 [#] 23	(27+)	C	J π : 1866.2 γ to (25+); assumed E2 cascade member.
21411.9 [#] 25	(29+)	C	J π : 2749 γ to (27+); assumed E2 cascade member.

[†] From a least-squares fit to E γ , by evaluators.

[‡] From $^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn}\gamma),(^{32}\text{S,pn}\gamma)$ (2002Je07) based on multipolarity determined by DCO ratios and band structure. Additional parenthesis have been added by the evaluators in some cases.

§ From RDDS in $^9\text{Be}(^{71}\text{Br},^{70}\text{Br}\gamma)$ (2014Ni09), except where noted.

(A): Configuration= $\pi g_{9/2} \otimes \nu g_{9/2}, \alpha=1$.

@ (B): Configuration= $\pi g_{9/2} \otimes \nu g_{9/2}, \alpha=0$.

& (C): Band based on 3027, (8+) level.

 $\gamma(^{70}\text{Br})$

E(level)	E γ [†]	I γ [†]	Mult. [‡]	α	Comments
933.6	933.6 3	100	E2	5.38 $\times 10^{-4}$	B(E2)(W.u.)=17.0 25.
1336.4	402.6 3	100	D	0.00320	
1657.0	320.7 3	100	E2	0.01264	B(E2)(W.u.)=26 6.
1760.4	424.0 5	100			
2002.3	665.7 3				
	1068.8 3		E2	3.92 $\times 10^{-4}$	
2350.9	348.6 4		D	0.00453	
	694.0 4				
2677.0	326.1 3	100	D	0.00532	
2683.0	390.7 4	47 7			
	1026.0 5	100 13	E2	4.30 $\times 10^{-4}$	
3027.3	344.4 5	100 11	D	0.00466	
	734.8 4	76 13			
3098.5	806.2 4	100	D+Q		
3547.2	1254.8 3	100	E2	2.93 $\times 10^{-4}$	
3681.1	998.0 5	100			
4446.2	765.0 4	39 7	E2	8.87 $\times 10^{-4}$	
	1418.6 7	100 9	E2	2.70 $\times 10^{-4}$	
	2155.0 12	23 4			
4531.2	1432.6 5	100			
4884.8	1337.6 3	100			
5443.3	997.1 5	100			
6050.9	1519.7 4	100			
6487.4	1602.6 4	100			
6787.9	1344.6 5	100			
7659.1	1608.2 6	100			
7712.4	1661.5 5	100			
8069.8	1582.4 4	100			
8430.7	1642.8 6	100			
9470.4	1758.0 5	100			
9507.4	1795.0 6	100			
9782.0	1712.2 6	100			
11667.1	1885.0 6	100			
13786.0	2118.9 7	100			
16157.7	2371.7 11	100			
18662.8	2505.0 13	100			
21411.9	2749	100			

[†] From $^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn}\gamma),(^{32}\text{S,pn}\gamma)$ (2002Je07).

[‡] From DCO ratios in $^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn}\gamma),(^{32}\text{S,pn}\gamma)$. Stretched Q are assumed E2.

Adopted Levels, Gammas (continued)

 $^{70}_{35}\text{Br}_{35}$

Adopted Levels, Gammas (continued)

^{70}Kr ϵ Decay

Parent ^{70}Kr : $E=0.0$; $J\pi=0+$; $T_{1/2}=40$ ms 6; $Q(\text{g.s.})=10480$ syst; $\% \epsilon + \% \beta^+$ decay=100.

^{70}Kr : $\Delta Q=200$ syst (2012Wa38).

No γ 's or protons have been observed in the decay of ^{70}Kr (2000Oi02). An upper limit of <1.3% for the β -delayed proton branching ratio was estimated in 2000Oi02.

