^{62}Cu ε+β^+ decay (9.672 min) 1971JoZN,1970Va11,1969Es03

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Huang Xiaolong, and Wang Xianghan	NDS 204,1 (2025)	30-Jun-2023

Parent: ^{62}Cu: E=0.0; J$^\pi$=1$^+$; T$_{1/2}$=9.672 min *8*; Q(ε)=3958.9 *5*; %ε+%β^+ decay=100

^{62}Cu-J$^\pi$,T$_{1/2}$: From Adopted Levels of ^{62}Cu.

^{62}Cu-Q(ε+β^+): From 2021Wa16.

1971JoZN (thesis) (also 1969Jo07, 1974Jo11): source from ^{62}Ni(p,n), E=7, 13 MeV, and from decay of ^{62}Zn parent. Measured Eγ, Iγ, and conversion electrons using a double-focusing magnetic spectrometer. 1969Jo07 reported four gamma rays and intensity of 511 annihilation radiation, but the latter is revised in 1971JoZN. More details can be found in the thesis (1971JoZN). A table of Eγ and Iγ values from 1971JoZN is also reproduced in 1974Jo11.

1970Va11: source from ^{62}Ni(p,n),E=6.8 MeV; measured Eγ, Iγ for nine γ rays, and the intensity of annihilation radiation.

1969Es03: source from ^{62}Zn parent produced in Cu(p,2n); measured Eγ, Iγ for five γ rays.

1975Ca40: source from ^{63}Cu(n,2n),E=14 MeV. Measured Eγ, Iγ for seven γ rays, and the intensity of annihilation radiation.

Others studies:

1993Os06 (also 2001Ko07): measured β^+ spectrum, deduced maximum Eβ, and Q(ε)=3967 *16*.

1976Ca31: measured $\gamma\gamma(\theta)$ using Ge(Li) and NaI(Tl) detectors; deduced E2/M1 mixing ratio for second 2$^+$ to first 2$^+$ transition.

1967An01: source from ^{62}Zn parent produced in Cu(p,2n); measured β^+ spectrum by a double-focusing iron yoke β spectrometer; deduced Eβ(max)=2934 *7*.

1964Sa32: source from ^{62}Zn parent produced in Cu(p,2n). Measured β^+ and ce spectra using double-focusing β spectrometer.

1954Nu27: source from ^{62}Zn parent produced in Cu(d,3n). Measured upper limit of γ intensity of <5% relative to total β^+ emission for 350-650 keV region, and <3% for higher-energy region. Deduced Eβ(max)=2910 *10*.

Half-life measurements of ^{62}Cu g.s.: Erratum of 2014Un01 published in 2020, also 2012Fi12 and 2002Un02, based on measured values of 9.68 min *4* using liquid scintillator and 9.673 min *26* using ionization chamber in 1997Zi06 at NIST; 1975Ca40, 1969Jo07, 1969Bo11, 1966Ch24, 1965Li11, 1965Eb01, 1961Sa19, 1958Po07, 1954Nu27, 1954Be84, 1952Ma28, 1951Go43, 1947Le07, 1939Cr03.

Production and identification of ^{62}Cu isotope: 1936He03, 1937Ri01, 1937He05, 1937Bo10, 1938St05, 1946Me01, 1950Gh62, 1950Ha65, 1954Nu27.

β measurements: 1949Be17, 1950Ha65, 1954Nu27, 1958Cr86, 1964Sa32, 1967An01.

$\beta\gamma$-coin: 1958Cr86 (1750β-1173γ coin).

Other γ-ray measurements: 1955Re08, 1957Br20, 1958Bu10.

Total decay energy of 3959.0 keV *12* deduced (by RADLIST code) from proposed decay scheme is in agreement with the expected value of 3958.9 keV *5*, indicating that decay scheme is complete.

^{62}Ni Levels

E(level)†	J$^\pi$‡	T$_{1/2}$‡	Comments
0.0	0$^+$	stable	
1173.03 *8*	2$^+$	1.442 ps *21*	
2048.79 *12*	0$^+$	1.40 ps *51*	J$^\pi$: from $\gamma\gamma(\theta)$ (1976Ca31).
2302.01 *7*	2$^+$	0.64 ps *14*	
2890.65 *20*	0$^+$	>3.1 ps	
3158.11 *14*	2$^+$	0.62 ps *+11−10*	
3257.8 *4*	2$^+$	0.71 ps *17*	
3270.48 *19*	1$^+$,2$^+$	0.125 ps *14*	
3370.01 *19*	1$^+$	0.30 ps *8*	
3518? *2*	2$^+$	0.41 ps *21*	
3859.2 *4*	(2)$^+$	0.277 ps *+17−9*	

† From least-squares fit to Eγ values.

‡ From the Adopted Levels.

