^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 202,59 (2025)	25-Feb-2025

Note that most of relative intensity values (normalized to Iγ=100 for 771γ) from 2000Ko51 are inconsistent with those in 1983Di04, probably due to different level populations at different beam energies. To preserve the intensity data in 2000Ko51 (less complete than 1983Di04), the evaluator has put data from 2000Ko51 in this separate dataset.

2000Ko51,2000KoZZ: E=fast neutrons was produced the BBP-K reactor at the Institute for Nuclear Physics, National Nuclear Center in Kazakhstan. Target was enriched metallic ^{65}Cu. Measured Eγ, Iγ, γγ(θ), Doppler-shift attenuation, Deduced levels, J, π, level populations, $T_{1/2}$, γ-ray multipolaries, mixing ratios. Comparisons with theoretical calculations.

1987DoZX: E(n)=reactor fast neutrons. Measured $T_{1/2}$ by DSAM.

1982De45, 1982El09: optical potential and deformation parameters from ^{65}Cu(n,n) and ^{65}Cu(n,n′).

Others: 1982Sh28, 1971Fr05, 1970Fe04, 1968Da14.

^{65}Cu Levels

P_{exp} under comments are experimental level populations in 2000Ko51.

E(level)[†‡]	Jπ[#]	$T_{1/2}$[&]	Comments
0.0	$3/2^-$		
770.77 *6*	$1/2^-$ [@]	0.11 ps *+7−4*	P_{exp}=34 *2*.
1115.41 *6*	$5/2^-$ [@]		Jπ: spin=5/2 also from 1115.6γ(θ) in 2000KoZX. P_{exp}=59 *6*.
1481.64 *7*	$7/2^-$ [@]	0.34 ps *+24−13*	Jπ: spin=7/2 also from 366.2γ(θ) and 1481.7γ(θ) in 2000KoZX. $T_{1/2}$: weighted average of 0.42 ps *+42−21* (2000Ko51) and 0.31 ps *+24−13* (1987DoZX). P_{exp}=22 *1*.
1623.35 *10*	$5/2^-$ [@]		Jπ: spin=5/2 also from 1623.2γ in 2000KoZX. P_{exp}=16.0 *5*.
1724.86 *6*	$3/2^-$ [@]	72 fs *+23−16*	Jπ: spin=3/2 also from 1724.7γ(θ) in 2000KoZX. $T_{1/2}$: weighted average of 125 fs *+83−42* (2000Ko51) and 67 fs *+23−15* (1987DoZX). P_{exp}=11.1 *3*.
2094.27 *8*	$7/2^-$		Jπ: $(7/2^-)$ from HFM analysis in 2000Ko51. P_{exp}=7.2 *4*.
2107.12 *9*	$(5/2)^-$	0.166 ps *+69−49*	Jπ: $(5/2^-)$ from HFM analysis in 2000Ko51 and spin=5/2 from 991.8γ(θ) in 2000KoZX. P_{exp}=6.6 *3*.
2212.61 *8*	$(1/2)^-$	0.111 ps *+69−35*	Jπ: $(1/2^-)$ from HFM analysis in 2000Ko51. P_{exp}=2.5 *3*.
2278.04 *12*	$7/2^-$		Jπ: $(7/2^-)$ from HFM analysis in 2000Ko51. P_{exp}=5.0 *2*.
2328.29 *23*	$3/2^-$ [@]	32 fs *8*	P_{exp}=3.9 *3*. Jπ: spin=3/2 also from 2328.7γ(θ) in 2000KoZX. $T_{1/2}$: weighted average of 21 fs *7* (2000Ko51), 45 fs *+9−6* from 1557.2γ and 29 fs *+16−11* from 2328.7γ in 1987DoZX.
2405.91 *11*	$(5/2^-,7/2^-)$		Jπ: $(5/2^-,7/2^-)$ from HFM analysis in 2000Ko51. P_{exp}=4.2 *3*.
2533.15 *31*	$(1/2,3/2,5/2^-)$		Jπ: $(1/2,3/2,5/2^-)$ from HFM analysis in 2000Ko51. P_{exp}=1.4 *2*.
2533.74 *12*	$(7/2^+,9/2^+)$ [@]		P_{exp}=3.5 *1*.
2593.95 *26*	$(5/2^-)$		Jπ: $(1/2^-,5/2^-)$ from HFM analysis in 2000Ko51.
2644.0 *6*	$(5/2^-)$		P_{exp}=2.9 *4*.

