^{18}O(^{18}O,p2nγ) 2018Lu08,2009Ch43

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 199,1 (2025)	30-Sep-2024

Adapted from a dataset in the XUNDL database compiled from 2018Lu08 by E.A. McCutchan (NNDC, BNL), April 23, 2018.
Also includes ^{24}Mg(^{18}O,Xγ) by 2007LiZN.

2018Lu08: E=24 MeV ^{18}O beam was provided by the ATLAS accelerator at Argonne National Laboratory. The target was 0.26 mg/cm^2 of ^{18}O (97% enrichment) on a 12.7 μm Ta backing. γ rays were detected with the Gammasphere array consisting of 101 Compton-suppressed HPGe detectors and charged particles were detected with the nearly 4π Microball detector consisting of 95 CsI(Tl) scintillators. Measured Eγ, Iγ, $\gamma\gamma$-coin, proton-γ-coin, $\gamma(\theta)$. Comparison to p-sd-pf shell model calculations using the PSDPF interaction.

2009Ch43: E=34 MeV ^{18}O beam was produced from the 14UD BARC-TIFR Pelletron facility. Target was 1.6 mg/cm^2 ^{18}O in the form of Ta_2O_5 prepared by heating a 50 mg/cm^2 Ta foil in an atmosphere of enriched oxygen. γ rays were detected with an array of seven Compton-suppressed Clover Ge detectors placed at 30°, 60°, 90°, 120° and 150° relative to the beam direction. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$(DCO), $\gamma\gamma(\theta$,lin pol). Deduced levels, J, π, γ-ray multipolarities. Comparisons with truncated (1p-1h) shell-model calculations in the *sdpf* orbital space.

2007LiZN: E=70 MeV ^{18}O beam was from the tandem accelerator of Japan Atomic Energy Agency. Target was 1 mg/cm^2 foil of enriched ^{24}Mg. γ rays were detected with the GEMINI-II array of 14 HPGe detectors at 47°, 72°, 90°, 105° and 144° with respect to the beam direction, and charged particles were detected with a silicon detector array of 20 ΔE detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin. Report 10 transitions belonging to ^{33}P but not placed in a level scheme.

^{33}P Levels

3990 and 7966 levels proposed in 2009Ch43 have been omitted by the evaluators because of revised placements of the depopulating transitions 2142γ and 1028γ, respectively, in later studies by 2016Fu09 and 2018Lu08.

Questionable levels in this dataset are not adopted in Adopted Levels by the evaluators.

E(level)[†]	J$^\pi$[‡]	Comments
0.0	1/2$^+$	
1431.85 *31*	3/2$^+$	
1847.93 *31*	5/2$^+$	
2538.5 *7*		
3490.9 *5*	5/2$^+$	
3628.3 *6*	7/2$^+$	
4048.3 *15*	5/2$^+$	
4227.0 *5*	7/2$^-$	
4856.6 *25*	(3/2,5/2)	J$^\pi$: from level scheme in Fig. 2 of 2018Lu08.
5054.3 *14*	5/2$^+$	
5190.4 *14*	(3/2$^+$,5/2)	J$^\pi$: from level scheme in Fig. 2 of 2018Lu08.
5206.6? *9*		
5220.7? *9*		
5234.8? *9*		
5406.7 *25*	(7/2)	J$^\pi$: $\gamma(\theta)$ for 3559 depopulating transition is consistent with ΔJ=1 or 0, but not ΔJ=2. Tendency of fusion-evaporation reactions to populate higher-lying high-spin states suggests J=7/2 (2018Lu08).
5415.6 *27*		
5453.6 *5*	9/2$^-$	
5503.6 *15*		
5639.5 *7*	11/2$^-$	
5729.0 *25*	(7/2)[#]	
5809.9 *27*		
5926.0 *26*	(7/2)[#]	
5991.8 *30*		
6325.4 *30*		
6424.2 *24*		

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$^{18}O(^{18}O,p2n\gamma)$ 2018Lu08,2009Ch43 (continued)

^{33}P Levels (continued)

