Coulomb excitation

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 160, 1 (2019)	21-Oct-2019

Additional information 1.
References: ^{155}Gd(x,x′γ).
1966As02: x=p.
1966Bo16: x=^{16}O, E=45 MeV.
1962Go23: x=p, E=3.1-3.4 MeV.
1959De29: x=p, E=4 MeV.
1958Ra12: x=p, E=4 MeV.
1958Ch36: x=p, E=3.7 MeV.
1957Be56: x=α, E=3.25 MeV.
1956Bj41: x=α, E=1.75 MeV.
1956He78: x=α, E=6 MeV.
1955Ma77: x=p, E=2.88 MeV.
1963El06: x=p, E≈4 MeV. Isotope-separated targets. Elastically and inelastically scattered (at 145°) particles were detected in a photographic emulsion in the focal plane of a heavy-particle spectrograph.
1969Tv01: x=^{16}O, E=48 MeV. Isotopically enriched (<6% impurities from the nearest masses) metallic targets. Scattered ions were detected at 90° using a surface-barrier detector. γ-ray yields were measured in a 6-cm^3 Ge(Li) detector placed at 55° with respect to the beam axis.
1978Br20: x=α, E=11-12 MeV. Elastically and inelastically scattered particles were detected at a scattering angle of 143° by means of an Enge split-pole spectrometer with a position-sensitive detector.
1992Ku15: x=^{58}Ni, E=240 MeV. Enriched (91.8% ^{155}Gd) metallic targets. Measured: $\gamma\gamma$; $\gamma(\theta)$, using a Compton-suppression spectrometer at seven angles between 0° and 90°; and level lifetimes, using the Doppler-shift recoil-distance method.
1998St28: x=^{58}Ni, E=180, 220, 230 MeV. Various enriched (77%, 91%) Targets, sputtered and rolled, having thicknesses between 1.1 and 1.8 mg/cm^2. Measured $\gamma(\theta$,H,T) in thin polarized Fe targets, particle-γ coin., $\gamma\gamma$ coin, Coul. ex., level Lifetimes using Doppler-broadened lineshapes, g-factors from Transient-field technique, mult and δ.
1997KiZS: x=^{90}Zr, E=390 MeV. Enriched (91.8%) self-supporting Metallic target. Measured particle-γ coincidences. Show level scheme up to (31/2$^-$) member.
1998St28 observe population of members of the mixed positive-parity band. Although some of this comes from decay γ′s from the (negative-parity) g.s. band, these authors conclude that this excess population indicates the presence of (dynamic) octupole correlations in this nucleus.
Other reports discussing Coul. ex. studies of ^{155}Gd are given in the following: 1992OsZX; 1993KuZY; 1996KiZV; 1997Ki16; 1997KiZS; 1997OsZZ; 1998OsZZ. These studies involve many of the same authors. Among other items, these reports treat the enhanced population of the mixed positive-parity band, extend the members of the g.s. band to higher spins, and propose a signature dependence of the γ-ray transition probabilities in the g.s. band. However, 1998St28 report no such signature dependence.
Band assignments are from the adopted values.

^{155}Gd Levels

The g-factors are from 1998St28, unless noted otherwise. They are obtained from measured transient hyperfine-field precessions at bombarding-particle (^{58}Ni) energies of 180 MeV and 230 MeV. These listed values are weighted averages of the values measured at these two energies. 1998St28 do not list + signs for their g factors, but the evaluator has included them here, since these authors do list negative values where appropriate.

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
0.0[&]	3/2$^-$		
59.9[a]	5/2$^-$	0.198 ns *17*	B(E2)↑=2.05 *7* T$_{1/2}$: calculated from B(E2)↑, δ=−0.198 *8* and α(60γ)=9.14. B(E2)↑: From 1978Br20. Other: 2.18 *10* (1963El06).

