^{60}Cu ε decay 1972Va19

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 114, 1849 (2013)	31-Dec-2012

Parent: ^{60}Cu: E=0.0; $J^\pi=2^+$; $T_{1/2}$=23.7 min *4*; Q(ε)=6128.0 *16*; %ε+%$β^+$ decay=100.0

Additional information 1.

Ge(Li)-NaI Compton suppression and annihilation-γ coin. Measured Eγ, Iγ (1972Va19). Measured γ(t), Eγ, Iγ with Ge(Li) (1982Gr10).

Data are from 1972Va19, except as noted. The results of 1982Gr10 are in good agreement with those of 1972Va19.

Others: 1947Le07, 1954Nu26, 1969Ho22, 1969Ra07.

^{60}Ni Levels

E(level)	J^π†	$T_{1/2}$	E(level)	J^π†	E(level)	J^π†
0.0	0^+	stable	3619.7 *4*		4356.6? *10*	$2^+,3^+$
1332.54 *14*	2^+		3736.0 *4*	2^+	4493.5 *3*	$1^+,2^+$
2158.95 *13*	2^+		3872.2 *9*	$1^+,2^+$	4536.1 *8*	2^+
2284.94 *18*	0^+		3887.6? *10*		4548.9 *4*	$1^+,2^+$
2505.8 *3*	4^+		3926.0 *4*	$2^+,3^+$	4579.1 *6*	2^+
2626.25 *16*	3^+		4007.8 *6*	2^+	4760.8 *5*	1,2
3124.16 *16*	2^+		4020.49 *23*	1^+	4844.2 *13*	1,2
3186.4 *6*			4078.63 *23*	$1^+,2^+$	4849.1 *6*	1,2,3
3194.16 *16*	$1^+,2^+$		4111.9? *6*		5048.6 *6*	1,2
3269.48 *18*	2^+		4319.0 *4*	2^+		
3393.5 *3*	2^+		4334.7 *7*	2		

† See Adopted Levels.

ε,$β^+$ radiations

ε branches have been obtained from I(γ+ce) imbalance at each level, assuming no direct ε feeding to the g.s. (2^+ to 0^+ transition).

E(decay)	E(level)	I$β^+$ †	Iε†	Log *ft*	I(ε+$β^+$)†	Comments
(1079.4 *17*)	5048.6		0.022 *8*	6.4 *2*	0.022 *8*	εK=0.8867; εL=0.09689; εM+=0.01638
(1278.9 *17*)	4849.1	0.0014 *6*	0.11 *4*	5.8 *2*	0.11 *4*	av Eβ=111.6 *9*; εK=0.8755; εL=0.09546; εM+=0.01613
(1283.8 *21*)	4844.2	0.00036 *14*	0.026 *10*	6.5 *2*	0.026 *10*	av Eβ=113.6 *11*; εK=0.8746; εL=0.09536; εM+=0.01612
(1367.2 *17*)	4760.8	0.0013 *5*	0.033 *11*	6.4 *1*	0.034 *11*	av Eβ=148.3 *10*; εK=0.8524; εL=0.09288; εM+=0.01570
(1548.9 *17*)	4579.1	0.0076 *18*	0.040 *10*	6.4 *1*	0.048 *11*	av Eβ=224.2 *10*; εK=0.7461 *18*; εL=0.08119 *20*; εM+=0.01372 *4*
(1579.1 *17*)	4548.9	0.071 *12*	0.31 *5*	5.6 *1*	0.38 *6*	av Eβ=237.0 *9*; εK=0.7212 *19*; εL=0.07846 *20*; εM+=0.01326 *4*
(1591.9 *18*)	4536.1	0.012 *3*	0.050 *12*	6.4 *1*	0.062 *14*	av Eβ=242.4 *10*; εK=0.7100 *21*; εL=0.07724 *23*; εM+=0.01305 *4*
(1634.5 *16*)	4493.5	0.185 *13*	0.58 *4*	5.3 *1*	0.76 *5*	av Eβ=260.5 *9*; εK=0.6717 *20*; εL=0.07306 *22*; εM+=0.01234 *4*
(1793.3 *18*)	4334.7	0.027 *7*	0.037 *9*	6.6 *1*	0.064 *15*	av Eβ=328.4 *10*; εK=0.5199 *22*; εL=0.05649 *24*; εM+=0.00954 *4*
(1809.0 *17*)	4319.0	0.072 *9*	0.095 *12*	6.2 *1*	0.167 *20*	av Eβ=335.2 *10*; εK=0.5050 *21*; εL=0.05488 *22*; εM+=0.00927 *4*
(2049.4 *16*)	4078.63	1.17 *8*	0.64 *5*	5.5 *1*	1.81 *12*	av Eβ=440.0 *10*; εK=0.3132 *14*; εL=0.03400 *15*; εM+=0.00574 *3*
(2107.5 *16*)	4020.49	0.96 *9*	0.44 *4*	5.7 *1*	1.40 *12*	av Eβ=465.6 *10*; εK=0.2779 *12*; εL=0.03016 *14*; εM+=0.005095 *23*

