^{208}Pb(^{14}C,3nγ) E=68 MeV 2017He15

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh et al. ,	NDS 175, 1 (2021)	19-May-2021

Adapted from compiled dataset in the XUNDL database by C.D. Nesaraja, Sept 28, 2017.

2017He15: E(^{14}C)=68 MeV beam from the FN Tandem accelerator at the Florida State University. Target was 50 mg/cm^2 thick enriched ^{208}Pb. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$(DCO) using array of seven Compton suppressed seven HPGe detectors and three clover HPGe detectors.

2000Ri12 (from the same group and lab as 2017He15): E(^{14}C)=68 MeV. Measured $\gamma\gamma$- and γ(ce)-coin using an array of eight Compton-suppressed HPGe detectors for γ rays, and a mini-orange magnetic spectrometer for conversion electrons. Deduced conversion coefficients and multipolarities.

^{219}Ra Levels

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	Comments
0.0	7/2$^+$		
16.6[#] 3	11/2$^+$	10 ms 3	%$\alpha\approx$100 (2018Sa45); %IT=? T$_{1/2}$: isomer half-life from 2018Sa45.
113.8[&] 2	9/2$^+$		
251.2[#] 5	15/2$^+$		
475.4[&] 6	13/2$^+$		
512.4[@] 7	17/2$^-$		
546.0[#] 7	19/2$^+$		
554.5[b] 6	13/2$^+$		
604.3[a] 7	15/2$^-$		
751.0[@] 7	21/2$^-$		
778.7[c] 8	15/2$^-$		
853.7[&] 7	17/2$^+$		
875.8[b] 7	17/2$^+$		
893.2[#] 7	23/2$^+$		
937.8[a] 7	19/2$^-$		
1053.3[@] 8	25/2$^-$		
1130.0[c] 8	19/2$^-$		
1244.4[&] 8	21/2$^+$		
1256.5[b] 8	21/2$^+$		
1288.0[#] 8	27/2$^+$		
1324.8[a] 8	23/2$^-$		
1411.1[@] 8	29/2$^-$		
1503.2[c] 10	23/2$^-$		
1636.8[&] 9	25/2$^+$		
1669.9[b] 14	25/2$^+$		
1701.2[#] 9	31/2$^+$		
1737.4[a] 8	27/2$^-$		
1833.1[@] 9	33/2$^-$		
1931.4[c] 16	27/2$^-$		
2036.5[&] 9	29/2$^+$		
2128.8[#] 10	35/2$^+$		
2151.1[a] 9	31/2$^-$		
2289.3[@] 10	37/2$^-$		
2458.2[&] 10	33/2$^+$		

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^{208}Pb(^{14}C,3nγ) E=68 MeV 2017He15 (continued)

^{219}Ra Levels (continued)

E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡
2566.4[a] 9	35/2−	3001.1[a] 10	39/2−	3449.6[a] 11	43/2−	3912.1[a] 16	47/2−
2579.0[#] 10	39/2+	3043.2[#] 11	43/2+	3520.1[#] 12	47/2+	4021.7[#] 14	51/2+
2767.1[@] 10	41/2−	3271.2[@] 12	45/2−	3773.9[&] 12	45/2+	4321.9?[@] 15	53/2−
2886.3[&] 10	37/2+	3318.7[&] 11	41/2+	3790.7[@] 13	49/2−		

† From least-squares fit to Eγ data. Note that reduced χ^2 is nearly zero, implying that γ-ray energy uncertainties are probably overestimated.

‡ From 2017He15, except as noted. The assignments are shown as definite in authors′ Table 1, but in parenthesis in their Fig. 1. Another email reply to the XUNDL compiler from T.C. Hensley on Oct 6, 2017 mentioned that all the assignments were definite.

\# Band(A): Band based on 11/2+. Alternating-parity band.

@ Band(a): Band based on 17/2−. Alternating-parity band.