E(level)[†]	J$^\pi$[‡]	Comments
6502.3 *29*		
6555.9 *25*		
6625.2 *29*		
6809.9 *12*	(9/2)[#]	
6937.5 *11*	(13/2)	J$^\pi$: 1298$\gamma(\theta)$ in 2018Lu08 is consistent with ΔJ=1 and excludes ΔJ=2. Tendency of fusion-evaporation reactions to populate higher-lying high-spin states suggests J=13/2 (2018Lu08), but DCO ratio of 1298γ-1028γ from 2009Ch43 supports ΔJ=2, giving J=15/2. Note that ΔJ=1 is also supported by $\gamma\gamma(\theta)$ in (^{12}C,αpnγ) (2016Fu09). $T_{1/2}$: expected to be in ps region as 1298γ shows a full Doppler shift (2009Ch43).
6951.0? *12*		
6988.2 *15*		
7998.8 *21*		
8086.7 *17*	(13/2)[#]	
9079.2 *13*	(15/2)	J$^\pi$: from level scheme in Fig. 2 of 2018Lu08.
10107.4 *15*	(17/2)	J$^\pi$: from level scheme in Fig. 2 of 2018Lu08.

[†] From a least-squares fit to γ-ray energies.
[‡] As proposed in 2009Ch43 based on their $\gamma\gamma(\theta)$(DCO) and $\gamma\gamma$(lin pol) data, unless otherwise noted.
[#] Proposed in 2018Lu08 based on theoretical predictions and γ-decay patterns.

$\gamma(^{33}P)$

DCO ratio corresponds to angles of 90° and 30° (or 150°). Expected ratios are ≈1 for ΔJ=2, quadrupole and ≈0.5 for ΔJ=1, dipole, when gated by ΔJ=2, quadrupole transition. Ratios are ≈2 for ΔJ=2, quadrupole and ≈1 for ΔJ=1, dipole, when gated on ΔJ=1, dipole transition (2009Ch43). Several DCO values are from e-mail reply received from the first author of 2009Ch43 on Sept 14, 2009.

For $\gamma\gamma$(lin pol) data under comments, a positive value indicates an electric nature and a negative value indicates a magnetic nature (2009Ch43).

E$_i$(level)	J$_i^\pi$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$_f^\pi$	Mult.[‡]	Comments
1431.85	3/2$^+$	1431.8 *4*	100	0.0	1/2$^+$	(M1+E2)	E$_\gamma$: other: 1432.1 *10* (2009Ch43). Iγ(rel)=64.2 *1* (2018Lu08, uncertainty adjusted to 1.3 by evaluators), >19 (2009Ch43). DCO=0.89 *15* gate on 736γ, ΔJ=1, POL=−0.022 *20* gate on 416γ.
1847.93	5/2$^+$	416.1 *4*	10.0 *30*	1431.85	3/2$^+$	M1+E2	E$_\gamma$: weighted average of 416.4 *10* (2009Ch43) and 416.0 *4* (2018Lu08). Other: 414 (2007LiZN). I$_\gamma$: unweighted average of 6.95 *22* (2009Ch43) and 13.0 *3* (2018Lu08). Iγ(rel)=13.0 *1* (2018Lu08, uncertainty adjusted to 0.3 by evaluators), 6.95 *22* (2009Ch43). DCO=0.87 *14* gate on 2379γ, ΔJ=1, POL=−0.188 *29* gate on 1432γ.
		1847.8 *4*	100.0 *20*	0.0	1/2$^+$	E2+M3	Others: Eγ=1848.1 *10*, Iγ=100.0 *30* (2009Ch43); 1848 (2007LiZN). Iγ(rel)=100.0 *1* (2018Lu08, uncertainty adjusted to 2.0 by evaluators), 100 *3* (2009Ch43). 2379γ-1848$\gamma(\theta)$ from 4227 level gives DCO=1.76 *34* and POL=+0.050 *20* for 1848γ, DCO=0.48 *10* and POL=+0.017 *15* for 2379γ, which is consistent with ΔJ=2, stretched Q for 1848γ and ΔJ=1, stretched D for 2379γ.