^{62}Cu $\varepsilon+\beta^+$ decay (9.672 min) 1971JoZN,1970Va11,1969Es03 (continued)

ε,β^+ radiations

E(decay)	E(level)	Iβ^+ †	Iε†	Log *ft*	I($\varepsilon+\beta^+$)†	Comments
(99.7 *12*)	3859.2		0.00037 *8*	5.64 *9*	0.00037 *8*	εK=0.86822 *37*; εL=0.11299 *27*; εM+=0.01879 *9*
(440.9 *23*)	3518?		0.0030 *10*	6.07 *15*	0.0030 *10*	εK=0.88138 *25*; εL=0.10190 *17*; εM+=0.01672 *7*
(588.9 *11*)	3370.01		0.0107 *11*	5.773 *45*	0.0107 *11*	εK=0.88226 *23*; εL=0.10116 *16*; εM+=0.01658 *7*
(688.4 *11*)	3270.48		0.0054 *11*	6.21 *9*	0.0054 *11*	εK=0.88264 *23*; εL=0.10084 *16*; εM+=0.01652 *7*
(701.1 *12*)	3257.8		0.0050 *11*	6.26 *10*	0.0050 *11*	εK=0.88268 *23*; εL=0.10080 *16*; εM+=0.01651 *7*
(800.8 *11*)	3158.11		0.0018 *4*	6.82 *10*	0.0018 *4*	εK=0.88295 *23*; εL=0.10058 *16*; εM+=0.01647 *7*
(1068.3 *12*)	2890.65	1.98×10^{-8} *42*	0.0025 *5*	6.93 *+10−8*	0.0025 *5*	av Eβ=22.95 *23*; εK=0.88342 *23*; εL=0.10018 *16*; εM+=0.01639 *7*
(1656.9 *11*)	2302.01	0.0200 *13*	0.0550 *48*	5.971 *29*	0.075 *5*	av Eβ=270.12 *21*; εK=0.6487 *26*; εL=0.07321 *31*; εM+=0.01198 *7*
(1910.1 *11*)	2048.79	0.078 *6*	0.070 *9*	5.998 *32*	0.148 *11*	av Eβ=378.85 *22*; εK=0.4153 *31*; εL=0.04682 *36*; εM+=0.00766 *6* E(β^+)=870 *10* (1964Sa32).
(2785.9 *11*)	1173.03	0.138 *10*	0.0137 *46*	7.038 *31*	0.152 *11*	av Eβ=769.79 *23*; εK=0.0796 *9*; εL=0.00895 *11*; εM+=0.001464 *18* E(β^+)=1750 *10* (1964Sa32), Iβ=1.8%.
(3958.9 *15*)	0.0	97.545 *11*	2.052 *11*	5.1710 *5*	99.597 *16*	av Eβ=1315.28 *24*; εK=0.01822 *22*; εL=0.002046 *25*; εM+=3.346×10^{-4} *43* E(decay): Eβ+(max)=2945 *16* (2001Ko07,1993Os06), 2934 *7* (1967An01), 2923 *7* (1964Sa32), 2910 *10* (1954Nu27). I($\varepsilon+\beta^+$): 100−(feeding to excited states). Other: measured Iβ=93.9% (1964Sa32).

† Absolute intensity per 100 decays.

γ(^{62}Ni)

Iγ normalization: γ-normalization factor deduced by evaluators from averaged total I($β^+$)=286×10^2 *15* (from 1971JoZN and 1970Va11) + (summed I(γ+ce)=115.5 *7* to the ground state) − (I$β^+$=69 *5*; deduced from I(γ+ce) intensity balances of 56.1 *22* at the 1173 level, 42.3 *20* at the 2049 level, and 21.4 *8* at the 2301 level, and respective theoretical I($β^+$)/I(ε) values)=100.

Measured intensity of $γ^\pm$ annihilation radiation: 581×10^2 *30* (1971JoZN,1974Jo11), 560×10^2 *32* (1970Va11), 503×10^2 *52* (1975Ca40), relative to 100 for 1173γ. Weighted average of values from 1971JoZN and 1970Va11: I($γ^\pm$)=571×10^2 *30*.