& Band(B): Band based on 9/2+. Alternating-parity band.

a Band(b): Band based on 15/2−. Alternating-parity band.

b Band(C): Band based on 13/2+. Alternating-parity band.

c Band(c): Band based on 15/2−. Alternating-parity band.

γ(^{219}Ra)

DCO for 145° and 90° gated by the 205γ. Expected ratios 0.99 for stretched dipoles, and 1.96 for stretched quadrupole transitions for gate on ΔJ=1, dipole 205γ. The numerical values were provided to the XUNDL compiler via an email reply by T.C. Hensley on Oct 2, 2017.

Eγ	Iγ	Ei(level)	J^π_i	Ef	J^π_f	Mult.†	δ	α‡	Comments
80.4 9	1.1 1	1324.8	23/2−	1244.4	21/2+				
84.1 6	14 1	937.8	19/2−	853.7	17/2+				
97.1 10	0.4 1	875.8	17/2+	778.7	15/2−				
97.2 2	>0.5	113.8	9/2+	16.6	11/2+	M1+E2	<1	7 4	α(L)exp=3.6 14 (2000Ri12) α(L)exp from gate at 362γ, and normalized to E2 for 334γ. Mult.,δ: from α(L)exp. Eγ: from 2000Ri12, uncertainty assigned by evaluators.
100.6 8	2.6 1	1737.4	27/2−	1636.8	25/2+				
108.2 9	1.0 1	2566.4	35/2−	2458.2	33/2+				
113.8 2		113.8	9/2+	0.0	7/2+	M1+E2	>0.5	8 3	α(L)exp=3.4 12 (2000Ri12) Eγ: from 2000Ri12, uncertainty assigned by evaluators. Mult.,δ: from α(L)exp. α(L)exp from gate at 362γ, and normalized to E2 for 334γ, corrected for M line of 97γ.
114.6 9	0.9 1	2151.1	31/2−	2036.5	29/2+				
114.8 10	0.6 1	3001.1	39/2−	2886.3	37/2+				
123.2 6	31 1	1411.1	29/2−	1288.0	27/2+	D			DCO=0.95 6
126.5 9	0.8 1	1256.5	21/2+	1130.0	19/2−				
128.9 7	6.4 4	604.3	15/2−	475.4	13/2+	E1		0.260	α(L)exp=0.057 49 (2000Ri12) Mult.: from α(L)exp. α(L)exp from gates at 362γ and 388γ, and normalized to E2 for 334γ, corrected for M line of 97γ.

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^{208}Pb(^{14}C,3nγ) E=68 MeV 2017He15 (continued)

γ(^{219}Ra) (continued)