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$^{18}O(^{18}O,p2n\gamma)$ 2018Lu08,2009Ch43 (continued)

$\gamma(^{33}P)$ (continued)

E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult. ‡	Comments
2538.5		690.4 *10*	31 *4*	1847.93	$5/2^+$		Iγ(rel)=1.6 *2* (2018Lu08).
		1106.4 *15*	40.4 *21*	1431.85	$3/2^+$		Iγ(rel)=2.1 *1* (2018Lu08, uncertainty adjusted to 0.11 by evaluators).
		2539.2 *20*	100 *4*	0.0	$1/2^+$		Iγ(rel)=5.2 *1* (2018Lu08, uncertainty adjusted to 0.2 by evaluators).
3490.9	$5/2^+$	1643.0 *10*	100 *4*	1847.93	$5/2^+$	D	E_γ: weighted average of 1642.7 *10* (2009Ch43) and 1643.2 *10* (2018Lu08). Other: 1643 (2007LiZN). I_γ: from 2009Ch43. Other: 100 *13* (2018Lu08). Iγ(rel)=2.3 *3* (2018Lu08), 6.93 *25* (2009Ch43). Mult.: Q assignment in 2009Ch43 is considered by the evaluators as incorrect, recalling that DCO for ΔJ=2, Q will be the same as for ΔJ=0, dipole. DCO=2.0 *3* gate on 736γ, ΔJ=1.
		2058.8 *10*	64 *12*	1431.85	$3/2^+$	D	E_γ: from 2009Ch43. Other: 2058.7 *12* (2018Lu08). I_γ: unweighted average of 75.8 *28* (2009Ch43) and 52 *9* (2018Lu08). Iγ(rel)=1.2 *2* (2018Lu08), 5.25 *19* (2009Ch43). DCO=0.91 *15* gate on 736γ, ΔJ=1.
		3490.9 *10*	9.0 *4*	0.0	$1/2^+$		E_γ: weighted average of 3491.1 *10* (2009Ch43) and 3490.4 *14* (2018Lu08). I_γ: from 2009Ch43. Other: 13 *9* (2018Lu08). Iγ(rel)=0.3 *2* (2018Lu08), 0.62 *3* (2009Ch43).
3628.3	$7/2^+$	1780.3 *10*	57.7 *23*	1847.93	$5/2^+$	D	E_γ: weighted average of 1780.5 *10* (2009Ch43) and 1779.9 *13* (2018Lu08). I_γ: weighted average of 58.5 *23* (2009Ch43) and 54 *5* (2018Lu08). Iγ(rel)=7.3 *7* (2018Lu08), 3.86 *15* (2009Ch43). DCO=0.38 *7* gate on 1848γ, ΔJ=2.