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^{60}Cu ε decay 1972Va19 (continued)

ε,β+ radiations (continued)

E(decay)	E(level)	Iβ+ †	Iε†	Log *ft*	I(ε+β+)†	Comments
(2120.2 *17*)	4007.8	0.15 *3*	0.064 *13*	6.5 *1*	0.21 *4*	av Eβ=471.2 *10*; εK=0.2708 *13*; εL=0.02939 *14*; εM+=0.004964 *23*
(2202.0 *17*)	3926.0	0.22 *5*	0.075 *16*	6.5 *1*	0.29 *6*	av Eβ=507.6 *10*; εK=0.2290 *10*; εL=0.02485 *11*; εM+=0.004198 *19*
(2255.8 *18*)	3872.2	0.069 *23*	0.021 *7*	7.0 *2*	0.09 *3*	av Eβ=531.5 *11*; εK=0.2056 *10*; εL=0.02231 *11*; εM+=0.003768 *18*
(2392.0 *17*)	3736.0	0.80 *8*	0.172 *16*	6.2 *1*	0.97 *9*	av Eβ=592.5 *10*; εK=0.1576 *7*; εL=0.01709 *7*; εM+=0.002887 *12*
(2734.5 *16*)	3393.5	0.86 *7*	0.092 *7*	6.6 *1*	0.95 *7*	av Eβ=748.0 *10*; εK=0.0859 *3*; εL=0.00930 *4*; εM+=0.001571 *6*
(2858.5 *16*)	3269.48	4.59 *22*	0.396 *19*	6.0 *1*	4.99 *23*	av Eβ=804.9 *10*; εK=0.07044 *23*; εL=0.00763 *3*; εM+=0.001289 *5*
(2933.8 *16*)	3194.16	11.6 *4*	0.88 *3*	5.6 *2*	12.5 *4*	av Eβ=839.6 *10*; εK=0.06280 *20*; εL=0.006803 *22*; εM+=0.001149 *4*
(2941.6‡ *17*)	3186.4					
(3003.8 *16*)	3124.16	49.0 *23*	3.34 *16*	5.1 *1*	52.3 *24*	av Eβ=872.0 *10*; εK=0.05663 *18*; εL=0.006134 *19*; εM+=0.001036 *4*
(3501.8 *16*)	2626.25	2.8 *3*	0.096 *10*	6.8 *1*	2.9 *3*	av Eβ=1104.2 *10*; εK=0.02948 *8*; εL=0.003191 *8*
(3969.1 *16*)	2158.95	15.0 *12*	0.306 *25*	6.4 *1*	15.3 *12*	av Eβ=1324.9 *10*; εK=0.01773 *4*; εL=0.001919 *4*; εM+=0.0003239 *7*
(4795.5 *16*)	1332.54	5 *3*	0.05 *3*	7.3 *3*	5 *3*	av Eβ=1720.1 *11*; εK=0.008543 *15*; εM+=0.0001560 *3*

† Absolute intensity per 100 decays.
‡ Existence of this branch is questionable.

γ(^{60}Ni)

Iγ normalization: From Σ(I(γ+ce)) to gs=100, assuming no direct ε feeding of the g.s. (2^+ to 0^+ transition).