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.†	α‡	Comments
131.0 *8*	2.5 *1*	3449.6	43/2⁻	3318.7	41/2⁺			
131.9 *6*	14 *1*	1833.1	33/2⁻	1701.2	31/2⁺	D		DCO=0.98 *5*
138.2 *10*	0.8 *1*	3912.1	47/2⁻	3773.9	45/2⁺			
142.1 *5*	45 *2*	893.2	23/2⁺	751.0	21/2⁻	E1	0.207	DCO=0.99 *5* α(L)exp<0.075 (2000Ri12) Mult.: from α(K)exp. α(K)exp from gate at 234γ, and normalized to E2 for 295γ.
160.2 *5*	61 *2*	1053.3	25/2⁻	893.2	23/2⁺	E1	0.1545	DCO=1.00 *6* α(L)exp<0.032 (2000Ri12) Mult.: from α(L)exp. α(L)exp from gate at 234γ, and normalized to E2 for 295γ.
160.4 *8*	2.3 *2*	2289.3	37/2⁻	2128.8	35/2⁺			
166.7 *10*	0.6 *1*	1669.9	25/2⁺	1503.2	23/2⁻			
188.1 *8*	2.7 *1*	2767.1	41/2⁻	2579.0	39/2⁺	D		DCO=0.98 *8*
205.1 *5*	88 *3*	751.0	21/2⁻	546.0	19/2⁺	E1	0.0849	α(K)exp=0.098 *21* (2000Ri12) Mult.: from α(K)exp. α(K)exp from gate at 359γ, and normalized to E2 for 295γ.
224.2 *10*	0.4 *1*	778.7	15/2⁻	554.5	13/2⁺			
227.9 *9*	1.3 *1*	3271.2	45/2⁻	3043.2	43/2⁺			
231.1 *8*	2.7 *1*	4021.7	51/2⁺	3790.7	49/2⁻			
234.6 *5*	100	251.2	15/2⁺	16.6	11/2⁺	E2	0.336	α(K)exp=0.124 *22* (2000Ri12); α(L)exp=0.153 *30* (2000Ri12) Mult.,δ: from α(K)exp and α(L)exp. α(K)exp and α(L)exp from gates at 359 and 396γ, and normalized to E2 for 295γ.
234.6 *5*	41 *1*	1288.0	27/2⁺	1053.3	25/2⁻			
238.6 *8*	5.6 *2*	751.0	21/2⁻	512.4	17/2⁻			
246.7 *9*	0.9 *1*	1503.2	23/2⁻	1256.5	21/2⁺			
249.0 *8*	2.2 *1*	3520.1	47/2⁺	3271.2	45/2⁻			
249.4 *8*	2.9 *2*	853.7	17/2⁺	604.3	15/2⁻			
254.2 *9*	0.9 *1*	1130.0	19/2⁻	875.8	17/2⁺			
261.2 *6*	29 *1*	512.4	17/2⁻	251.2	15/2⁺	E1	0.0482	α(K)exp<0.047 (2000Ri12) Mult.: from α(K)exp. α(K)exp from gate at 234γ, and normalized to E2 for 295γ.
261.5 *7*	1.6 *2*	1931.4	27/2⁻	1669.9	25/2⁺			
270.7 *9*	1.0 *1*	3790.7	49/2⁻	3520.1	47/2⁺			
276.2 *8*	2.5 *1*	3043.2	43/2⁺	2767.1	41/2⁻			
289.6 *7*	9.3 *4*	2579.0	39/2⁺	2289.3	37/2⁻			
290.1 *6*	34 *1*	1701.2	31/2⁺	1411.1	29/2⁻	E1	0.0379	DCO=1.06 *14* α(K)exp<0.051 (2000Ri12) Mult.: from α(K)exp. α(K)exp from gate at 295γ, and normalized to E2 for 235γ.
294.8 *5*	95 *3*	546.0	19/2⁺	251.2	15/2⁺			
295.7 *6*	18 *1*	2128.8	35/2⁺	1833.1	33/2⁻			
299.1 *8*	3.1 *2*	2036.5	29/2⁺	1737.4	27/2⁻			
300.2# *9*	1.6 *1*	4321.9?	53/2⁻	4021.7	51/2⁺			
302.3 *6*	12 *1*	1053.3	25/2⁻	751.0	21/2⁻	E2	0.1492	α(K)exp=0.068 *29* (2000Ri12) Mult.: from α(K)exp. δ(M3/E2)<0.08. α(K)exp from gate at 295γ, and normalized to E2 for 235γ.
306.6 *9*	1.2 *2*	1244.4	21/2⁺	937.8	19/2⁻			

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^{208}Pb(^{14}C,3nγ) E=68 MeV 2017He15 (continued)

γ(^{219}Ra) (continued)