		2196.5 *10*	100.0 *32*	1431.85	$3/2^+$	Q	E_γ,I_γ: from 2009Ch43. Other: Eγ=2196.3 *15*, Iγ=100 *4* (2018Lu08). Iγ(rel)=13.5 *4* (2018Lu08, uncertainty adjusted to 0.5 by evaluators), 6.60 *21* (2009Ch43). DCO=1.9 *3* gate on 186γ, ΔJ=1.
4048.3	$5/2^+$	1509.9 *19*	5.6 *14*	2538.5			Iγ(rel)=0.4 *1* (2018Lu08).
		2616.2 *21*	100.0 *28*	1431.85	$3/2^+$		Iγ(rel)=7.1 *1* (2018Lu08, uncertainty adjusted to 0.2 by evaluators).
4227.0	$7/2^-$	736.0 *5*	8.58 *34*	3490.9	$5/2^+$	D	E_γ: weighted average of 736.2 *10* (2009Ch43) and 735.9 *5* (2018Lu08). I_γ: weighted average of 8.42 *28* (2009Ch43) and 9.3 *6* (2018Lu08). Iγ(rel)=4.4 *3* (2018Lu08), 8.25 *27* (2009Ch43). DCO=0.73 *12* gate on 1848γ, ΔJ=2.
		2378.7 *9*	100.0 *21*	1847.93	$5/2^+$	(E1)	E_γ: weighted average of 2378.8 *10* (2009Ch43) and 2378.6 *9* (2018Lu08). I_γ: from 2018Lu08. Other: 100.0 *31* (2009Ch43). Iγ(rel)=47.3 *4* (2018Lu08, uncertainty adjusted to 1.0 by evaluators), 98 *3* (2009Ch43). ΔJ=1 from DCO=0.48 *10* gate on 1848γ, POL=+0.017 *15* gate on 1848γ. See comments for 1848γ from 1848 level.
		2794.6 *13*	0.85 *21*	1431.85	$3/2^+$		Iγ(rel)=0.4 *1* (2018Lu08).
		4227.0 *15*	0.42 *21*	0.0	$1/2^+$	[E3]	Iγ(rel)=0.2 *1* (2018Lu08).
4856.6	(3/2,5/2)	3008.5 *25*	100	1847.93	$5/2^+$		Iγ(rel)=2.4 *3* (2018Lu08).
5054.3	$5/2^+$	2514.7 *20*	12 *4*	2538.5			Iγ(rel)=0.3 *1* (2018Lu08).
		3206.5 *25*	100 *8*	1847.93	$5/2^+$		Iγ(rel)=2.5 *2* (2018Lu08).
		3623.8 *26*	52 *8*	1431.85	$3/2^+$		Iγ(rel)=1.3 *2* (2018Lu08).