 ^{70}Br Levels

<u>E(level)</u>	<u>$J\pi$</u>
0.0	0+

 β^+, ϵ Data

<u>$E\epsilon$</u>	<u>E(level)</u>	<u>$I\beta^+$</u>	<u>$I\epsilon^\dagger$</u>	<u>$\text{Log } ft$</u>	<u>$I(\epsilon+\beta^+)^\dagger$</u>
(10480)	0.0	≤ 99.8	≤ 0.155	≥ 3.3	≤ 100

† Absolute intensity per 100 decays.

 $^9\text{Be}(^{71}\text{Br}, ^{70}\text{Br}\gamma)$ 2014Ni09

2014Ni09: ^{71}Br beam from fragmentation of 150 MeV/nucleon ^{78}Kr beam by ^9Be target, followed by separation using A1900 fragment separator at NSCL-MSU facility. Measured $E\gamma$, $I\gamma$, $T_{1/2}$ by RDDS technique using the TRIPLEX device (TRIPLEX) placed at the target position of S800 spectrograph. Calibration of distances was done using known lifetime of 4.2 ps 2 for first 2+ state in ^{62}Zn , which was strongly populated in the experiment. Gamma rays were detected gated on recoil particles using SeGA array of 15 segmented HPGe detectors.

 ^{70}Br Levels

<u>E(level)†</u>	<u>$J\pi^\S$</u>	<u>$T_{1/2}^\ddagger$</u>	<u>Comments</u>
0.0	0+		
934	2+	2.74 ps 40	
1337	(3+)	22 ps 10	
1658	(5+)	374 ps 83	$T_{1/2}$: from lineshape using forward angle data.

† From $E\gamma$.

‡ From Recoil-distance Doppler Shift (RDDS) method (2014Ni09).

§ From the Adopted Levels.

 $\gamma(^{70}\text{Br})$

<u>$E\gamma^\dagger$</u>	<u>E(level)</u>	<u>$I\gamma^\dagger$</u>
321	1658	11.9 17
403	1337	23.6 26
934	934	100

† From 2014Ni09.

⁴⁰Ca(³⁶Ar,αpnγ),(³²S,pnγ) 2002Je07

2002Je07: ⁴⁰Ca (³⁶Ar,αpnγ) with E(³⁶Ar)=145 MeV. Measured E_γ, I_γ, γγ, γγ(θ), particle-γ coin using Gammasphere array with 73 Ge detectors and Microball array with 95 CsI detectors. Neutrons were detected with a 30-detector neutron shell. Deduced DCO ratios.

2002Je07: ⁴⁰Ca(³²S,pnγ) (for low-spin studies) with E(³²S)=80-100 MeV. Measured E_γ, I_γ, γγ and γγ(θ) using Gammasphere array consisting of 69 Compton-suppressed detectors, a 30-element neutron detector, a LEPS detector, BC501 liquid scintillator neutron detectors. Deduced DCO ratios.

2001De46: ⁴⁰Ca(³²S,pnγ) with E(³²S)=90 MeV. Measured E_γ, I_γ, γγ γγ(θ). Deduced DCO ratios. In one experiment GASP array with 40 Compton-suppressed Ge detectors, inner BGO ball, ISIS Si-ball of 40 ΔE-E Si detectors, and neutron detectors were used. In a second experiment EUROBALL array with 15 'clusters' and 26 'clover' composite detectors were used with a 4π charged-particle device EUCLIDES consisting of 40 Si ΔE-E telescopes. Neutrons were detected with a an array of 50 liquid scintillators.

2002Je07 and 2001De46 disagree about the location of 9⁺ isomer. 2001De46 assigns E_{lev} and J^π of the 9⁺ isomer mainly based on the systematics. 2002Je02 assigns E_{lev} and J^π based on measured E_γs and multipolarities deduced from DCO measurements. The ambiguity of the location of the isomer was clarified in β-decay studies (2004Ka38), where an energy of 2.23 MeV 9 was determined, in good agreement with the excitation energy assigned in 2002Je07.