Measured γγ(θ) with NaI, 1966Sh12. Results:

Correlation	A_2	A_4
1332-826	- 0.30 *3*	+ 0.15 *5*
1332-952	+ 0.27 *8*	+ 0.91 *12*
1332-1035	- 0.03 *8*	+ 0.03 *12*
1332-1792	+ 0.38 *2*	+ 0.06 *4*

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	α†	Comments
120.5 *3*	0.22 *2*	2626.25	3^+	2505.8	4^+	M1+E2	0.15 *13*	α(K)=0.14 *12*; α(L)=0.015 *13*; α(M)=0.0021 *18*; α(N+..)=8.E−5 *7* α(N)=8.E−5 *7*
467.3 *2*	4.0 *2*	2626.25	3^+	2158.95	2^+	M1(+E2)	0.0015 *6*	α=0.0015 *6*; α(K)=0.0014 *5*; α(L)=0.00014 *5*; α(M)=1.9×10^{-5} *7*; α(N+..)=8.E−7 *3* α(N)=8.E−7 *3*
497.9 *2*	1.9 *1*	3124.16	2^+	2626.25	3^+			
(611@)	≤0.026@	3736.0	2^+	3124.16	2^+			
(614@)	≤0.025@	4007.8	2^+	3393.5	2^+			
643.2 *3*	1.10 *6*	3269.48	2^+	2626.25	3^+			
681[b] *1*	0.04 *2*	3186.4		2505.8	4^+	M1+E2	0.00055 *11*	α=0.00055 *11*; α(K)=0.00049 *10*; α(L)=4.9×10^{-5} *10*; α(M)=6.8×10^{-6} *14*; α(N+..)=2.9×10^{-7} *6* α(N)=2.9×10^{-7} *6*

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^{60}Cu ε decay 1972Va19 (continued)

γ(^{60}Ni) (continued)

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	δ[&]	α[†]	Comments
739.6 *10*	0.09 *3*	3926.0	2$^+$,3$^+$	3186.4					
748 *1*	0.065 *28*	3872.2	1$^+$,2$^+$	3124.16	2$^+$				
826.4 *2*	24.7 *12*	2158.95	2$^+$	1332.54	2$^+$	M1+E2	+1.2 *3*	0.000350 *15*	α=0.000350 *15*; α(K)=0.000315 *13*; α(L)=3.09×10^{-5} *13*; α(M)=4.35×10^{-6} *19*; α(N+..)=1.86×10^{-7} *8* α(N)=1.86×10^{-7} *8*
839.2 *4*	0.52 *8*	3124.16	2$^+$	2284.94	0$^+$				
896.3 *5*	0.15 *6*	4020.49	1$^+$	3124.16	2$^+$				
909.2 *2*	2.3 *1*	3194.16	1$^+$,2$^+$	2284.94	0$^+$				
952.4 *2*	3.1 *2*	2284.94	0$^+$	1332.54	2$^+$	Q			
965.2 *3*	0.34 *7*	3124.16	2$^+$	2158.95	2$^+$				
984.5 *6*	0.09 *5*	3269.48	2$^+$	2284.94	0$^+$	[E2]		0.000251 *4*	α=0.000251 *4*; α(K)=0.000225 *4*; α(L)=2.21×10^{-5} *4*; α(M)=3.11×10^{-6} *5*; α(N+..)=1.334×10^{-7} *19* α(N)=1.334×10^{-7} *19*
994[b]	0.04 *3*	3619.7		2626.25	3$^+$				
1027[b]	0.10 *6*	3186.4		2158.95	2$^+$	M1+E2		0.000208 *20*	α=0.000208 *20*; α(K)=0.000187 *18*; α(L)=1.83×10^{-5} *18*; α(M)=2.57×10^{-6} *25*; α(N+..)=1.11×10^{-7} *1* α(N)=1.11×10^{-7} *10*
1035.2 *2*	4.2 *2*	3194.16	1$^+$,2$^+$	2158.95	2$^+$				
1110.5 *4*	1.2 *2*	3269.48	2$^+$	2158.95	2$^+$				
1173.2[‡]	0.3 *1*	2505.8	4$^+$	1332.54	2$^+$	E2(+M3)		0.00039 *22*	α=0.00039 *22*; α(K)=0.00034 *20*; α(L)=3.4×10^{-5} *20*; α(M)=5.E−6 *3*; α(N+..)=3.E−6 *3* α(N)=2.1×10^{-7} *12*; α(IPF)=3.E−6 *3*
(1224[@])	≤0.05[@]	4493.5	1$^+$,2$^+$	3269.48	2$^+$				
1234.2 *7*	0.12 *5*	3393.5	2$^+$	2158.95	2$^+$				
1293.7 *2*	2.1 *2*	2626.25	3$^+$	1332.54	2$^+$	M1+E2		0.000151 *11*	α=0.000151 *11*; α(K)=0.000115 *7*; α(L)=1.12×10^{-5} *7*; α(M)=1.57×10^{-6} *10*; α(N+..)=2.3×10^{-5} *4* α(N)=6.8×10^{-8} *4*; α(IPF)=2.3×10^{-5} *4*
1307.1 *6*	0.12 *3*	4493.5	1$^+$,2$^+$	3186.4					
1332.5[‡]	100	1332.54	2$^+$	0.0	0$^+$	E2		0.0001625 *23*	α=0.0001625 *23*; α(K)=0.0001137 *16*; α(L)=1.108×10^{-5} *16*; α(M)=1.560×10^{-6} *22* α(N)=6.73×10^{-8} *10*; α(IPF)=3.61×10^{-5} *5*
1420.1 *5*	0.13 *2*	3926.0	2$^+$,3$^+$	2505.8	4$^+$				
1425.1 *6*	0.08 *2*	4548.9	1$^+$,2$^+$	3124.16	2$^+$				
1451.4 *5*	0.19[#] *3*	3736.0	2$^+$	2284.94	0$^+$	[E2]		0.0001754 *25*	α=0.0001754 *25*;