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$^{18}O(^{18}O,p2n\gamma)$ 2018Lu08,2009Ch43 (continued)

$\gamma(^{33}P)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	Comments
5190.4	(3/2$^+$,5/2)	2652.8 *20*	21 *7*	2538.5			Iγ(rel)=0.3 *1* (2018Lu08).
		3340.9 *28*	57 *22*	1847.93	5/2$^+$		Iγ(rel)=0.8 *3* (2018Lu08).
		3757.8 *25*	100 *22*	1431.85	3/2$^+$		Iγ(rel)=1.4 *3* (2018Lu08).
5206.6?		979.5[@&] *10*		4227.0	7/2$^-$		
5220.7?		993.7[@&] *10*		4227.0	7/2$^-$		
5234.8?		1008.0[@&] *10*		4227.0	7/2$^-$		
5406.7	(7/2)	3558.6 *25*	100	1847.93	5/2$^+$		Iγ(rel)=4.1 *5* (2018Lu08). Mult.: ΔJ=1 or 0 from $\gamma(\theta)$ (2018Lu08).
5415.6		2877.0 *26*	100	2538.5			Iγ(rel)=0.4 *1* (2018Lu08).
5453.6	9/2$^-$	219[@&]		5234.8?			
		233[@&]		5220.7?			
		247.0[@&] *10*		5206.6?			
		1226.5 *6*	100.0 *22*	4227.0	7/2$^-$		Eγ: weighted average of 1226.8 *10* (2009Ch43) and 1226.4 *6* (2018Lu08). Other: 1226 (2007LiZN). Iγ: other: 100.0 *32* (2009Ch43). Iγ(rel)=27.5 *3* (2018Lu08, uncertainty adjusted to 0.6 by evaluators), 50.2 *16* (2009Ch43).
		1825.3 *8*	9.10 *30*	3628.3	7/2$^+$	D	Eγ: weighted average of 1825.1 *10* (2009Ch43) and 1825.4 *8* (2018Lu08). Iγ: weighted average of 9.32 *30* (2009Ch43) and 8.7 *4* (2018Lu08). Iγ(rel)=2.4 *1* (2018Lu08), 4.68 *15* (2009Ch43). DCO=0.49 *9* gate on 1848γ, ΔJ=2.
		3605.8 *10*	1.5 *4*	1847.93	5/2$^+$		Eγ: weighted average of 3606.0 *10* (2009Ch43) and 3605.1 *16* (2018Lu08). Iγ(rel)=0.4 *1* (2018Lu08).
		4021.6 *17*	0.7 *4*	1431.85	3/2$^+$	[E3]	Iγ(rel)=0.2 *1* (2018Lu08).
5503.6		1276.7 *18*	77 *15*	4227.0	7/2$^-$		Iγ(rel)=1.0 *2* (2018Lu08).
		3655.3 *25*	100 *23*	1847.93	5/2$^+$		Iγ(rel)=1.3 *3* (2018Lu08).
5639.5	11/2$^-$	186.0 *8*	73 *4*	5453.6	9/2$^-$	D	Eγ: weighted average of 186.2 *10* (2009Ch43) and 185.9 *8* (2018Lu08). Other: 185 (2007LiZN). Iγ: unweighted average of 69.5 *25* (2009Ch43) and 76.8 *19* (2018Lu08). Iγ(rel)=15.9 *2* (2018Lu08, uncertainty adjusted to 0.4 by evaluators), 33.2 *12* (2009Ch43). DCO=0.67 *15* gate on 1848γ, ΔJ=2.
		1412.3 *7*	100.0 *24*	4227.0	7/2$^-$	E2+M3	Eγ: weighted average of 1412.6 *10* (2009Ch43) and 1412.2 *7* (2018Lu08). Other: 1411 (2007LiZN). Iγ: other: 100.0 *34* (2009Ch43). Iγ(rel)=20.7 *3* (2018Lu08, uncertainty adjusted to 0.5 by evaluators), 47.8 *16* (2009Ch43). DCO=0.94 *15* gate on 1848γ, ΔJ=2, POL=+0.048 *10* gate on 1848γ.
5729.0	(7/2)	3880.8 *25*	100	1847.93	5/2$^+$		Iγ(rel)=1.4 *3* (2018Lu08).
5809.9		3271.3 *26*	100	2538.5			Iγ(rel)=0.10 *5* (2018Lu08).
5926.0	(7/2)	4077.8 *26*	100	1847.93	5/2$^+$		Iγ(rel)=3.0 *2* (2018Lu08).
5991.8		4143.6 *30*	100	1847.93	5/2$^+$		Iγ(rel)=0.7 *3* (2018Lu08).
6325.4		4477.1 *30*	100	1847.93	5/2$^+$		Iγ(rel)=0.8 *3* (2018Lu08).
6424.2		2795.8 *23*	100	3628.3	7/2$^+$		Iγ(rel)=2.3 *5* (2018Lu08).
6502.3		3963.6 *28*	100	2538.5			Iγ(rel)=0.10 *5* (2018Lu08).
6555.9		2927.4 *24*	100	3628.3	7/2$^+$		Iγ(rel)=1.2 *3* (2018Lu08).

