^{60}Ga $\varepsilon+\beta^+$ decay (69.4 ms) 2001Ma96,2021Or01

Parent: ^{60}Ga: E=0; $J^\pi=2^+$; $T_{1/2}$=69.4 ms *2*; Q(ε)=14160 *15*; $\%\varepsilon+\%\beta^+$ decay=100

^{60}Ga-J^π: From Adopted Levels of ^{60}Ga.

^{60}Ga-$T_{1/2}$: Weighted average of 70 ms *15* (2001Ma96), 70 ms *13* (2002Lo13), 76 ms *3* (2017Ku12), 70.8 ms *20* (2020Gi02), and 69.4 ms *2* (2021Or01).

^{60}Ga-Q($\varepsilon+\beta^+$): Deduced by evaluators using ^{60}Ga mass excesses of −40015 *15*; weighted average of −40016 *15* (2021Or01), −40005 *30* (2021Pa44), and −40034 *46* (2023Wa10).

^{60}Ga-$\%\varepsilon+\%\beta^+$ decay: $\%(\varepsilon+\beta^+)$p=1.6 *7*, $\%(\varepsilon+\beta^+)\alpha$<0.023 *20*.

2001Ma96: ^{60}Ga was produced by ^{28}Si(^{36}Ar,p3n) reaction at 4.71 MeV/nucleon at the GSI On-Line Mass Separator. ^{60}Ga was implanted into a tape for $\beta\gamma$ measurements and implanted into a carbon foil for $\beta\pi$ measurements. Positrons were detected using a plastic scintillator; γ rays were detected using Clover Ge detectors; particles were detected using Si ΔE-E telescopes. A total of 802 proton events were observed. Measured Eγ, Iγ, $\gamma\gamma$, $\beta\gamma\gamma$, βp, $\beta\alpha$, half-life. Measured $\%(\varepsilon+\beta^+)$p=1.6 *7*, $\%(\varepsilon+\beta^+)\alpha$<0.023 *20*.

2021Or01: ^{60}Ga was produced via ^{9}Be(^{78}Kr,X) using 345 MeV/nucleon ^{78}Kr from the RIBF at RIKEN on a 5 mm ^{9}Be target. Fragments were separated, selected and identified by the BigRIPS separator according to Bρ-ΔE-ToF, and transported and implanted into the WAS3ABi array consisting of three DSSSDs at the exit of the ZeroDegree spectrometer. γ rays were detected using the EURICA array of HPGe detectors. Measured Eγ, Iγ, implant-decay time correlations. Deduced ^{60}Ga $T_{1/2}$ and mass excess.

The decay scheme is considered incomplete due to a large gap of about 9 MeV between the highest observed level at E=4852 and Q(ε) value=14160 *15*. There may be missing transitions from unobserved levels in the gap.

^{60}Zn Levels

E(level)	J^π	Comments
0	0^+	
1003.53 *10*	2^+	
2558.54 *23*	(2^+)	
4851.97 *32*	2^+	isobaric analog state (T=1) of ^{60}Ga g.s.

ε,β^+ radiations

E(decay)	E(level)	Iβ^+ ‡	Iε‡	Log *ft*†	I($\varepsilon+\beta^+$)†‡
(9308 *15*)	4851.97	44.0 *32*	0.058 *5*	3.66 *4*	44.1 *32*
(11602 *15*)	2558.54	9.2 *10*	0.0061 *7*	4.85 *5*	9.2 *10*
(13157 *15*)	1003.53	17 *5*	0.008 *2*	4.9 *+2−1*	17 *5*

† $\varepsilon+\beta^+$-feeding from γ+ce intensity balance at each level. Quoted I($\varepsilon+\beta^+$) values are considered upper limits due to the incomplete decay scheme, and the associated log *ft* values are considered lower limits.

‡ Absolute intensity per 100 decays.

$\gamma(^{60}Zn)$

Iγ normalization: Absolute γ-ray intensities per 100 decays of ^{60}Ga were measured by 2021Or01 based on the total number of implanted ^{60}Ga and γ-ray detection efficiencies.

Eγ	Iγ†	E$_i$(level)	J_i^π	E$_f$	J_f^π	Comments
x669.3 *3*	0.58 *15*					$\%I\gamma$=0.36 *9*
x850.8 *1*	1.21 *16*					$\%I\gamma$=0.75 *10*
x913.9 *3*	0.48 *16*					$\%I\gamma$=0.30 *10*
1003.5 *1*	100 *5*	1003.53	2^+	0	0^+	$\%I\gamma$=62.0 *31* Eγ: from 2021Or01. Other: 1003.7 *2* (2001Ma96). Iγ: from 2021Or01. Other: 100 *17* (2001Ma96).