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^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ (continued)

^{65}Cu Levels (continued)

E(level)[†‡]	Jπ[#]	$T_{1/2}$[&]	Comments
			Jπ: (7/2⁻,5/2⁻) from HFM analysis in 2000Ko51.
2649.44 *16*	(5/2⁻)	8.3 fs *+42−35*	Jπ: (5/2⁻,7/2⁻) from HFM analysis in 2000Ko51. P_{exp}=2.6 *2*.
2668.67 *21*	(1/2⁻)[@]	4.2 fs *35*	P_{exp}=1.2 *1*.
2753.31 *21*	(7/2⁺,9/2⁺)[@]	35 fs *14*	P_{exp}=2.6 *2*.
2839.15 *21*	(7/2⁺)	21 fs *+8−6*	Jπ: (7/2⁺,9/2⁺) from HFM analysis in 2000Ko51. $T_{1/2}$: weighted average of 18 fs *+8−6* (2000Ko51) and 24 fs *+9−6* (1987DoZX). P_{exp}=2.1 *1*.
2862.1 *2*	(1/2⁻)[@]		P_{exp}=0.8 *1*.
2865.96 *28*	(7/2⁻,5/2⁻)[@]	12.5 fs *+42−35*	P_{exp}=2.0 *1*.
2871.69 *30*	(3/2⁻)[@]		P_{exp}=1.5 *1*.
2892.91 *14*	(3/2⁻)[@]		P_{exp}=1.4 *1*.
2901.83 *18*	(5/2⁻)[@]		P_{exp}=1.8 *2*.
2944.80 *21*	(1/2⁻)[@]		P_{exp}=0.66 *7*.
2974.27 *20*	(3/2⁻)[@]		P_{exp}=1.2 *1*.
2996.66 *19*	(11/2⁻)	9.0 fs *42*	Jπ: (9/2⁻,5/2⁻) from HFM analysis in 2000Ko51. P_{exp}=1.5 *2*.
3032.5 *2*	(1/2⁻)[@]		P_{exp}=0.67 *7*.
3080.50 *12*	(3/2)⁺	83 fs *+56−42*	Jπ: (3/2⁺,5/2⁺) from HFM analysis in 2000Ko51. P_{exp}=1.2 *2*.
3113.1 *2*	(1/2⁻,3/2⁻)[@]		P_{exp}=0.5 *2*.
3119.23 *21*	(7/2⁻,5/2⁻)[@]	0.21 ps *+28−7*	P_{exp}=1.4 *1*.
3160.14 *21*	(1/2⁻,3/2⁻)[@]		P_{exp}=0.49 *6*.
3240.64 *21*	(3/2,5/2⁺)		Jπ: (1/2,3/2,5/2⁺) from HFM analysis in 2000Ko51. P_{exp}=0.45 *7*.
3260.77 *15*	(1/2⁻,5/2⁻,7/2⁻)		Jπ: (1/2,5/2,7/2⁻) from HFM analysis in 2000Ko51. P_{exp}=1.2 *2*.
3355.28 *21*	(7/2⁻)[@]		P_{exp}=1.27 *12*.
3428.23 *21*		49 fs *14*	P_{exp}=0.35 *7*.

[†] Additional information 1.
[‡] From a least-squares fit to γ-ray energies.
[#] From Adopted Levels. Some of the assignments are adopted from 2000Ko51 which are based on comparisons of measured level populations P_{exp} with calculations using the Hauser-Feshbach-Moldauer (HFM) formalism, as noted or given under comments where available.
[@] The same assignments are given in 2000Ko51 based on Hauser-Feshbach-Moldauer analysis of measured P_{exp}.
[&] From DSAM in 2000Ko51, unless otherwise noted.