E_γ	I_γ	E_i(level)	J^π_i	E_f	J^π_f	Mult.†	α‡	Comments
307.1 *8*	1.9 *2*	2458.2	33/2$^+$	2151.1	31/2$^-$			
311.9 *8*	2.1 *2*	1636.8	25/2$^+$	1324.8	23/2$^-$			
317.6 *9*	0.7 *1*	3318.7	41/2$^+$	3001.1	39/2$^-$			
319.9 *9*	1.5 *1*	2886.3	37/2$^+$	2566.4	35/2$^-$			
321.3 *10*	0.4 *1*	875.8	17/2$^+$	554.5	13/2$^+$			
324.3 *10*	0.3 *1*	3773.9	45/2$^+$	3449.6	43/2$^-$			
333.5 *7*	5.7 *3*	937.8	19/2$^-$	604.3	15/2$^-$			
347.2 *6*	30 *1*	893.2	23/2$^+$	546.0	19/2$^+$	E2	0.0991	α(K)exp=0.048 *7* (2000Ri12) Mult.: from α(K)exp. δ(M3/E2)<0.03. α(K)exp from gate at 234γ, and normalized to E2 for 295γ.
351.3 *9*	0.4 *1*	1130.0	19/2$^-$	778.7	15/2$^-$			
353.1 *9*	1.9 *2*	604.3	15/2$^-$	251.2	15/2$^+$			
357.8 *6*	33 *1*	1411.1	29/2$^-$	1053.3	25/2$^-$	E2	0.0911	DCO=1.97 *6* α(K)exp=0.038 *11* (2000Ri12) Mult.: from α(K)exp. δ(M3/E2)<0.02. α(K)exp from gate at 234γ, and normalized to E2 for 295γ.
361.6 *8*	3.2 *8*	475.4	13/2$^+$	113.8	9/2$^+$	E2	0.0887	α(K)exp=0.051 *16* (2000Ri12) Mult.: from α(K)exp. δ(M3/E2)<0.09. α(K)exp from gate at 129γ, and normalized to E2 for 334γ.
373.2 *10*	0.2 *1*	1503.2	23/2$^-$	1130.0	19/2$^-$			
378.3 *9*	1.0 *1*	853.7	17/2$^+$	475.4	13/2$^+$			
380.7 *9*	1.0 *1*	1256.5	21/2$^+$	875.8	17/2$^+$			
387.0 *7*	5.5 *3*	1324.8	23/2$^-$	937.8	19/2$^-$			
390.7 *10*	0.3 *1*	1244.4	21/2$^+$	853.7	17/2$^+$			
392.4 *9*	0.9 *1*	1636.8	25/2$^+$	1244.4	21/2$^+$			
394.8 *6*	11 *1*	1288.0	27/2$^+$	893.2	23/2$^+$	Q		DCO=1.93 *10*
399.7 *10*	0.6 *1*	2036.5	29/2$^+$	1636.8	25/2$^+$			
412.5 *7*	4.4 *3*	1737.4	27/2$^-$	1324.8	23/2$^-$			
413.2 *7*	4.8 *3*	1701.2	31/2$^+$	1288.0	27/2$^+$	Q		DCO=1.92 *10*
413.4# *10*	0.7 *2*	1669.9	25/2$^+$	1256.5	21/2$^+$			
413.7 *7*	6.7 *3*	2151.1	31/2$^-$	1737.4	27/2$^-$			
415.4 *8*	3.8 *2*	2566.4	35/2$^-$	2151.1	31/2$^-$			
421.7 *8*	2.4 *2*	2458.2	33/2$^+$	2036.5	29/2$^+$			
422.0 *6*	25 *1*	1833.1	33/2$^-$	1411.1	29/2$^-$	Q		DCO=1.99 *5*
425.4 *9*	1.6 *2*	937.8	19/2$^-$	512.4	17/2$^-$			
427.6 *8*	3.9 *2*	2128.8	35/2$^+$	1701.2	31/2$^+$	Q		DCO=2.03 *12*
428.1# *10*	0.2 *1*	1931.4	27/2$^-$	1503.2	23/2$^-$			
428.1 *9*	1.1 *1*	2886.3	37/2$^+$	2458.2	33/2$^+$			
432.5 *10*	0.4 *1*	3318.7	41/2$^+$	2886.3	37/2$^+$			
434.7 *8*	2.1 *2*	3001.1	39/2$^-$	2566.4	35/2$^-$			
448.6 *8*	2.0 *1*	3449.6	43/2$^-$	3001.1	39/2$^-$			
450.1 *8*	3.1 *2*	2579.0	39/2$^+$	2128.8	35/2$^+$			
455.3 *8*	2.6 *2*	3773.9	45/2$^+$	3318.7	41/2$^+$			
456.2 *6*	15 *1*	2289.3	37/2$^-$	1833.1	33/2$^-$	Q		DCO=1.98 *11*
458.8 *8*	2.1 *5*	475.4	13/2$^+$	16.6	11/2$^+$	M1	0.224	α(K)exp=0.33 *11* (2000Ri12) Mult.: from α(K)exp. δ(E2/M1)<0.6. α(K)exp from gates at 129γ and 334γ, and normalized to E2 for 362γ.
462.5# *1*	0.6 *1*	3912.1	47/2$^-$	3449.6	43/2$^-$			
464.2 *8*	2.1 *1*	3043.2	43/2$^+$	2579.0	39/2$^+$			
477.0 *8*	2.1 *2*	3520.1	47/2$^+$	3043.2	43/2$^+$	Q		DCO=1.93 *6*
477.7 *7*	7.1 *3*	2767.1	41/2$^-$	2289.3	37/2$^-$			