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Coulomb excitation (continued)

^{155}Gd Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	T$_{1/2}$[#]	Comments
107.5[e]	9/2$^+$		
117.9[e]	7/2$^+$		
146.0[&]	7/2$^-$	0.102 ns *11*	B(E2)↑=1.18 *4*; g=+0.10 *12* B(E2)↑: From 1978Br20. Other: 1.14 *15* (1963El06). g: Weighted average of +0.19 *9* and −0.06 *11*. T$_{1/2}$: calculated from B(E2)↑, α(86γ)=3.14, α(146γ)=0.649, and I(γ+ce)(146)/I(γ+ce)(86)=0.132 *15*.
214.3[e]	13/2$^+$		
230.0[e]	11/2$^+$		
251.6[a]	9/2$^-$	58 ps *6*	g=+0.27 *7* g: Weighted average +0.15 *10* and +0.37 *9*. T$_{1/2}$: from 1992Ku15.
321.5	5/2$^-$		B(E2)↑=0.003 B(E2)↑: Deduced by the evaluator from the statement by 1969Tv01 that the experimental cross section for exciting the 321 level corresponds to B(E2)↑=0.1 (E2) single-particle unit (note that the single-particle unit used by 1969Tv01 is five times as large as the E2 Weisskopf unit used in the Nuclear Data Sheets evaluations).
392.3[&]	11/2$^-$	23 ps *2*	g=+0.28 *6* g: Weighted average of +0.27 *9* and +0.28 *7*. T$_{1/2}$: from 1992Ku15.
422.5?			1969Tv01 report B(E2)↑=0.0065 *20* for this level, based on their value of 0.0065 *20* for the partial B(E2)↑(362.5γ) and treat it as the J^{π}=1/2$^-$ member of the 1/2[530] band. 1986Sc25 report no level at this energy, but do establish the existence of a J^{π}=7/2$^+$ state at 423.4 keV which has a γ-decay pattern quite different from that shown by 1969Tv01. Further, 1986Sc25 place the 1/2$^-$ member of 1/2[530] at 451.3 keV. Since there is no obvious configuration assignment for this level and since only one γ is shown by 1969Tv01 as deexciting it, the evaluator regards its existence and properties as uncertain.
423.9[e]	17/2$^+$		
450.5[b]	3/2$^-$		B(E2)↑=0.020 *7* B(E2)↑: Weighted average of the two B(E2)↑ values computed by the evaluator from partial B(E2)↑(390.5γ) and partial B(E2)↑(450.5γ) using the adopted properties of the deexciting transitions.
453.8[e]	15/2$^+$		
487.0			J$^{\pi}$: 1969Tv01 assign this level, deexcited by two questionably placed γ rays, as the 5/2$^-$ member of the 1/2[530] band. 1986Sc25 report levels at 488.72 and 485.98 keV having J^{π}=5/2$^+$ and (9/2$^-$), respectively. They also place the 5/2$^-$ member of 1/2[530] at 581.46 keV. Which, if either, of these levels corresponds to the 487 level of 1969Tv01 is an open question at this time.
534.2[a]	13/2$^-$	15 ps *2*	g=+0.29 *5* g: Weighted average of +0.27 *6* and +0.33 *10*. T$_{1/2}$: 1992Ku15 report τ=32 ps *3*, but 1998St28 point out that this is not consistent with their listed B(M1) and B(E2) values and that these values are consistent with τ=21 ps *3*. The evaluator has adopted this latter value.
558.0[c]	1/2$^-$		B(E2)↑=0.015 *6* B(E2)↑: Computed by the evaluator from partial B(E2)↑(558.0γ) and the adopted properties of the deexciting transitions.
591.5[d]	3/2$^-$		B(E2)↑=0.022 *14* B(E2)↑: Computed by the evaluator from partial B(E2)↑(531.5γ) and the adopted properties of the deexciting transitions.
614.0[c]	3/2$^-$	14[@] ps *+7−3*	B(E2)↑=0.022 *7* B(E2)↑: Weighted average of the two B(E2)↑ values computed by the evaluator from partial B(E2)↑(554.0γ) and partial B(E2)↑(614.0γ) using the adopted properties of the deexciting transitions.
647.3[d]	5/2$^-$	14[@] ps *+16−6*	B(E2)↑=0.015 *8*

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Coulomb excitation (continued)