All data presented here are from 2002Je07, unless stated otherwise. Stronger transitions, I_γ>10%, as seen by 2001De46 are in agreement with 2002Je07. Some of the weaker transitions reported by 2001De46 have not been confirmed, these are:

E _γ	I _γ (I _γ (403γ)=100)	E(lev)
274 1	3.4 17	1931
421.0 6	7 3	2352
470.4 6	19 3	3148
595 1	5.1 17	1931
654 1	3.4 17	3679
963.4	9 3	2965
1025 1	5 3	3990
1104	5 2	2761
1468	5 2	2682

⁷⁰Br Levels

No 1+ (expected T=0) level has been seen below 800 keV.

E(level) [†]	Jπ [‡]	T _{1/2}	Comments
0.0	0+	79.1 ms 8	T _{1/2} : From the Adopted Levels.
933.6 3	2+		
1336.4 4	3+		
1657.0 5	5+		
1760.4 7	(3+)		
2002.3 4	4+		
2292.3 § 8	9+	2.2 s 2	T _{1/2} : From the Adopted Levels. E(level): a tentative (9+) isomer proposed by 2001De46 at 1214 is assigned at 2293 by 2002Je07.
2350.9 5	(5+)		
2677.0 6	(6+)		
2683.0 7	7+		
3027.3 8	(8+)		
3098.5 # 9	(10+)		
3547.2 § 8	11+		
3681.1 8	(8+)		
4446.2 9	(10+)		
4531.2 # 10	(12+)		
4884.8 § 9	(13+)		
5443.3 10	(12+)		
6050.9 # 11	(14+)		
6487.4 § 10	(15+)		
6787.9 11	(14+)		
7659.1 13	(16+)		
7712.4 # 12	(16+)		
8069.8 § 11	(17+)		
8430.7 13	(16+)		
9470.4 13	(18+)		
9507.4 # 14	(18+)		
9782.0 § 12	(19+)		
11667.1 § 14	(21+)		
13786.0 § 15	(23+)		

Continued on next page (footnotes at end of table)

$^{40}\text{Ca}(^{36}\text{Ar},\alpha\text{pn}\gamma),(^{32}\text{S,pn}\gamma)$ 2002Je07 (continued) ^{70}Br Levels (continued)

$E(\text{level})^\dagger$	$J\pi^\ddagger$
16157.7 § 19	(25+)
18662.8 § 23	(27+)
21411.9 § 25	(29+)

† From a least-squares fit to E_γ , by evaluators.

‡ From 2002Je07.

§ (A): Configuration= $((\pi g_{9/2}) (v g_{9/2}))$, $\alpha=1$.

(B): Configuration= $((\pi g_{9/2}) (v g_{9/2}))$, $\alpha=0$.

 $\gamma(^{70}\text{Br})$

$E_\gamma^\dagger$	$E(\text{level})$	$I_\gamma^\dagger$	Mult. §	Comments
320.7 ‡ 3	1657.0	97 12	E2	DCO=0.93 15, 0.90 12. I_γ : 52 6.
326.1 3	2677.0		D	DCO=0.31 9. I_γ : 30 6.
344.4 5	3027.3	46 5	D	DCO=0.52 14. I_γ : 9 3.
348.6 4	2350.9		D	DCO=0.47 16. I_γ : 51 6.
390.7 4	2683.0	27 4		
402.6 ‡ 3	1336.4	100	D	DCO=0.76 9, 0.52 14. I_γ : 100.
424.0 5	1760.4			I_γ : 10 3.
665.7 3	2002.3			I_γ : 13 3.
694.0 4	2350.9			I_γ : 25 4.
734.8 4	3027.3	35 6		
765.0 4	4446.2	31 5	E2	DCO=1.00 22.
806.2 4	3098.5	24 3	D+Q	DCO=0.76 8.
933.6 3	933.6		E2	DCO=0.87 13.
997.1 5	5443.3	123 9		I_γ : for 998.0+997.1. DCO=1.18 15 for 998.0+997.1.
998.0 5	3681.1	123 9		I_γ : for 998.0+997.1. DCO=1.18 15 for 998.0+997.1.
1026.0 ‡ 5	2683.0	57 7	E2	DCO=1.09 25. I_γ : 34 6.
1068.8 3	2002.3		E2	DCO=0.85 10. I_γ : 78 9.
1254.8 3	3547.2	77 4	E2	DCO=0.99 15.
1337.6 3	4884.8	61 4		
1344.6 5	6787.9	55 6		
1418.6 7	4446.2	80 7	E2	DCO=0.92 15.
1432.6 5	4531.2	27 4		
1519.7 4	6050.9	22 3		
1582.4 4	8069.8	44 6		
1602.6 4	6487.4	47 6		
1608.2 6	7659.1	5 1		
1642.8 6	8430.7	46 4		
1661.5 5	7712.4	12 3		
1712.2 6	9782.0	30 5		
1758.0 5	9470.4	8 2		
1795.0 6	9507.4	7 2		
1885.0 6	11667.1	12 3		
2118.9 7	13786.0	9 2		
2155.0 12	4446.2	18 3		
2371.7 11	16157.7	5 2		
2505.0 13	18662.8	3 1		
2749	21411.9			E_γ : From Figure 3 of 2002Je07, not listed in Table I.