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^{60}Cu ε decay 1972Va19 (continued)

γ(^{60}Ni) (continued)

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	δ[&]	α[†]	Comments
									α(K)=9.51×10^{-5} *14*; α(L)=9.26×10^{-6} *13*; α(M)=1.304×10^{-6} *19*; α(N+..)=6.98×10^{-5} α(N)=5.63×10^{-8} *8*; α(IPF)=6.97×10^{-5} *10*
(1486[@])	≤0.06[@]	4111.9?		2626.25	3$^+$				
1579.5 *6*	0.10 *4*	4849.1	1,2,3	3269.48	2$^+$				
(1606[@])	≤0.04[@]	4111.9?		2505.8	4$^+$				
(1693[@])	0.04[@] *3*	4319.0	2$^+$	2626.25	3$^+$				
1713[b]	0.02 *3*	3872.2	1$^+$,2$^+$	2158.95	2$^+$				
1735.4 *6*	0.07 *2*	4020.49	1$^+$	2284.94	0$^+$				
1767.0 *5*	0.11 *5*	3926.0	2$^+$,3$^+$	2158.95	2$^+$				
1791.6 *3*	51.6 *26*	3124.16	2$^+$	1332.54	2$^+$	M1+E2	−0.21 *4*	0.000237 *4*	α=0.000237 *4*; α(K)=5.93×10^{-5} *9*; α(L)=5.75×10^{-6} *8*; α(M)=8.10×10^{-7} *12*; α(N+..)=0.000171 *3* α(N)=3.52×10^{-8} *5*; α(IPF)=0.000171 *3*
(1813[@])	≤0.023[@]	4319.0	2$^+$	2505.8	4$^+$				
1861.6 *3*	5.4 *3*	3194.16	1$^+$,2$^+$	1332.54	2$^+$				
1919.7 *4*	0.79 *8*	4078.63	1$^+$,2$^+$	2158.95	2$^+$				
1936.9 *3*	2.5 *1*	3269.48	2$^+$	1332.54	2$^+$				
2061.0 *3*	0.90 *5*	3393.5	2$^+$	1332.54	2$^+$				
(2135[@])	0.020[@] *15*	4760.8	1,2	2626.25	3$^+$				
2158.9 *2*	3.8 *2*	2158.95	2$^+$	0.0	0$^+$	(E2)		0.000439 *7*	α=0.000439 *7*; α(K)=4.45×10^{-5} *7*; α(L)=4.31×10^{-6} *6*; α(M)=6.08×10^{-7} *9*; α(N+..)=0.000390 *6* α(N)=2.64×10^{-8} *4*; α(IPF)=0.000390 *6*
2176 *2*	0.059 *17*	4334.7	2	2158.95	2$^+$				
2263.6 *8*	0.13 *4*	4548.9	1$^+$,2$^+$	2284.94	0$^+$				
2334.4 *12*	0.04 *2*	4493.5	1$^+$,2$^+$	2158.95	2$^+$				
2377.0 *10*	0.070 *15*	4536.1	2$^+$	2158.95	2$^+$				
2389.6 *10*	0.14 *4*	4548.9	1$^+$,2$^+$	2158.95	2$^+$				
2403.3 *6*	0.88 *9*	3736.0	2$^+$	1332.54	2$^+$				
(2420[@])	≤0.03[@]	4579.1	2$^+$	2158.95	2$^+$				
2540 *2*	0.029 *14*	3872.2	1$^+$,2$^+$	1332.54	2$^+$				
(2555[@])	≤0.03[@]	3887.6?		1332.54	2$^+$				
(2602[@])	0.023[@] *12*	4760.8	1,2	2158.95	2$^+$				
2675.3 *8*	0.15 *3*	4007.8	2$^+$	1332.54	2$^+$				
2687.9 *3*	0.50 *8*	4020.49	1$^+$	1332.54	2$^+$				
2746.1 *3*	1.2 *1*	4078.63	1$^+$,2$^+$	1332.54	2$^+$				
(2779[@])	≤0.024[@]	4111.9?		1332.54	2$^+$				
2889.6 *7*	0.023 *9*	5048.6	1,2	2158.95	2$^+$				
2986.3 *5*	0.14 *2*	4319.0	2$^+$	1332.54	2$^+$				
(3002[@])	≤0.024[@]	4334.7	2	1332.54	2$^+$				
(3024[@])	≤0.029[@]	4356.6?	2$^+$,3$^+$	1332.54	2$^+$				
3124.1 *3*	5.4 *3*	3124.16	2$^+$	0.0	0$^+$				
3160.8 *3*	0.66 *3*	4493.5	1$^+$,2$^+$	1332.54	2$^+$				
3194.1 *3*	2.3 *1*	3194.16	1$^+$,2$^+$	0.0	0$^+$				