γ(^{65}Cu)

A_2 and A_4 values under comments are from 2000KoZX.

E_γ[#]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[@]	Comments
255 *1*	0.9 *1*	2533.74	(7/2⁺,9/2⁺)	2278.04	7/2⁻			
311.5 *5*	1.0 *2*	2405.91	(5/2⁻,7/2⁻)	2094.27	7/2⁻			
366.2 *1*	9.0 *5*	1481.64	7/2⁻	1115.41	5/2⁻	M1+E2	−0.03 *1*	A_2=−0.15 *4*, A_4=+0.02 *2*.
382.4 *2*	0.5 *2*	2107.12	(5/2)⁻	1724.86	3/2⁻			
471.0 *2*	0.8 *3*	2094.27	7/2⁻	1623.35	5/2⁻			

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^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ (continued)

γ(^{65}Cu) (continued)

E_γ[#]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[@]	Comments
487 *1*	0.2 *1*	2212.61	(1/2)$^-$	1724.86	3/2$^-$			
499.8 *3*	2.2 *4*	2593.95	(5/2$^-$)	2094.27	7/2$^-$			
507 *1*	4.5 *5*	1623.35	5/2$^-$	1115.41	5/2$^-$			
609.7 *1*	6.2 *3*	1724.86	3/2$^-$	1115.41	5/2$^-$			
612.7 *1*	1.8 *3*	2094.27	7/2$^-$	1481.64	7/2$^-$			
624.9[†] *1*	2.7 *1*	2107.12	(5/2)$^-$	1481.64	7/2$^-$			E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=625.48.
659 *1*	0.4 *1*	2753.31	(7/2$^+$,9/2$^+$)	2094.27	7/2$^-$			
732 *1*	0.5 *1*	2839.15	(7/2$^+$)	2107.12	(5/2)$^-$			
770.7 *1*	45 *2*	770.77	1/2$^-$	0.0	3/2$^-$			
785.6 *4*	0.5 *1*	2892.91	(3/2$^-$)	2107.12	(5/2)$^-$			
794.6 *2*	0.6 *1*	2901.83	(5/2$^-$)	2107.12	(5/2)$^-$			
852.5 *1*	3.2 *1*	1623.35	5/2$^-$	770.77	1/2$^-$			
879.9 *2*	0.9 *1*	2974.27	(3/2$^-$)	2094.27	7/2$^-$			
902.0 *4*	0.8 *2*	2996.66	(11/2$^-$)	2094.27	7/2$^-$			
924.3 *1*	2.0 *2*	2405.91	(5/2$^-$,7/2$^-$)	1481.64	7/2$^-$			
924.8 *3*	0.8 *1*	2649.44	(5/2$^-$)	1724.86	3/2$^-$			
943.8 *2*	1.2 *1*	2668.67	(1/2$^-$)	1724.86	3/2$^-$			
954.0 *1*	1.1 *1*	1724.86	3/2$^-$	770.77	1/2$^-$			
978.8 *1*	7.0 *2*	2094.27	7/2$^-$	1115.41	5/2$^-$			
991.8 *1*	3.0 *1*	2107.12	(5/2)$^-$	1115.41	5/2$^-$	M1+E2	0.32 *10*	δ: or 0.86 *15* (2000KoZX). A_2=+0.19 *3*, A_4=−0.01 *1*.
1024.9[†] *1*	0.24 *4*	2649.44	(5/2$^-$)	1623.35	5/2$^-$			E_γ: uncertainty multiplied by a factor of 3 in the fitting; level-energy difference=1026.09.