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^{18}O(^{18}O,p2nγ) 2018Lu08,2009Ch43 (continued)

γ(^{33}P) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	Comments
6625.2		4086.5 *28*	100	2538.5			Iγ(rel)=0.2 *2* (2018Lu08).
6809.9	(9/2)	1170 *1*	100 *40*	5639.5	11/2$^-$		Eγ: from 2009Ch43, unplaced by authors. Placement from 2018Lu08 with Eγ=1170.9 *24*. Iγ(rel)=1.0 *4* (2018Lu08).
		2586.2 *30*	80 *30*	4227.0	7/2$^-$		Iγ(rel)=0.8 *3* (2018Lu08).
6937.5	(13/2)	1298.1 *10*	100	5639.5	11/2$^-$	D	Eγ: from 2009Ch43. Other: 1297.6 *18* (2018Lu08), 1297 (2007LiZN). Mult.: 1298γ(θ) in 2018Lu08 is consistent with ΔJ=1 and excludes ΔJ=2; ΔJ=1 is also supported by $\gamma\gamma$(θ) in (^{12}C,αpnγ) (2016Fu09). But DCO ratio of 1298γ-1028γ from 2009Ch43 supports ΔJ=2. Iγ(rel)=4.6 *2* (2018Lu08), 5.45 *19* (2009Ch43). DCO=2.1 *4* gate on 1028γ, ΔJ=1.
6951.0?		1311.5[@&] *10*		5639.5	11/2$^-$		
6988.2		2760.8 *19*	100	4227.0	7/2$^-$		Iγ(rel)=0.4 *2* (2018Lu08).
7998.8		2359.2 *20*	100	5639.5	11/2$^-$		Iγ(rel)=0.4 *2* (2018Lu08).
8086.7	(13/2)	2448.0 *22*	100 *30*	5639.5	11/2$^-$		Iγ(rel)=1.0 *3* (2018Lu08).
		2632.0 *24*	60 *30*	5453.6	9/2$^-$		Iγ(rel)=0.6 *3* (2018Lu08).
9079.2	(15/2)	2090.7 *15*	50 *25*	6988.2			Iγ(rel)=0.10 *5* (2018Lu08).
		2141.6 *10*	100 *50*	6937.5	(13/2)		Eγ: from 2009Ch43, but placed from a 3990 level; placement from 2018Lu08 with Eγ=2142.0 *17*. The same placement is also made in (^{12}C,αpnγ) (2016Fu09). Other: 2141 (2007LiZN). Iγ(rel)=0.2 *1* (2018Lu08), 1.45 *7* (2009Ch43).
10107.4	(17/2)	1028.0 *10*	100 *43*	9079.2	(15/2)	D	Eγ: weighted average of 1028.3 *10* (2009Ch43) and 1027.6 *13* (2018Lu08). It is placed by 2009Ch43 from a 7966 level, not seen in other studies; the placement is from 2018Lu08 and also 2016Fu09 in (^{12}C,αpnγ). Other: 1026 (2007LiZN). Iγ(rel)=0.7 *3* (2018Lu08), 2.18 *8* (2009Ch43). DCO=0.65 *12* gate on 1848γ, ΔJ=2.
		3170.3 *19*	29 *14*	6937.5	(13/2)		Iγ(rel)=0.2 *1* (2018Lu08).

[†] From 2018Lu08, unless otherwise noted. Quoted intensities are branching ratios relative to the strongest Iγ=100 from each level, converted from original relative Iγ values given under comments. Uncertainties of some relative Iγ values from 2018Lu08 are unrealistically small and most likely include only statistical uncertainties, e.g., Iγ(1848γ)=100.0 *1*. In the averaging process, the evaluators have added, in quadrature, a 2% systematic uncertainty typical for in-beam gamma spectroscopy measurements with the Gammasphere, as consulted with the Gammasphere expert Dirk Weisshaar at FRIB.

[‡] As proposed by 2009Ch43 based on $\gamma\gamma$(θ)(DCO) and $\gamma\gamma$(lin pol) data, but polarization coefficients were not listed in the paper for all the γ rays where multipolarities have been assigned. The evaluators have replaced M1 and E1 with D and E2 with Q where there is no supporting data from 2009Ch43 for M or E nature of a transition.

[#] Unplaced γ from 2009Ch43; not reported in 2018Lu08.

[@] Weak γ ray seen in 2009Ch43; not seen in 2018Lu08; thus considered as uncertain by the evaluators.

[&] Placement of transition in the level scheme is uncertain.