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^{60}Cu ε decay 1972Va19 (continued)

γ(^{60}Ni) (continued)

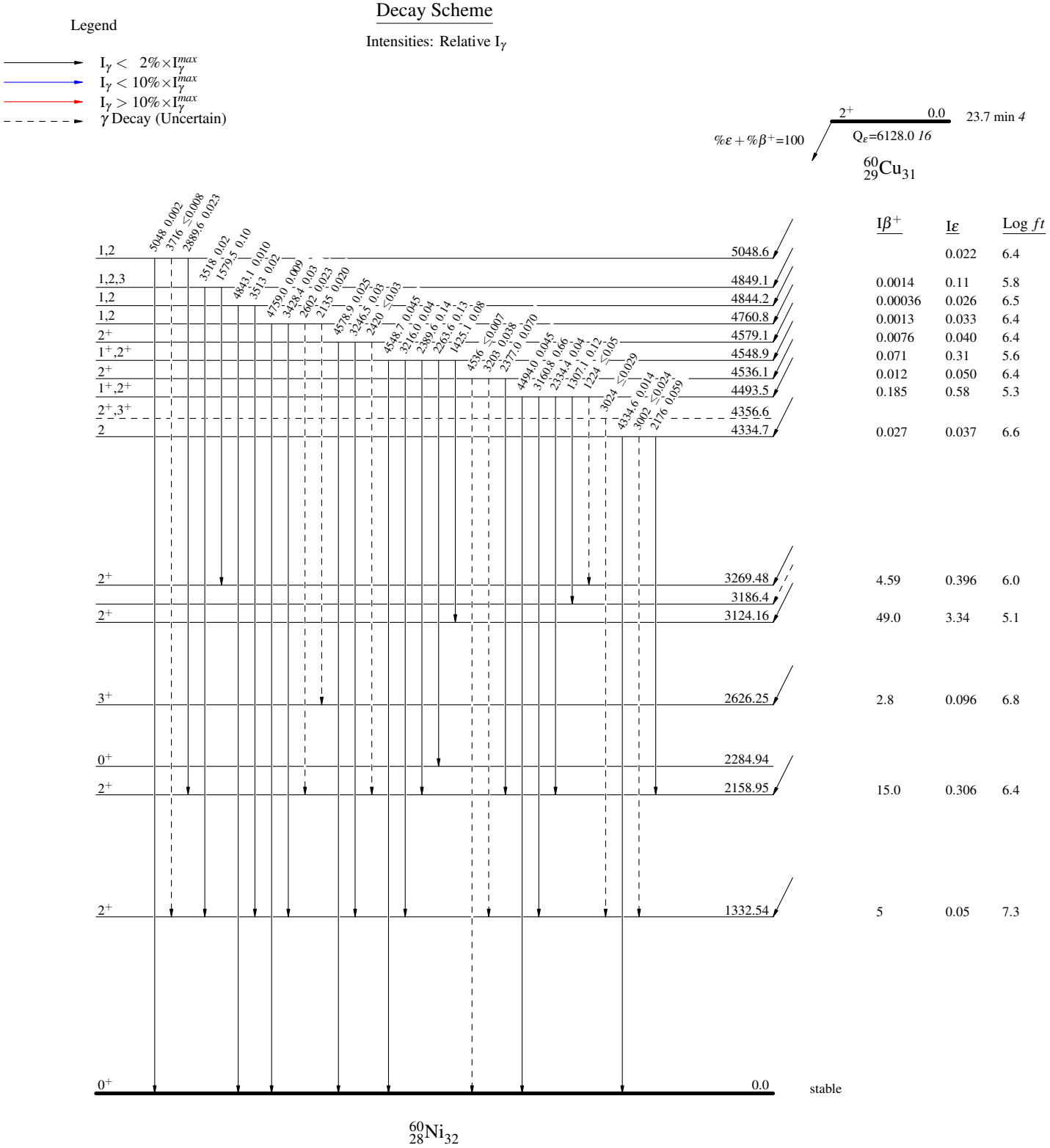
E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	α[†]	Comments
3203[b]	0.038 *12*	4536.1	2^+	1332.54	2^+			
3216.0 *7*	0.04 *2*	4548.9	$1^+,2^+$	1332.54	2^+			
3246.5 *15*	0.03 *1*	4579.1	2^+	1332.54	2^+			
3269.4 *3*	0.88 *5*	3269.48	2^+	0.0	0^+	[E2]	0.000920 *13*	α=0.000920 *13*; α(K)=2.22×10^{-5} *4*; α(L)=2.14×10^{-6} *3*; α(M)=3.02×10^{-7} *5*; α(N+..)=0.000895 *13* α(N)=1.314×10^{-8} *19*; α(IPF)=0.000895 *13*
3393.4 *8*	0.06 *2*	3393.5	2^+	0.0	0^+	[E2]	0.000969 *14*	α=0.000969 *14*; α(K)=2.09×10^{-5} *3*; α(L)=2.02×10^{-6} *3*; α(M)=2.85×10^{-7} *4*; α(N+..)=0.000945 *14* α(N)=1.239×10^{-8} *18*; α(IPF)=0.000945 *14*
3428.4 *8*	0.03 *1*	4760.8	1,2	1332.54	2^+			
3513 *2*	0.02 *1*	4844.2	1,2	1332.54	2^+			
3518 *2*	0.02 *1*	4849.1	1,2,3	1332.54	2^+			
(3716[@])	≤0.008[@]	5048.6	1,2	1332.54	2^+			
3735.6 *13*	0.03 *1*	3736.0	2^+	0.0	0^+	[E2]	0.001096 *16*	α=0.001096 *16*; α(K)=1.80×10^{-5} *3*; α(L)=1.742×10^{-6} *25*; α(M)=2.45×10^{-7} *4*; α(N+..)=0.001076 *15* α(N)=1.068×10^{-8} *15*; α(IPF)=0.001076 *15*