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^{208}Pb(^{14}C,3nγ) E=68 MeV 2017He15 (continued)

γ(^{219}Ra) (continued)

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[†]	Comments
501.7 *9*	1.3 *1*	4021.7	51/2+	3520.1	47/2+		
504.1 *8*	2.9 *2*	3271.2	45/2−	2767.1	41/2−	Q	DCO=1.94 *21*
519.2 *10*	0.5 *1*	3790.7	49/2−	3271.2	45/2−		
531.2[#] *10*	0.13 *7*	4321.9?	53/2−	3790.7	49/2−		E_γ: uncertainty of 0.1 keV in 2017He15 increased to 1.0 by evaluators, consistent with uncertainties for other weak γ rays.
537.9 *6*	10 *1*	554.5	13/2+	16.6	11/2+		
573.8 *8*	2.5 *2*	1324.8	23/2−	751.0	21/2−		
624.6 *7*	2.5 *3*	875.8	17/2+	251.2	15/2+		
682.3 *10*	0.4 *1*	3449.6	43/2−	2767.1	41/2−		
684.0 *8*	3.0 *2*	1737.4	27/2−	1053.3	25/2−		
710.6 *8*	1.0 *1*	1256.5	21/2+	546.0	19/2+		
711.9 *9*	1.4 *1*	3001.1	39/2−	2289.3	37/2−		
733.3 *8*	2.2 *2*	2566.4	35/2−	1833.1	33/2−		
740.0 *9*	1.9 *2*	2151.1	31/2−	1411.1	29/2−		
776.8[#] *10*	0.2 *1*	1669.9	25/2+	893.2	23/2+		

† From DCO ratio gated on ΔJ=1, dipole 205γ. Mult=Q are expected to be ΔJ=2, E2, for band assignments, and from no evidence for levels of half-lives longer than a few tens of ns to allow possible M2 transitions.