^{155}Gd Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
			B(E2)↑: Computed by the evaluator from partial B(E2)↑(647.3γ) and the adopted properties of the deexciting transitions.
657.5[c]	5/2⁻		
721.0			Interpreted by 1969Tv01 as the 7/2⁻ member of the β-vibrational band built on the g.s. and shown by them as deexciting via a questionable 721.0 γ only. 1986Sc25 do not confirm this level, reporting instead a 720.62 level having positive parity and a quite different pattern of deexciting γ rays.
729.6[&]	15/2⁻	5.8 ps *11*	g=+0.35 *6* g: Weighted average of +0.39 *8* and +0.31 *9*. $T_{1/2}$: computed from a weighted average of τ=10.3 ps *11* (1992Ku15) and τ=7.0 ps *+10−8* (1998St28).
737.2[e]	21/2⁺		
787.3[e]	19/2⁺		
897.0[a]	17/2⁻	4.9 ps *3*	g=+0.26 *10* g: Weighted average of +0.23 *13* and +0.30 *15*. $T_{1/2}$: computed from a weighted average of τ=7.5 ps *8* (1992Ku15) and τ=6.8 ps *7* (1998St28).
1028.0	(7/2⁻)		Assigned as the bandhead of a K^{π}=7/2⁻ band (the K+2 γ-vibration built on the g.s.) by 1969Tv01. 1986Sc25 report a 1028.0 level, but it has a pattern of deexciting γ′s that is quite different from that shown by 1969Tv01.
1142.4[&]	19/2⁻	2.4 ps *2*	g=+0.31 *11* g-factor based on measurement at E(^{58}Ni)=230 MeV only. $T_{1/2}$: computed from a weighted average of τ=3.4 ps *4* (1992Ku15) and τ=3.5 ps *4* (1998St28).
1326.7[a]	21/2⁻	2.4 ps *4*	$T_{1/2}$: computed from a weighted average of τ=4.2 ps *5* (1992Ku15) and τ=3.0 ps *4* (1998St28).
1615.1[&]	23/2⁻		
1809[a]	25/2⁻		E(level): from 1992Ku15 and 1997KiZS. 1998St28 do not report this γ or this level.
2134[&]	27/2⁻		From 1997KiZS.
2330[a]	29/2⁻		From 1997KiZS.
2699[&]	(31/2⁻)		From 1997KiZS.

[†] Members of the g.s. and mixed positive-parity bands are from 1998St28, unless noted otherwise.
[‡] From the adopted values.
[#] From 1992Ku15, Doppler-shift recoil-distance method, and 1998St28, Doppler-broadened line-shape analysis, unless noted otherwise.
[@] Calculated by the evaluator using the listed B(E2) value and the adopted δ and γ branching for the transition to the g.s.
[&] Band(A): g.s. band, signature=−1/2 portion. At low spins, the dominant configuration is 3/2[521].
[a] Band(a): g.s. band, signature=+1/2 portion. At low spins, the dominant configuration is 3/2[521].
[b] Band(B): Member of the 1/2[530] band.
[c] Band(C): 1/2[521] band member.
[d] Band(D): Member of the β-vibrational band built on the g.s.
[e] Band(E): Member of the mixed positive-parity band.

γ(^{155}Gd)

E_i(level)	J^{π}_i	E_{γ}[†]	I_{γ}[@]	E_f	J^{π}_f	Mult.[&]	δ[a]	Comments
59.9	5/2⁻	59.9	100	0.0	3/2⁻	M1+E2	−0.198 *8*	δ: adopted value.
146.0	7/2⁻	86.1	100	59.9	5/2⁻	M1+E2	−0.184 *23*	δ: adopted value.
		146.0	33	0.0	3/2⁻	E2		I_{γ}: adopted value.
214.3	13/2⁺	106.8		107.5	9/2⁺	E2		

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Coulomb excitation (continued)