1052.1 *1*	2.6 *1*	2533.74	(7/2$^+$,9/2$^+$)	1481.64	7/2$^-$			
1115.6 *1*	100 *5*	1115.41	5/2$^-$	0.0	3/2$^-$	D+Q	−0.50 *15*	A_2=−0.17 *4*, A_4=−0.002 *9*.
1162.6 *1*	5.7 *2*	2278.04	7/2$^-$	1115.41	5/2$^-$			
1163 *1*	2.3 *4*	2644.0	(5/2$^-$)	1481.64	7/2$^-$			
1212.7 *4*	1.2 *1*	2328.29	3/2$^-$	1115.41	5/2$^-$			
1219.9 *2*	0.45 *5*	2944.80	(1/2$^-$)	1724.86	3/2$^-$			
1245 *1*	0.60 *5*	2865.96	(7/2$^-$,5/2$^-$)	1623.35	5/2$^-$			
1261.0 *2*	1.0 *1*	3355.28	(7/2$^-$)	2094.27	7/2$^-$			
1271.9 *3*	1.2 *1*	2753.31	(7/2$^+$,9/2$^+$)	1481.64	7/2$^-$			
1290.2 *3*	1.2 *2*	2405.91	(5/2$^-$,7/2$^-$)	1115.41	5/2$^-$			
1337.9[‡] *1*	0.7 *2*	2107.12	(5/2)$^-$	770.77	1/2$^-$			E_γ: very poor fit and omitted in the fitting; level-energy difference=1336.34.
1357.5 *2*	1.61 *11*	2839.15	(7/2$^+$)	1481.64	7/2$^-$			
1384 *1*	0.30 *5*	2865.96	(7/2$^-$,5/2$^-$)	1481.64	7/2$^-$			
1441.9 *1*	1.4 *3*	2212.61	(1/2)$^-$	770.77	1/2$^-$			
1481.7 *1*	30 *1*	1481.64	7/2$^-$	0.0	3/2$^-$	E2		A_2=+0.21 *6*, A_4=−0.02 *2*.
1493.2 *5*	0.3 *1*	2974.27	(3/2$^-$)	1481.64	7/2$^-$			
1495 *1*	0.15 *5*	3119.23	(7/2$^-$,5/2$^-$)	1623.35	5/2$^-$			
1515.1 *2*	0.7 *1*	2996.66	(11/2$^-$)	1481.64	7/2$^-$			
1529 *1*	0.1	2644.0	(5/2$^-$)	1115.41	5/2$^-$			
1534 *1*	0.1	2649.44	(5/2$^-$)	1115.41	5/2$^-$			
1557.2 *4*	1.3 *2*	2328.29	3/2$^-$	770.77	1/2$^-$			
1623.2 *3*	10.5 *3*	1623.35	5/2$^-$	0.0	3/2$^-$	D+Q	1.75 *50*	A_2=+0.13 *3*, A_4=−0.03 *3*.
1637.6 *2*	1.24 *9*	3119.23	(7/2$^-$,5/2$^-$)	1481.64	7/2$^-$			
1724.7 *1*	9.5 *1*	1724.86	3/2$^-$	0.0	3/2$^-$	M1+E2	0.32 *5*	A_2=+0.09 *3*, A_4=0.
1732 *1*	0.17 *5*	3355.28	(7/2$^-$)	1623.35	5/2$^-$			
1762.2 *5*	0.7 *2*	2533.15	(1/2,3/2,5/2$^-$)	770.77	1/2$^-$			
1805 *1*	0.20 *5*	3428.23		1623.35	5/2$^-$			

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^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ (continued)

γ(^{65}Cu) (continued)