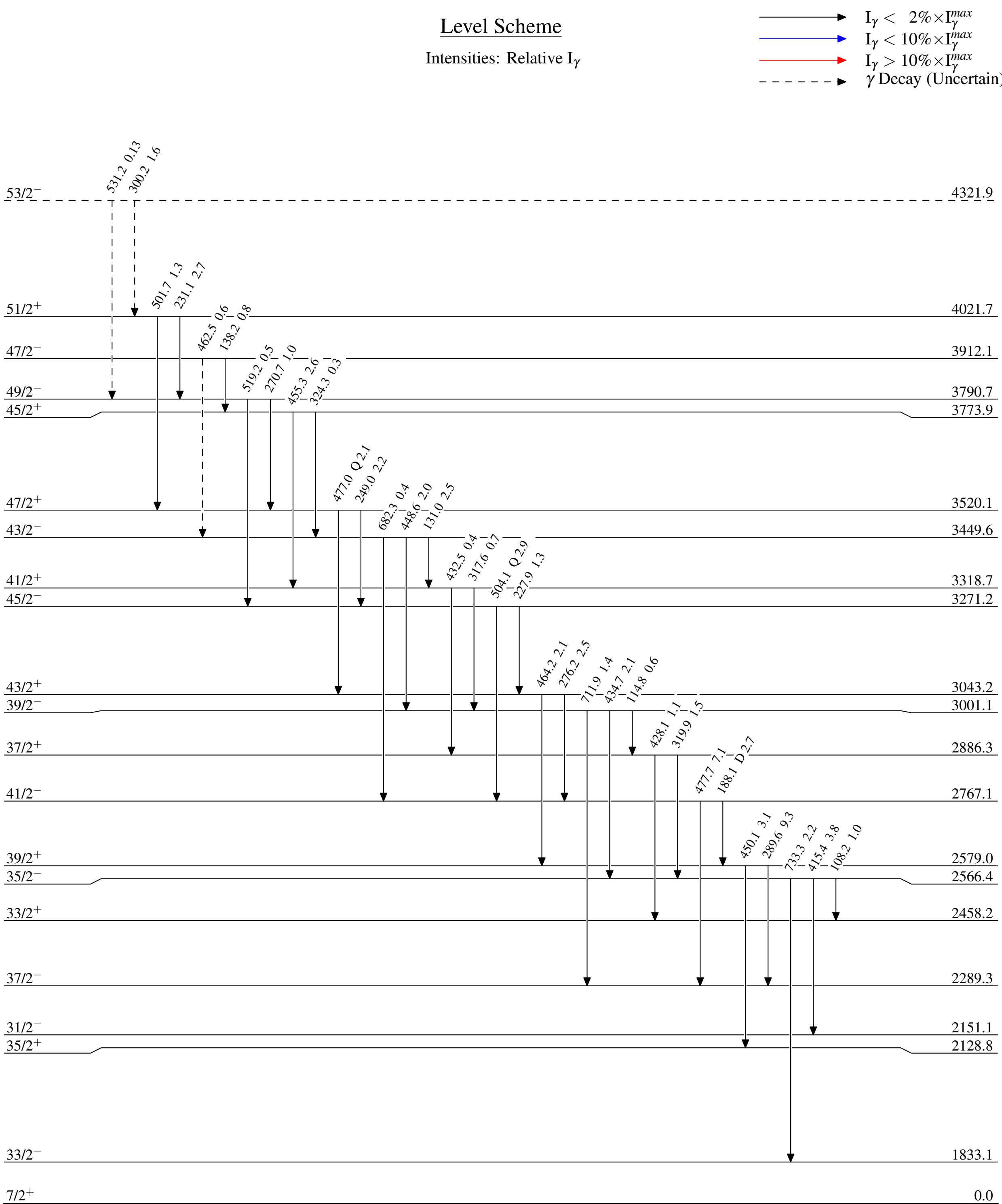
‡ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

Placement of transition in the level scheme is uncertain.