3872 *3*	0.013 *5*	3872.2	$1^+,2^+$	0.0	0^+			
4007.8 *15*	0.09 *3*	4007.8	2^+	0.0	0^+	[E2]	0.001191 *17*	α=0.001191 *17*; α(K)=1.622×10^{-5} *23*; α(L)=1.566×10^{-6} *22*; α(M)=2.21×10^{-7} *3*; α(N+..)=0.001173 α(N)=9.60×10^{-9} *14*; α(IPF)=0.001173 *17*
4020.4 *4*	0.87 *9*	4020.49	1^+	0.0	0^+			
4078.3 *4*	0.07 *2*	4078.63	$1^+,2^+$	0.0	0^+			
4319.4 *10*	0.05 *1*	4319.0	2^+	0.0	0^+			
4334.6 *11*	0.014 *2*	4334.7	2	0.0	0^+			
4494.0 *7*	0.045 *9*	4493.5	$1^+,2^+$	0.0	0^+			
(4536[@])	≤0.007[@]	4536.1	2^+	0.0	0^+			
4548.7 *7*	0.045 *9*	4548.9	$1^+,2^+$	0.0	0^+			
4578.9 *8*	0.025 *7*	4579.1	2^+	0.0	0^+			
4759.0 *12*	0.009 *6*	4760.8	1,2	0.0	0^+			
4843.1 *16*	0.010 *3*	4844.2	1,2	0.0	0^+			
5048 *3*	0.002 *1*	5048.6	1,2	0.0	0^+			

[†] Additional information 2.
[‡] Energy assumed for calibration.
[#] Only a part of Iγ can be accounted for by this transition, see 1972Va19.
[@] Unobserved transition, estimated upper limit for Iγ.
[&] From γγ correlations given above.
[a] For absolute intensity per 100 decays, multiply by 0.88 *1*.
[b] Placement of transition in the level scheme is uncertain.