E_γ[#]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[@]	Comments
1821 *2*	0.2 *1*	2593.95	(5/2⁻)	770.77	1/2⁻			
1830 *1*	0.21 *5*	2944.80	(1/2⁻)	1115.41	5/2⁻			
1872 *1*	0.5 *1*	2644.0	(5/2⁻)	770.77	1/2⁻			
1879.1† *2*	1.1 *2*	2649.44	(5/2⁻)	770.77	1/2⁻			E_γ: uncertainty multiplied by a factor of 2 in the fitting; level-energy difference=1878.65.
1964 *1*	0.3 *1*	3080.50	(3/2)⁺	1115.41	5/2⁻			
2044.7 *2*	0.37 *5*	3160.14	(1/2⁻,3/2⁻)	1115.41	5/2⁻			
2093.5† *1*	3.9 *2*	2094.27	7/2⁻	0.0	3/2⁻			E_γ: uncertainty multiplied by a factor of 3 in the fitting; level-energy difference=2094.23.
2102 *2*	0.6 *1*	2871.69	(3/2⁻)	770.77	1/2⁻			
2106.5 *5*	0.7 *2*	2107.12	(5/2)⁻	0.0	3/2⁻			
2122.2 *2*	0.15 *5*	2892.91	(3/2⁻)	770.77	1/2⁻			
2125.2 *2*	0.30 *6*	3240.64	(3/2,5/2⁺)	1115.41	5/2⁻			
2145.2 *2*	0.10 *2*	3260.77	(1/2⁻,5/2⁻,7/2⁻)	1115.41	5/2⁻			
2212.5 *1*	0.9 *1*	2212.61	(1/2)⁻	0.0	3/2⁻			
2279 *1*	0.2 *1*	2278.04	7/2⁻	0.0	3/2⁻			
2309.7 *1*	0.9 *2*	3080.50	(3/2)⁺	770.77	1/2⁻			
2328.7 *4*	1.4 *2*	2328.29	3/2⁻	0.0	3/2⁻	M1+E2	−1.25 *30*	A_2=−0.09 *3*, A_4=−0.03 *4*.
2389 *1*	0.12 *3*	3160.14	(1/2⁻,3/2⁻)	770.77	1/2⁻			
2533.2 *4*	0.7 *2*	2533.15	(1/2,3/2,5/2⁻)	0.0	3/2⁻			
2593.7 *5*	0.5 *1*	2593.95	(5/2⁻)	0.0	3/2⁻			
2650.1 *3*	0.35 *5*	2649.44	(5/2⁻)	0.0	3/2⁻			
2657.4 *2*	0.15 *5*	3428.23		770.77	1/2⁻			
2753.0 *3*	1.0 *1*	2753.31	(7/2⁺,9/2⁺)	0.0	3/2⁻			
2862.0 *2*	0.8 *1*	2862.1	(1/2⁻)	0.0	3/2⁻			
2865.7 *3*	1.1 *1*	2865.96	(7/2⁻,5/2⁻)	0.0	3/2⁻			
2871.6 *3*	0.9 *1*	2871.69	(3/2⁻)	0.0	3/2⁻			
2892.8 *2*	0.8 *1*	2892.91	(3/2⁻)	0.0	3/2⁻			
2902.0 *3*	1.2 *2*	2901.83	(5/2⁻)	0.0	3/2⁻			
3032.4 *2*	0.67 *7*	3032.5	(1/2⁻)	0.0	3/2⁻			
3113.0 *2*	0.5 *2*	3113.1	(1/2⁻,3/2⁻)	0.0	3/2⁻			
3239 *2*	0.15 *3*	3240.64	(3/2,5/2⁺)	0.0	3/2⁻			
3260.8 *2*	1.1 *2*	3260.77	(1/2⁻,5/2⁻,7/2⁻)	0.0	3/2⁻			
3355 *1*	0.10 *5*	3355.28	(7/2⁻)	0.0	3/2⁻			

† Poor fit; uncertainty multiplied by a factor in the fitting.
‡ Very poor fit and omitted in the fitting.
# From 2000Ko51, unless otherwise noted. Intensities are relative to Iγ(1115.6γ)=100.
@ From γγ(θ) in 2000KoZX, with electric or magnetic characters determined based on RUL and measured $T_{1/2}$ where available.