$\gamma(^{155}Gd)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[@]	E_f	J_f^π	Mult.[&]	δ[a]	Comments
230.0	$11/2^+$	112.1	50 *15*	117.9	$7/2^+$	E2		
		122.5	100	107.5	$9/2^+$			
251.6	$9/2^-$	105.6	93	146.0	$7/2^-$	M1+E2	−0.22 *5*	I_γ: adopted value. Mult.,δ: from 1992Ku15.
		133.7	7.6 *4*	117.9	$7/2^+$	[E1]		
		191.7	100	59.9	$5/2^-$	E2		
321.5	$5/2^-$	261.5[‡]		59.9	$5/2^-$			
		321.5[‡]		0.0	$3/2^-$			
392.3	$11/2^-$	140.7	46 *2*	251.6	$9/2^-$	M1+E2	−0.283 *19*	E_γ: 1992Ku15 report Eγ=140.0 *1*. Mult.,δ: mult from 1992Ku15 and 1998St28 with δ weighted average of −0.32 *5* from (n,γ) dataset(1992Ku15) and −0.276 *21* (1998St28).
		246.3	100	146.0	$7/2^-$	E2		E_γ: 1992Ku15 report Eγ=245.5 *1*.
		284.8	13 *1*	107.5	$9/2^+$	E1(+M2)	−0.007 *13*	Mult.,δ: δ from $\gamma\gamma(\theta)$ (1998St28). Mult established from necessity for a parity change in the transition.
422.5?		362.5[‡b]		59.9	$5/2^-$			From γ branching considerations, it is tempting to associate this γ with the 364.0γ known to deexcite the 450.5 level. The energy fit implied by this placement does not seem to be particularly good, but, since the 422 level is not likely to be appreciably populated in Coul. ex., there does not appear to be any other place among the Coulomb-excited levels for this γ.
423.9	$17/2^+$	209.6		214.3	$13/2^+$			
450.5	$3/2^-$	305.0[‡]		146.0	$7/2^-$			
		390.5[‡]		59.9	$5/2^-$			Partial B(E2)↑=0.0055 *20* (1969Tv01).
		450.5[‡]		0.0	$3/2^-$			Partial B(E2)↑=0.0075 *45* (1969Tv01).
453.8	$15/2^+$	223.8	100	230.0	$11/2^+$			
		239.5	40 *6*	214.3	$13/2^+$			
487.0		235.0[‡b]		251.6	$9/2^-$			
		487.0[‡b]		0.0	$3/2^-$			
534.2	$13/2^-$	141.9	22 *1*	392.3	$11/2^-$	M1+E2	−0.20 *3*	δ: weighted average of −0.14 *4* (1992Ku15) and −0.217 *22* (1998St28).
		282.6 *1*	100	251.6	$9/2^-$	E2		
		304.2	6.6 *4*	230.0	$11/2^+$	E1(+M2)	−0.001 *29*	Mult.,δ: δ from $\gamma\gamma(\theta)$ (1998St28). Mult established from necessity for a parity change in the transition.
558.0	$1/2^-$	497.0[‡b]		59.9	$5/2^-$			
		558.0[‡]		0.0	$3/2^-$			Partial B(E2)↑=0.014 *6* (1969Tv01).
591.5	$3/2^-$	531.5[‡]		59.9	$5/2^-$			Partial B(E2)↑=0.0055 *35* (1969Tv01).
		591.5[‡b]		0.0	$3/2^-$			
614.0	$3/2^-$	554.0[‡]		59.9	$5/2^-$			Partial B(E2)↑=0.010 *4* (1969Tv01).
		614.0[‡]		0.0	$3/2^-$			Partial B(E2)↑=0.011 *5* (1969Tv01).
647.3	$5/2^-$	587.0[‡b]		59.9	$5/2^-$			
		647.3[‡]		0.0	$3/2^-$			Partial B(E2)↑=0.0045 *25* (1969Tv01).
657.5	$5/2^-$	597.5[‡b]		59.9	$5/2^-$			
721.0		721.0[‡b]		0.0	$3/2^-$			
729.6	$15/2^-$	195.4	19 *1*	534.2	$13/2^-$	M1+E2	−0.26 *13*	δ: simple average of −0.13 *5* (1992Ku15) and

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Coulomb excitation (continued)