$^{208}Pb(^{14}C,3n\gamma)$ E=68 MeV 2017He15

Level Scheme

Intensities: Relative I_γ

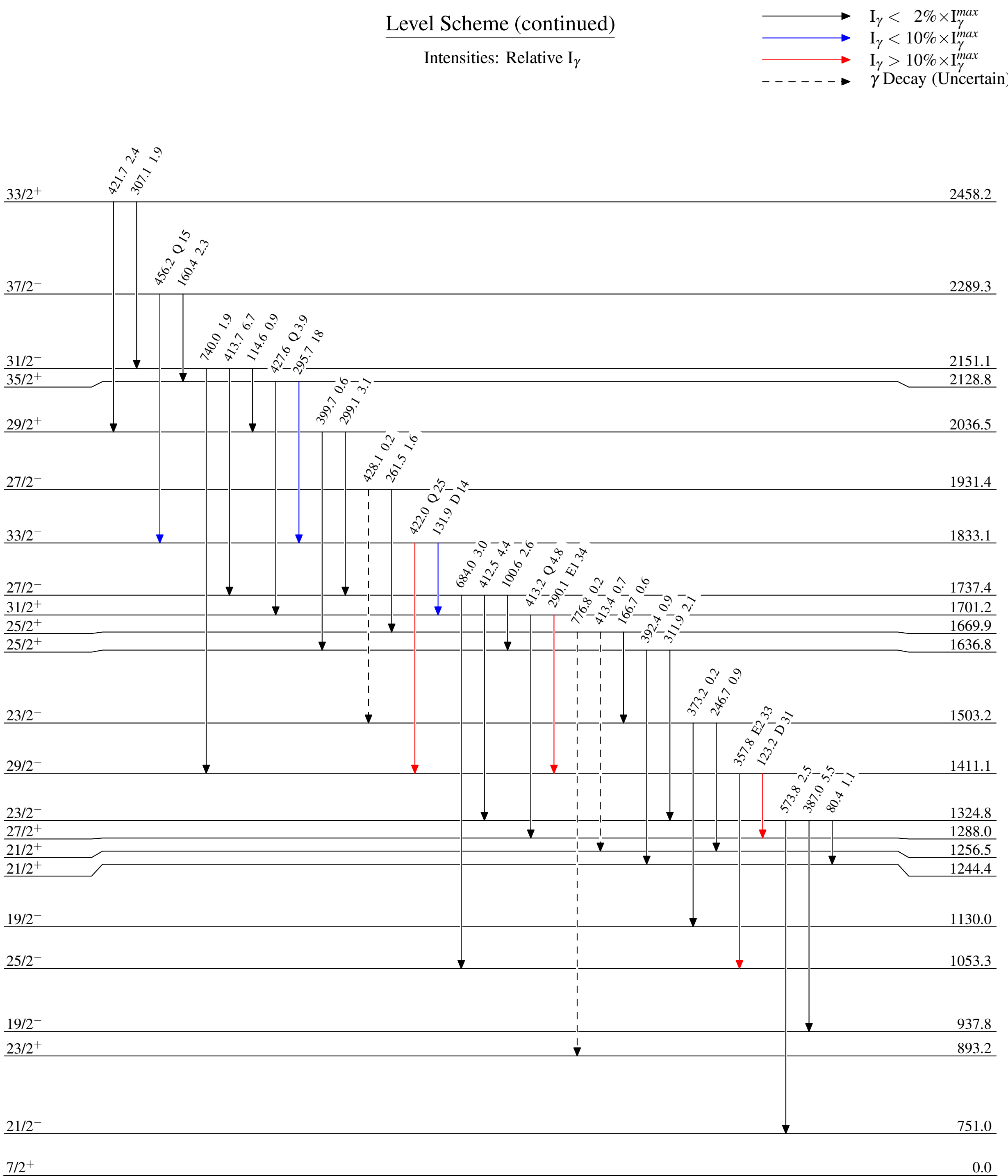


$^{219}_{88}Ra_{131}$

$^{208}Pb(^{14}C,3n\gamma)$ E=68 MeV 2017He15

Level Scheme (continued)