^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ

Level Scheme

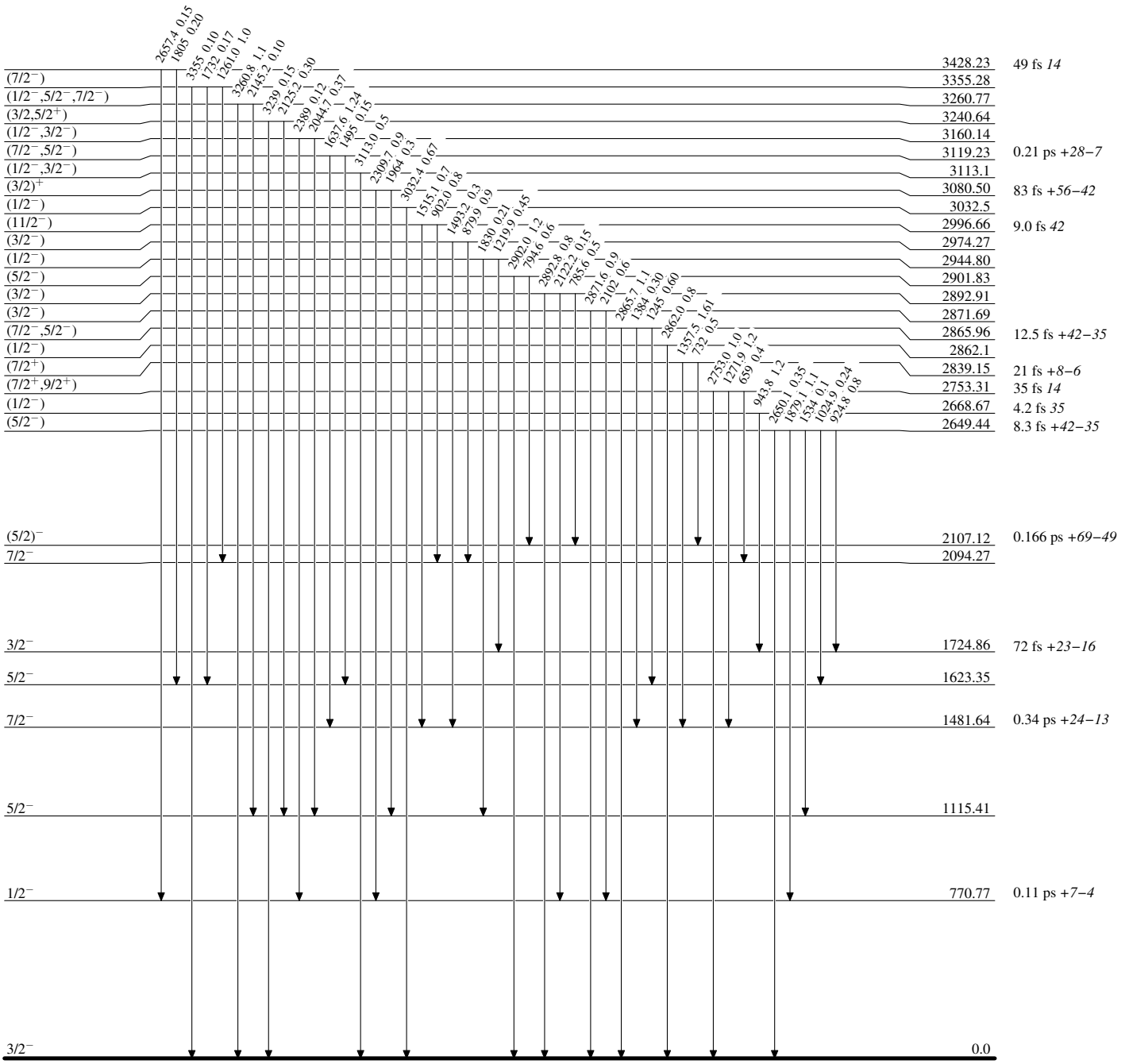
Intensities: Relative I_γ

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$