$E_γ$[†]	$I_γ$[‡a]	E_i(level)	$J^π_i$	E_f	$J^π_f$	Mult.[&]	δ[&]	α[b]	Comments
(479.36[@] *6*)	0.070[@] *18*	3370.01	1$^+$	2890.65	0$^+$				%Iγ=0.00024 *6* $I_γ$: <0.13 (1971JoZN).
(856.08[@] *12*)	0.037[@] *12*	3158.11	2$^+$	2302.01	2$^+$	M1+E2			%Iγ=0.00013 *4* $I_γ$: <0.11 (1971JoZN).
875.66 *11*	42.9 *20*	2048.79	0$^+$	1173.03	2$^+$	E2		3.35×10^{-4} *5*	%Iγ=0.150 *10* α(K)=0.000301 *5*; α(L)=2.96×10^{-5} *5*; α(M)=4.17×10^{-6} *6*; α(N)=1.781×10^{-7} *25* Eγ=875.71 *7*, Iγ=44 *2* (1971JoZN,1974Jo11). Eγ=875.2 *3*, Iγ=0.15% *1* (1970Va11), normalized to 42.9 *29*. Eγ=875.2 *3*, Iγ=33.0 *30* (1969Es03, Iγ is much lower than in other studies, not used in averaging). Eγ=875.7 *12*, Iγ=0.16% *1* (1975Ca40), normalized to 41.0 *26*. (876γ)(1173γ)(θ): A_2=+0.38 *4*, A_4=+1.19 *8* (1976Ca31).
(968.2[@] *5*)	>0.10[@]	3270.48	1$^+$,2$^+$	2302.01	2$^+$				%Iγ=0.000349 *18* $I_γ$: <0.11 (1971JoZN).
(968.2[@] *4*)	0.026[@] *10*	3859.2	(2)$^+$	2890.65	0$^+$				%Iγ=9.1×10^{-5} *35* $I_γ$: <0.12 (1971JoZN).
1067.0[#] *10*	0.19[#] *10*	3370.01	1$^+$	2302.01	2$^+$	M1+E2	+1.6 *+41−11*		%Iγ=0.00066 *35*
1128.98 *10*	9.3 *5*	2302.01	2$^+$	1173.03	2$^+$	M1+E2+E0	+3.1 *1*	2.44×10^{-4} *14*	%Iγ=0.0325 *24* Eγ=1128.98 *10*, Iγ=9.5 *5* (1971JoZN,1974Jo11). Eγ=1129.1 *4*, Iγ=0.034% *4* (1970Va11), normalized to 9.7 *12*. Eγ=1128.7 *5*, Iγ=10.0 *30* (1969Es03). Eγ=1129.3 *14*, Iγ=0.034% *3* (1975Ca40), normalized to 8.7 *8*. α: from measured α(K)exp=1.95E−4 *11* (2019Ev01) in (p,p′γ). δ: +3.0 *+7−20* from γγ(θ) data (1976Ca31),

From ENSDF

γ(^{62}Ni) (continued)

E_γ[†]	I_γ[‡a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[&]	δ[&]	α[b]	$I_{(\gamma+ce)}$[a]	Comments
										uncertainty at 90% confidence level. (1129γ)(1173γ)(θ): A_2=−0.31 *6*, A_4=+0.26 *12* (1976Ca31).
1172.97 *10*	100	1173.03	2^+	0.0	0^+	E2		1.72×10^{-4} *3*		%Iγ=0.349 *18* α(K)=0.0001501 *21*; α(L)=1.466×10^{-5} *21*; α(M)=2.06×10^{-6} *3*; α(N)=8.89×10^{-8} *13* Eγ=1173.02 *10*, Iγ=100 (1971JoZN,1974Jo11). Eγ=1172.7 *3*, Iγ=0.35% *2* (1970Va11), normalized to 100 *6*. Eγ=1172.6 *4*, Iγ=100.0 (1969Es03). Eγ=1173.3 *18*, Iγ=0.390% *40* (1975Ca40), normalized to 100 *10*.
(1221.0[@] *3*)	<0.81[@]	3270.48	1^+,2^+	2048.79	0^+					%Iγ=0.00283 *15* I_γ: <0.08 (1971JoZN).
(1321.22[@] *33*)	0.32[@] *7*	3370.01	1^+	2048.79	0^+					%Iγ=0.00112 *25* I_γ: <0.11 (1971JoZN).
1717.6 *4*	0.81 *12*	2890.65	0^+	1173.03	2^+	E2		2.55×10^{-4} *4*		%Iγ=0.0028 *4* α(K)=6.80×10^{-5} *10*; α(L)=6.61×10^{-6} *10*; α(M)=9.31×10^{-7} *13*; α(N)=4.03×10^{-8} *6* Eγ=1717.6 *4*, Iγ=0.76 *12* (1971JoZN,1974Jo11). Eγ=(1718), Iγ=0.004% *2* (1970Va11), normalized to 1.1 *6*. Eγ=1717.4 *19*, Iγ=0.006% *2* (1975Ca40), normalized to 1.5 *5*. Mult.: E2(+M1), δ=−4.1 *+13−30*.
1985.0[#] *10*	0.30[#] *10*	3158.11	2^+	1173.03	2^+	(M1+E2)	+0.13 *8*	3.05×10^{-4} *4*		%Iγ=0.00105 *35* α(K)=4.94×10^{-5} *7*; α(L)=4.78×10^{-6} *7*; α(M)=6.74×10^{-7} *10*; α(N)=2.93×10^{-8} *5*
(2048.6)		2048.79	0^+	0.0	0^+	E0			0.109 *15*	%Iγ=0.000380 *20* $I_{(\gamma+ce)}$: from ce(K)(2048γ)/ce(K)(876γ)= 0.084 *11* (1981Pa10) in (p,p′γ).
2084.8 *4*	1.4 *3*	3257.8	2^+	1173.03	2^+	M1+E2	+1.03 *+22−70*			%Iγ=0.0049 *11* Eγ=2084.6 *4*, Iγ=1.5 *3* (1971JoZN,1974Jo11). Eγ=2085.3 *6*, Iγ=0.005% *1* (1970Va11), normalized to 1.43 *29*. Eγ=2083.6 *20*, Iγ=0.004% *2* (1975Ca40), normalized to 1.0 *5*.
2097.6 *3*	0.83 *11*	3270.48	1^+,2^+	1173.03	2^+					%Iγ=0.0029 *4* Eγ=2097.6 *3*, Iγ=0.87 *11*