$\gamma(^{155}Gd)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[@]	E_f	J_f^π	Mult.[&]	δ[a]	Comments
								-0.39 *5* (1998St28). Uncertainty chosen to overlap the two values.
729.6	$15/2^-$	337.3	100	392.3	$11/2^-$	E2		
		515.3	6.7 *6*	214.3	$13/2^+$	[E1]		
737.2	$21/2^+$	313.3		423.9	$17/2^+$			
787.3	$19/2^+$	333.5		453.8	$15/2^+$			
		363.4		423.9	$17/2^+$			
897.0	$17/2^-$	167.4	9 *1*	729.6	$15/2^-$	M1+E2	−0.15 *4*	E_γ: 1992Ku15 report Eγ=166.6 *1*. δ: from 1992Ku15.
		362.8	100	534.2	$13/2^-$	E2		E_γ: 1992Ku15 report Eγ=361.5 *1*.
		443.2	0.9 *2*	453.8	$15/2^+$	[E1]		
1028.0	$(7/2^-)$	882.0[‡b]		146.0	$7/2^-$			
		968.0[‡]		59.9	$5/2^-$			
		1028.2[‡]		0.0	$3/2^-$			
1142.4	$19/2^-$	245.4	18 *12*	897.0	$17/2^-$	M1+E2	−0.20 *4*	E_γ: 1992Ku15 report Eγ=244.4 *1*. I_γ,δ: from 1992Ku15.
		412.8	100 *42*	729.6	$15/2^-$	E2		E_γ: 1992Ku15 report Eγ=411.0 *1*. I_γ: from 1992Ku15.
1326.7	$21/2^-$	184.3	6 *2*	1142.4	$19/2^-$	[M1+E2]		
		429.7	100	897.0	$17/2^-$	E2		E_γ: 1992Ku15 report Eγ 427.7 *1*.
		539.4	8 *2*	787.3	$19/2^+$	[E1]		
1615.1	$23/2^-$	473.3		1142.4	$19/2^-$			
1809	$25/2^-$	483 *2*		1326.7	$21/2^-$			
2134	$27/2^-$	519[#]		1615.1	$23/2^-$			
2330	$29/2^-$	521[#]		1809	$25/2^-$			
2699	$(31/2^-)$	565[#]		2134	$27/2^-$			

[†] From 1998St28, except where noted otherwise.
[‡] From 1969Tv01.
[#] From 1997KiZS.
[@] Relative γ branching from each level (1998St28), unless noted otherwise.
[&] From the adopted values, unless noted otherwise.
[a] From $\gamma(\theta)$ data of 1992Ku15 and particle-γ angular-correlation data of 1998St28, unless noted otherwise. From RUL, the D+Q and Q multipolarities must be M1+E2 and E2 rather than E1+M2 and M2, respectively.
[b] Placement of transition in the level scheme is uncertain.