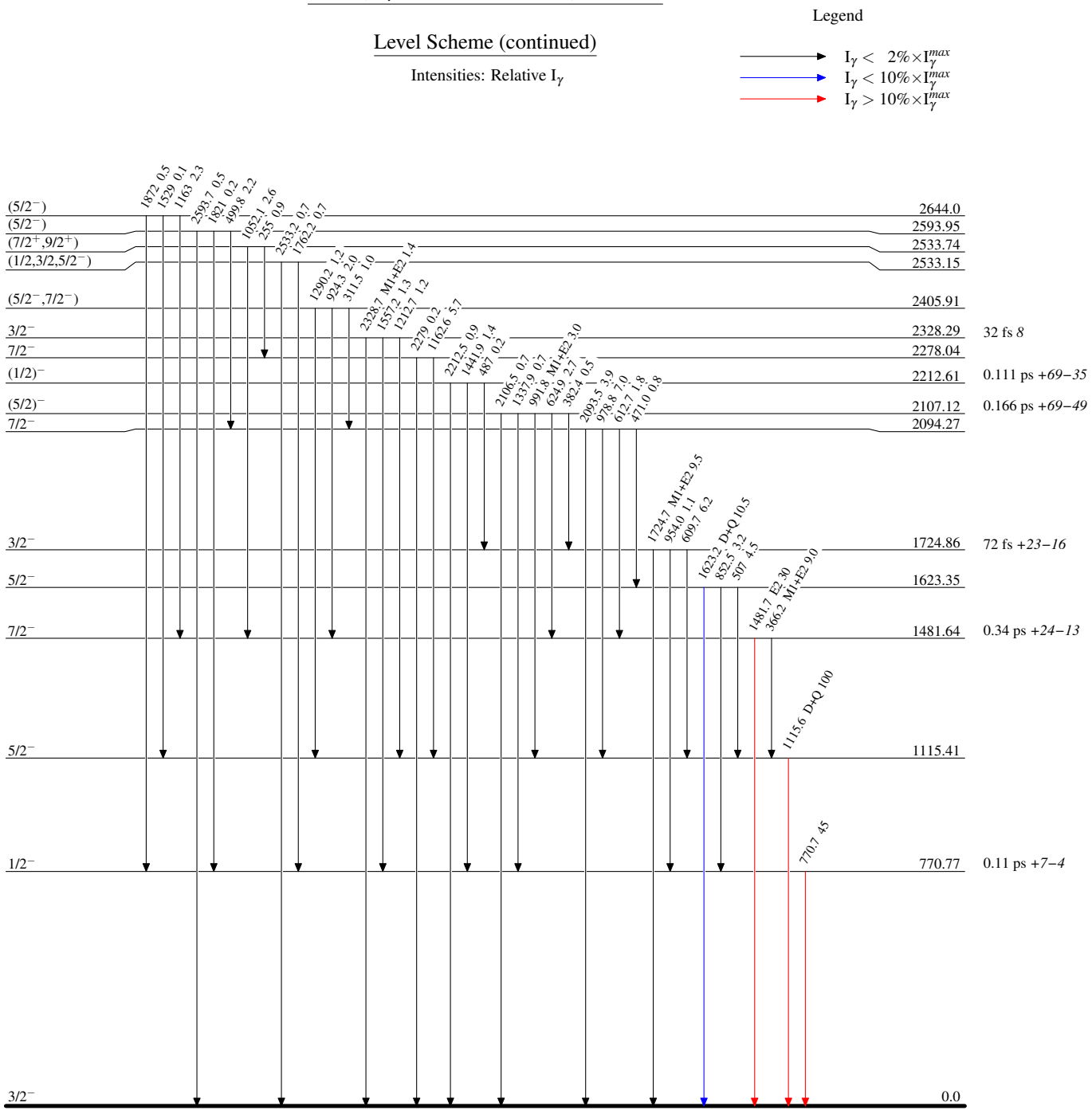


$^{65}_{29}Cu_{36}$

^{65}Cu(n,n′γ) E=fast 2000Ko51,2000KoZZ

Level Scheme (continued)

Intensities: Relative I_γ



$^{65}_{29}Cu_{36}$