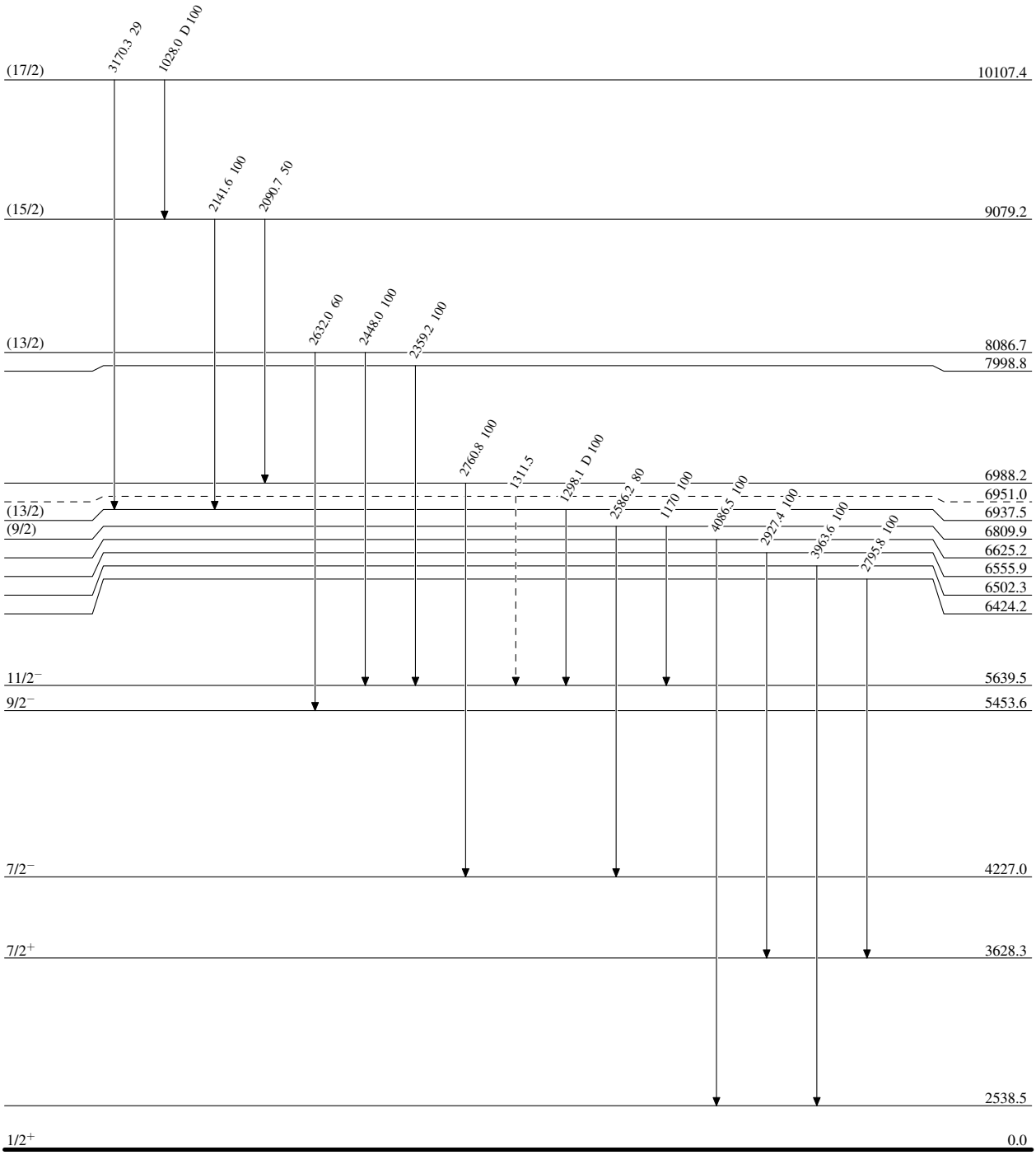
[x] γ ray not placed in level scheme.

^{18}O(^{18}O,p2nγ) 2018Lu08,2009Ch43 Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