^{60}Cu ε decay 1972Va19

Decay Scheme

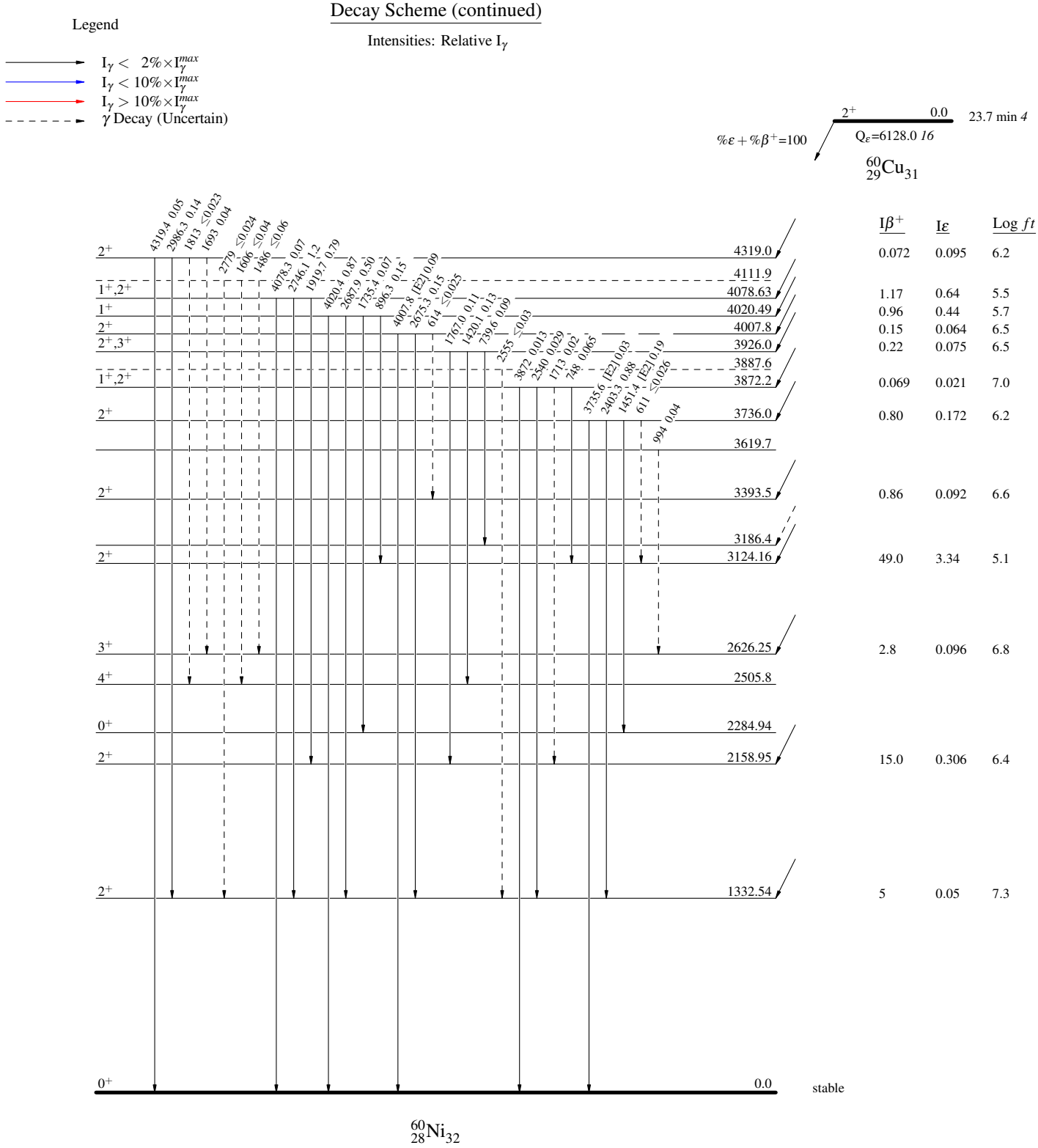
Intensities: Relative I_γ



^{60}Cu ε decay 1972Va19

Decay Scheme (continued)