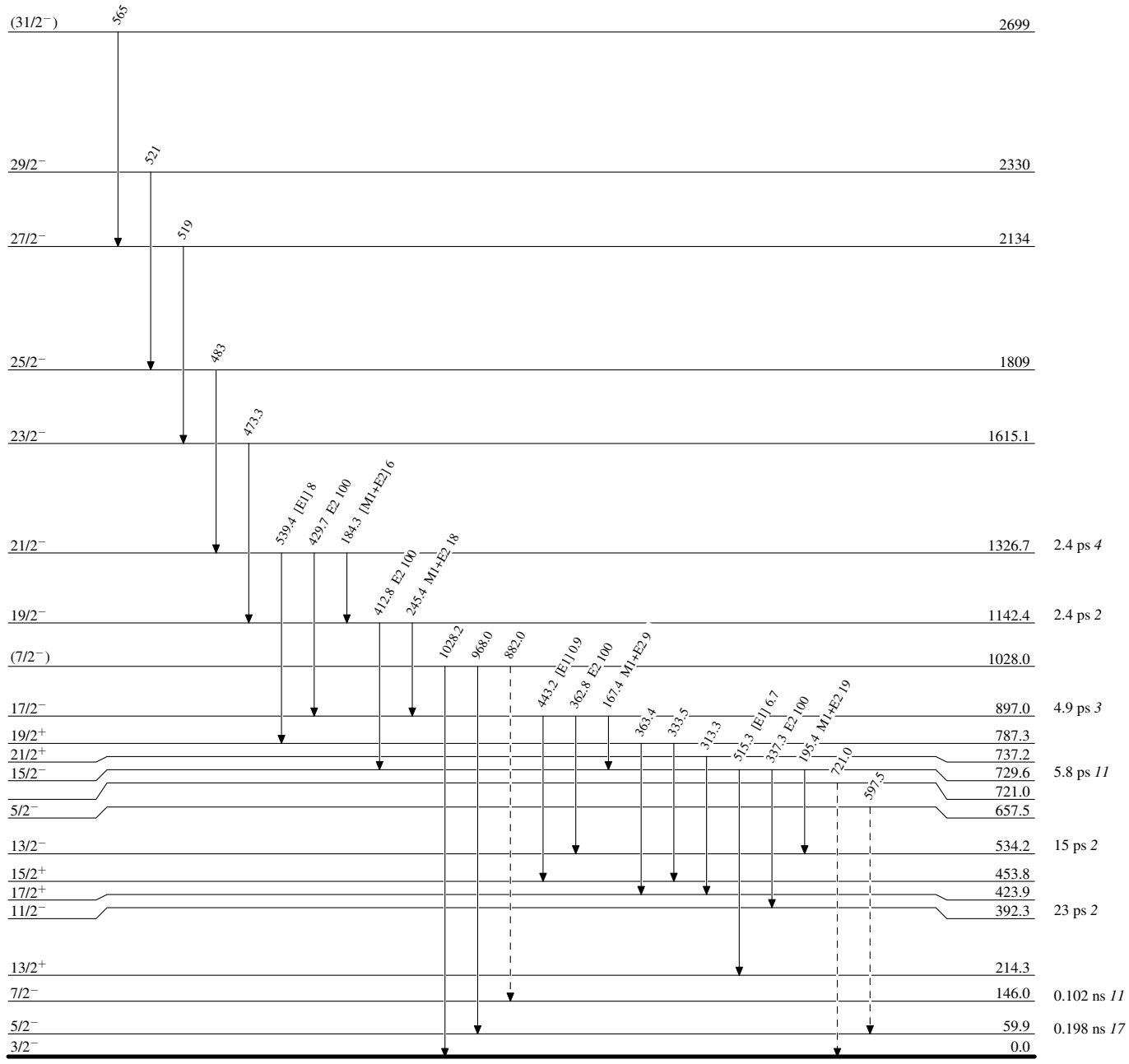
Coulomb excitation

Legend

Level Scheme

Intensities: Relative photon branching from each level

– – – – – – ► γ Decay (Uncertain)