$^{62}_{28}$Ni$_{34}$-4

$\gamma(^{62}$Ni) (continued)

E_γ[†]	I_γ[‡a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	δ[&]	α[b]	Comments
									(1971JoZN,1974Jo11). Eγ=(2097), Iγ=0.002% *1* (1970Va11), normalized to 0.57 *29*.
2301.95 *8*	12.4 *6*	2302.01	2^+	0.0	0^+	E2		5.04×10^{-4} *71*	%Iγ=0.0433 *31* α(K)=3.97×10^{-5} *6*; α(L)=3.85×10^{-6} *6*; α(M)=5.42×10^{-7} *8*; α(N)=2.35×10^{-8} *4* Eγ=2301.96 *8*, Iγ=12.1 *6* (1971JoZN,1974Jo11). Eγ=2301.8 *5*, Iγ=0.044% *3* (1970Va11), normalized to 12.6 *9*. Eγ=2301.6 *5*, Iγ=18.0 *20* (1969Es03, Iγ is much higher as compared to values in other studies, not used in averaging). Eγ=2302.5 *20*, Iγ=0.051% *15* (1975Ca40), normalized to 13.1 *13*.
2345[c] *2*	0.86 *29*	3518?	2^+	1173.03	2^+	(M1+E2)	+0.32 *6*		%Iγ=0.0030 *10* E_γ,I_γ: from 1970Va11. Evaluators treat this γ as uncertain as with the intensity given in 1970Va11, it should have been detected in 1971JoZN and 1969Es03. Eγ=2345 *2*, Iγ=0.003% *1* (1970Va11), normalized to 0.86 *29*; γ placed from a 3518.2, 2^+ level. Eγ=2346.8 *27*, Iγ=0.003% (1975Ca40), normalized to 0.77; γ placed from a 3520 level.
3158.2[#] *10*	0.18[#] *4*	3158.11	2^+	0.0	0^+	E2			%Iγ=0.00063 *14*
3257.3[#] *10*	0.042[#] *19*	3257.8	2^+	0.0	0^+	E2			%Iγ=0.00015 *7*
3271.4[#] *4*	0.21[#] *3*	3270.48	$1^+,2^+$	0.0	0^+				%Iγ=0.00073 *11*
3369.9 *3*	2.48 *23*	3370.01	1^+	0.0	0^+	(M1)			%Iγ=0.0087 *9* Eγ=3369.9 *3*, Iγ=2.32 *14* (1971JoZN,1974Jo11). Eγ=3371.1 *15*, Iγ=0.011% *1* (1970Va11), normalized to 3.14 *29*. Eγ=3369.0 *20*, Iγ=2.5 *10* (1969Es03).
3861.7[#] *11*	0.08[#] *2*	3859.2	$(2)^+$	0.0	0^+				%Iγ=0.00028 *7*

[†] Weighted averages of available values from 1971JoZN (1974Jo11), 1970Va11 and 1969Es03, with exceptions noted.
[‡] Weighted averages of available values from 1971JoZN (1974Jo11), 1970Va11, 1969Es03, and 1975Ca40, with exceptions noted.
[#] γ from 1971JoZN, 1974Jo11 only.
[@] γ expected from the Adopted Levels, Gammas dataset. Intensity is based on γ-ray branching ratios in the Adopted dataset. This γ is not reported in ^{62}Cu ε decay, likely below the detection limit in the available decay studies of ^{62}Cu decay.
[&] From the Adopted Gammas.
[a] For absolute intensity per 100 decays, multiply by 0.00349 *18*.
[b] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with “Frozen Orbitals” approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
[c] Placement of transition in the level scheme is uncertain.

$^{62}_{28}$Ni$_{34}$-5

^{62}Cu $\varepsilon+\beta^+$ decay (9.672 min) 1971JoZN,1970Va11,1969Es03