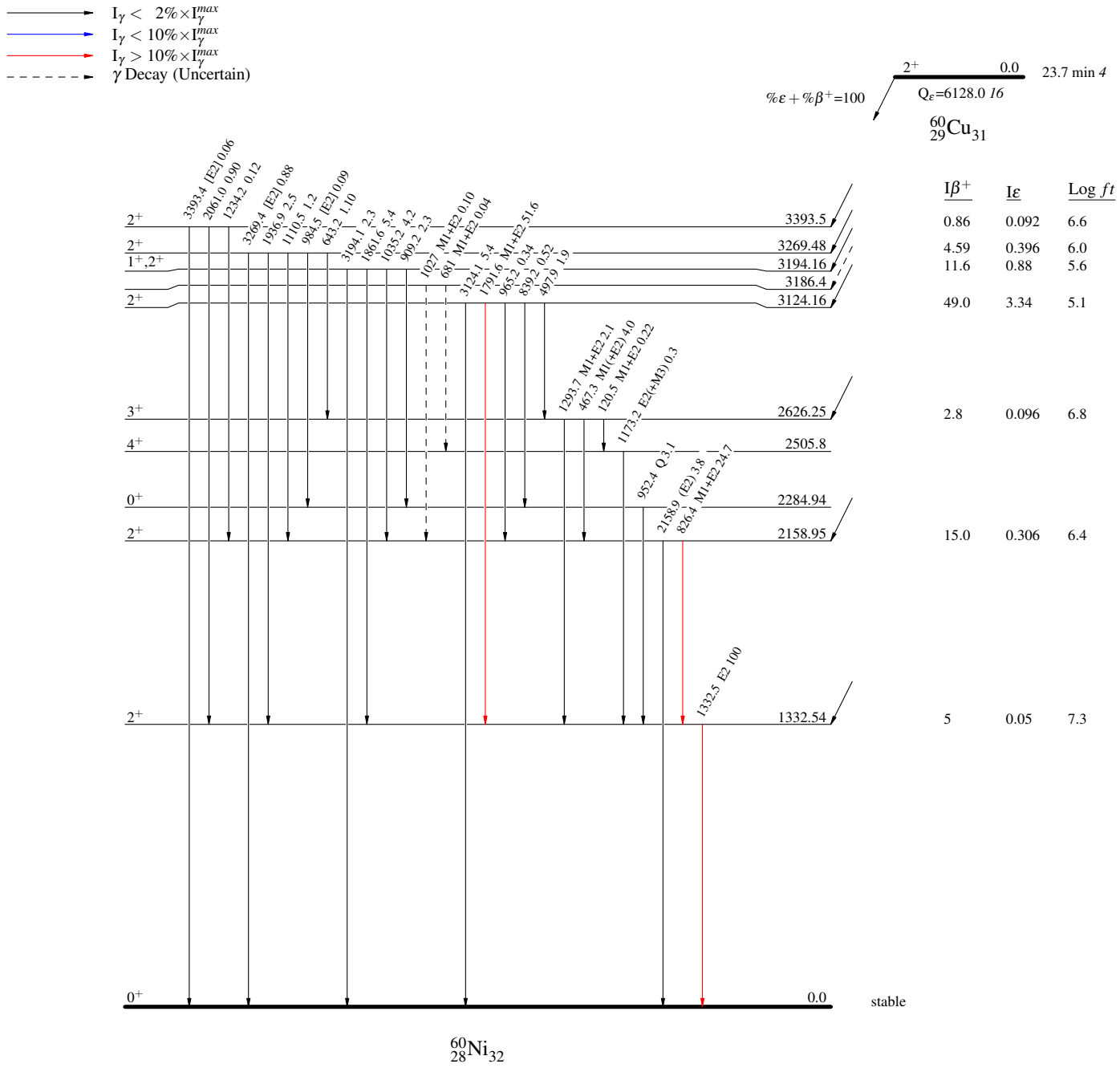
Intensities: Relative I_γ



^{60}Cu ε decay 1972Va19

Decay Scheme (continued)

Intensities: Relative I_γ



	Iβ+	Iε	Log *ft*
3393.5	0.86	0.092	6.6
3269.48	4.59	0.396	6.0
3194.16	11.6	0.88	5.6
3124.16	49.0	3.34	5.1
2626.25	2.8	0.096	6.8
2158.95	15.0	0.306	6.4
1332.54	5	0.05	7.3