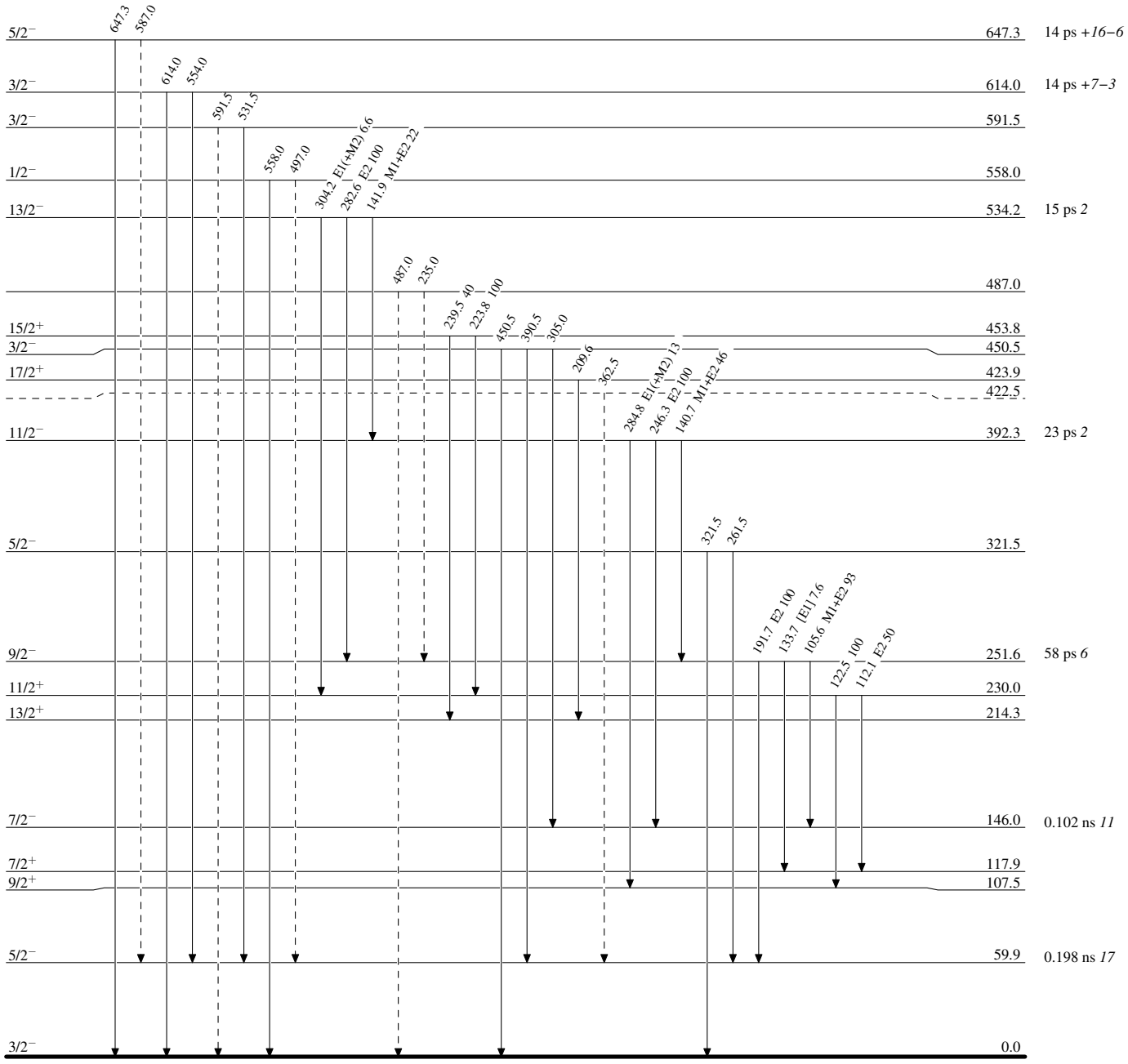
$^{155}_{64}Gd_{91}$

Coulomb excitation Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

- - - - - - ► γ Decay (Uncertain)