† From 2002Je07. I_γ are from $(^{36}\text{Ar},\alpha\text{pn}\gamma)$. Values for $(^{32}\text{S,pn}\gamma)$ are given as comments.

‡ Average of values from two experiments $(^{36}\text{Ar},\alpha\text{pn}\gamma)$ and $(^{32}\text{S,pn}\gamma)$ (2002Je07).

§ From DCO ratios in 2002Je07. A ratio of <0.55 is assigned pure D and ≥ 0.85 a stretched Q. The latter is assumed to be E2.

Adopted Levels

S(n)=16590 SY; S(p)=2130 SY; Q(α)=-2010 SY 2012Wa38.

$\Delta S(n)=450$, $\Delta S(p)=200$, $\Delta Q(\alpha)=360$ (2012Wa38) S(2p)=1340 syst 196, Q(ϵp)=8200 syst 200 (2012Wa38).

1995B106: produced by projectile fragmentation of ^{78}Kr at E=73 MeV/nucleon (Ni(^{78}Kr ,X)) at SISI/LISE facility at GANIL. ^{70}Kr was identified using TOF and $\Delta E-E$.

2000O102: produced by 1 GeV proton-induced spallation in a Nb foil (Nb(p,X)) at Cern. Isotopes separated using ISOLDE. A plastic scintillator, a HPGe detector (as a β telescope) and a gas-Si detector (to detect the β -delayed protons) were used. Measured $T_{1/2}$ using the time correlation between the proton pulse and $\beta(t)$. Subset of results presented in 2002O102.

2002B117: produced by fragmentation of ^{78}Kr beam ($^9\text{Be}(^{78}\text{Kr},X)$) at E=73MeV/nucleon at GANIL. Separated using LISE3 and identified through ΔE and TOF measurements. A silicon telescope was used. Measured $T_{1/2}$ from time correlation between ion implantation and β events in the silicon strip detector.

2014Ro14: produced by fragmentation of a ^{78}Kr beam on a natural Ni target with E(^{78}Kr)=70 MeV/nucleon. Separated using the LISE3 spectrometer and identified using ΔE -TOF measurements. A silicon telescope was used. Measured $T_{1/2}$ from time correlation between ion implantation and β events in the silicon strip detector.

 ^{70}Kr Levels

E(level)	J π	$T_{1/2}$	Comments
0.0	0+	40 ms 6	% ϵ +% β^+ =100; % ϵp ≤1.3 (2000O102). $T_{1/2}$: from implant- $\beta(t)$ in 2014Ro14. Others: 42 ms 31 (2002B117) and 57 ms 21 (2000O102). $T_{1/2}$ is consistent with superallowed ϵ decay to ^{70}Br g.s. (2000O102).

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