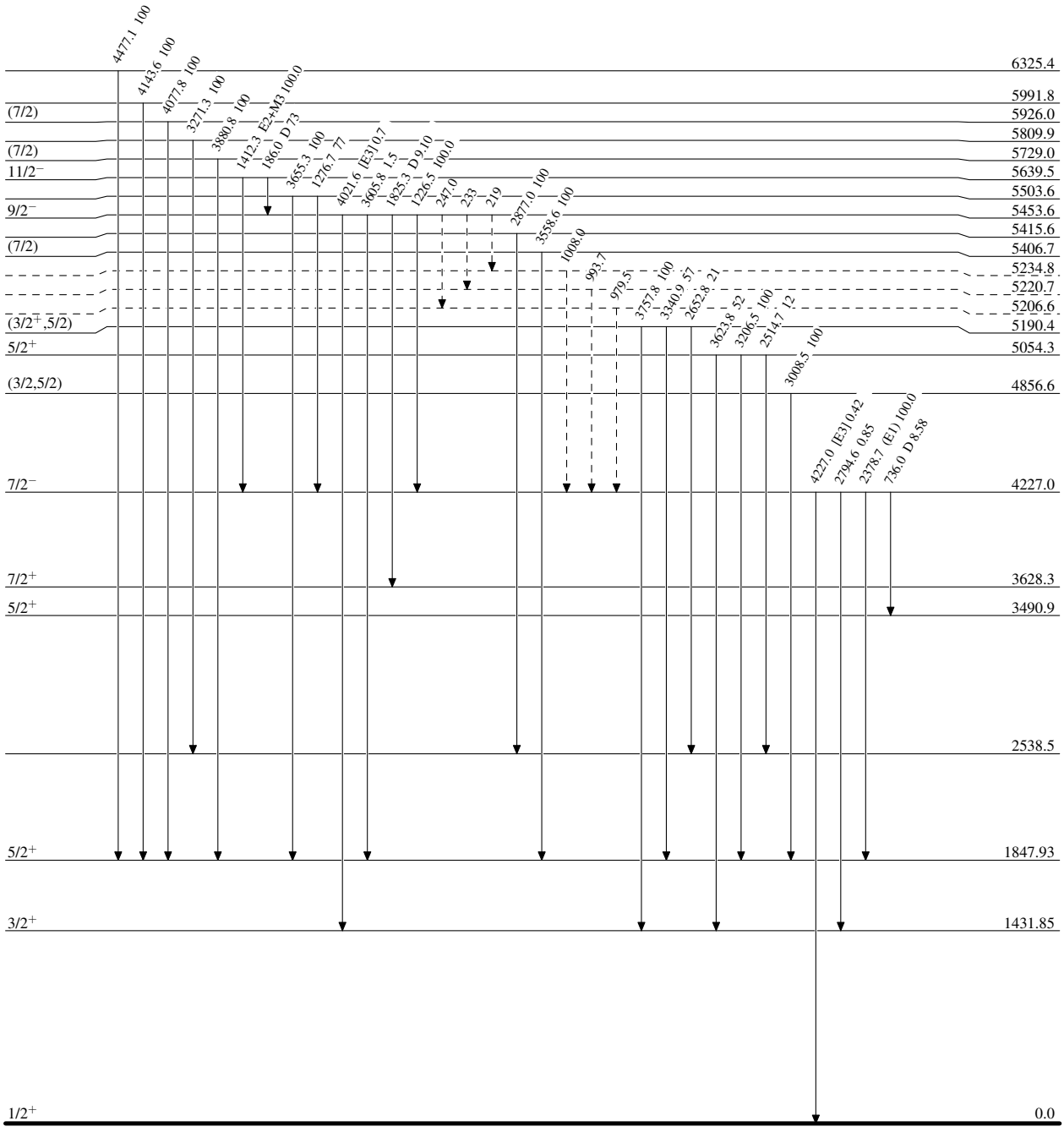
$^{33}_{15}P_{18}$

$^{18}O(^{18}O,p2n\gamma)$ 2018Lu08,2009Ch43 Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

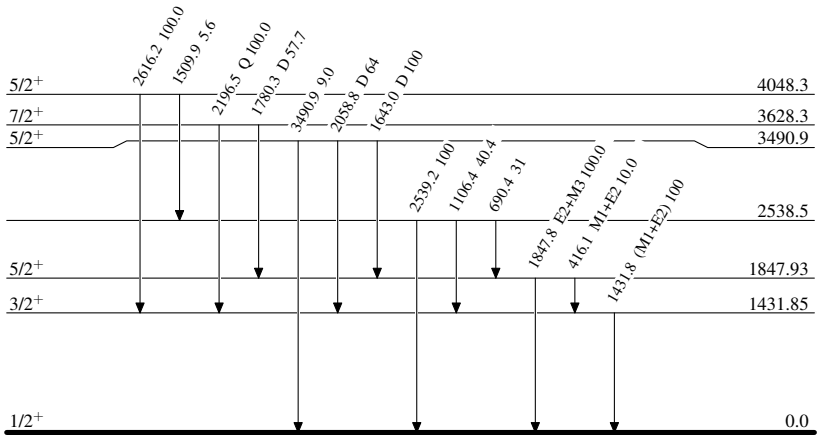


$^{33}_{15}P_{18}$

^{18}O(^{18}O,p2nγ) 2018Lu08,2009Ch43

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{33}_{15}P_{18}$