Continued on next page (footnotes at end of table)

^{60}Ga $\varepsilon+\beta^+$ decay (69.4 ms) 2001Ma96,2021Or01 (continued)

$\gamma(^{60}Zn)$ (continued)

E_γ	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Comments
x1028.6 *2*	0.61 *13*					%Iγ=0.38 *8*
x1188.4 *1*	2.58 *16*					%Iγ=1.60 *10*
x1201.8 *2*	0.47 *11*					%Iγ=0.29 *7*
x1413.7 *2*	0.57 *11*					%Iγ=0.35 *7*
x1442.1 *1*	0.65 *13*					%Iγ=0.40 *8*
x1481.4 *1*	2.10 *16*					%Iγ=1.30 *10*
1554.7 *3*	11.3 *8*	2558.54	(2$^+$)	1003.53	2$^+$	%Iγ=7.0 *5* E_γ: from 2021Or01. Other: 1554.9 *6* (2001Ma96). I_γ: from 2021Or01. Other: 12 *5* (2001Ma96).
x1780.8 *6*	0.32 *16*					%Iγ=0.20 *10*
x2047.2 *4*	1.13 *32*					%Iγ=0.70 *20*
2293.2 *4*	10.2 *8*	4851.97	2$^+$	2558.54	(2$^+$)	%Iγ=6.3 *5* E_γ: from 2021Or01. Other: 2293.0 *10* (2001Ma96). I_γ: from 2021Or01. Other: 10 *5* (2001Ma96).
x2334.2 *3*	1.29 *32*					%Iγ=0.80 *20*
x2434.2 *2*	2.90 *32*					%Iγ=1.80 *20*
2558.8 *4*	13.7 *10*	2558.54	(2$^+$)	0	0$^+$	%Iγ=8.5 *6* E_γ: weighted average of 2559.0 *8* (2001Ma96) and 2558.7 *4* (2021Or01). I_γ: from 2021Or01. Other: 13 *5* (2001Ma96).
x2624.3 *5*	0.48 *16*					%Iγ=0.30 *10*
x2826.0 *2*	2.10 *32*					%Iγ=1.30 *20*
x2884.0 *4*	1.29 *32*					%Iγ=0.80 *20*
x2996.8 *2*	3.2 *5*					%Iγ=1.98 *31*
x3337.4 *1*	11.5 *10*					%Iγ=7.1 *6*
x3394.8 *1*	11.3 *10*					%Iγ=7.0 *6*
3848.5 *4*	61 *5*	4851.97	2$^+$	1003.53	2$^+$	%Iγ=37.8 *31* E_γ: from 2021Or01. Other: 3848.3 *7* (2001Ma96). I_γ: from 2021Or01. Other: 57 *13* (2001Ma96).
x3889.1 *3*	4.5 *13*					%Iγ=2.8 *8*
x4000.9 *2*	4.5 *7*					%Iγ=2.8 *4*
x4805.0 *4*	0.65 *16*					%Iγ=0.40 *10*
x4850.2 *5*	0.32 *16*					%Iγ=0.20 *10*
x4891.9 *3*	0.65 *16*					%Iγ=0.40 *10*

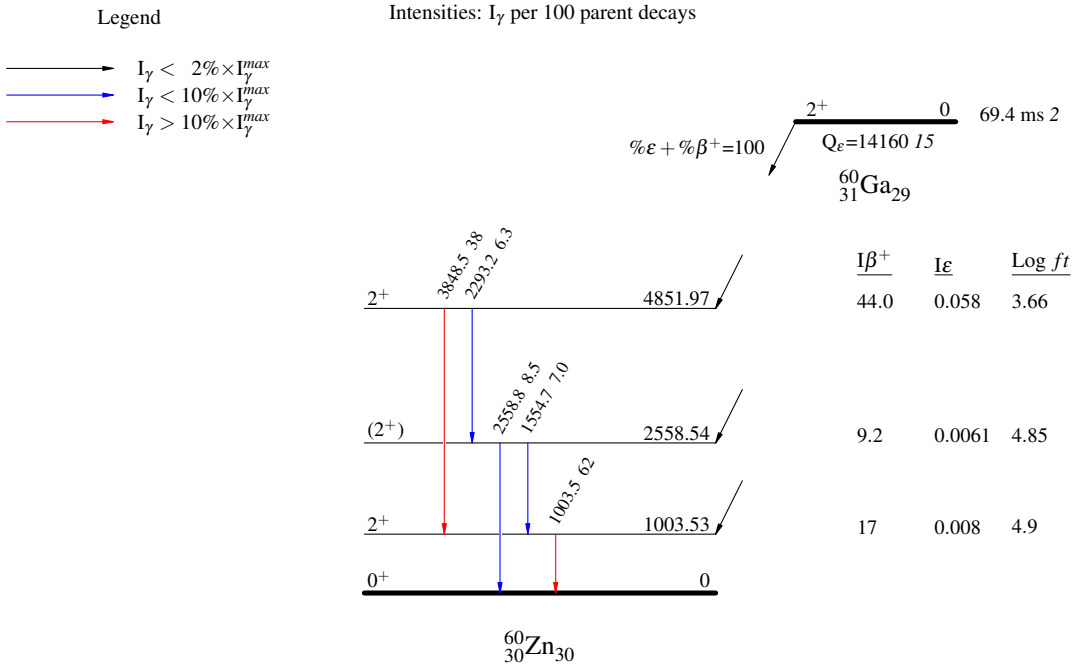
† For absolute intensity per 100 decays, multiply by 0.62.

x γ ray not placed in level scheme.

^{60}Ga ε+β$^+$ decay (69.4 ms) 2001Ma96,2021Or01

Decay Scheme

Intensities: I_γ per 100 parent decays



	Iβ$^+$	Iε	Log *ft*
4851.97	44.0	0.058	3.66
2558.54	9.2	0.0061	4.85
1003.53	17	0.008	4.9