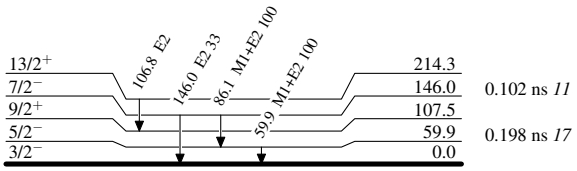


$^{155}_{64}Gd_{91}$

Coulomb excitation

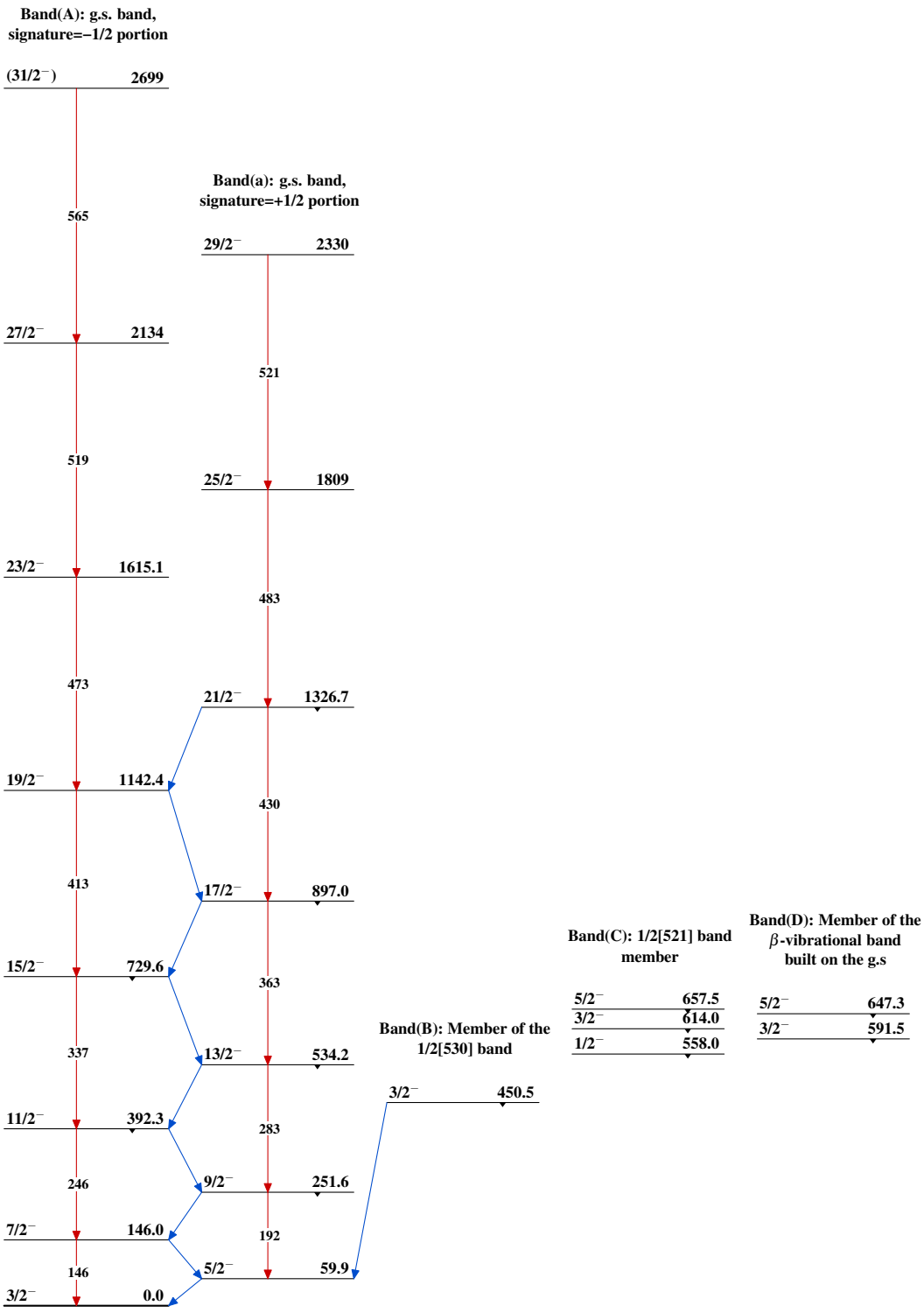
Level Scheme (continued)

Intensities: Relative photon branching from each level



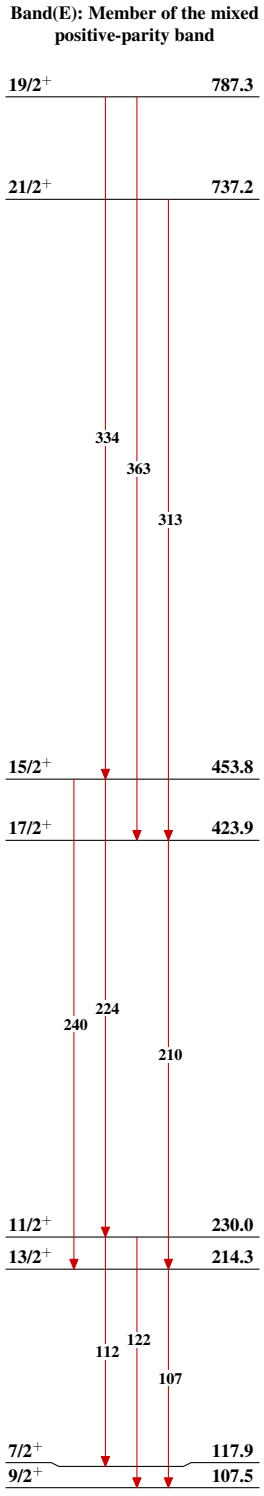
$^{155}_{64}Gd_{91}$

Coulomb excitation



$^{155}_{64}Gd_{91}$

Coulomb excitation (continued)



$^{155}_{64}Gd_{91}$