Intensities: Relative I_γ

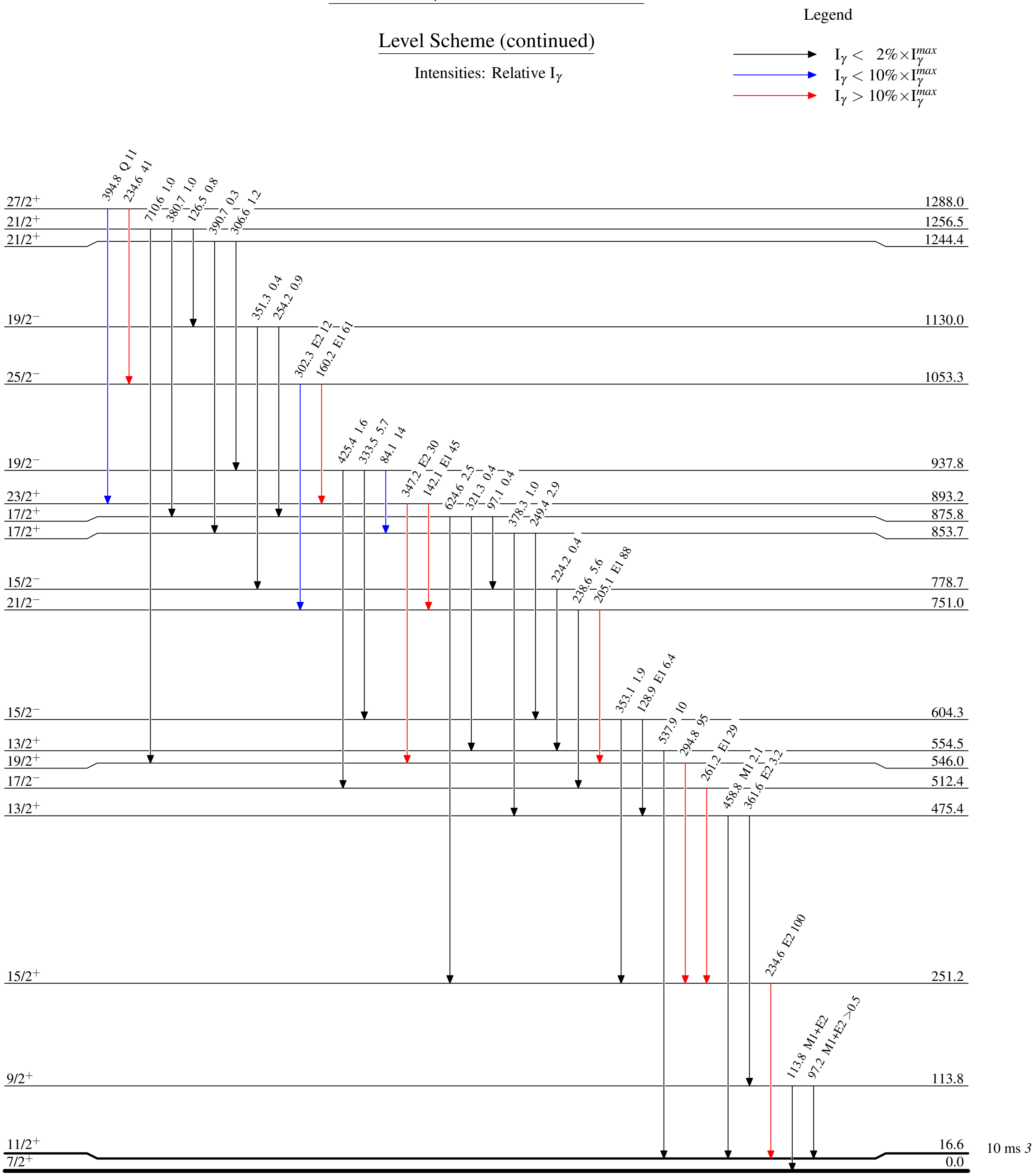


$^{219}_{88}Ra_{131}$

$^{208}Pb(^{14}C,3n\gamma)$ E=68 MeV 2017He15

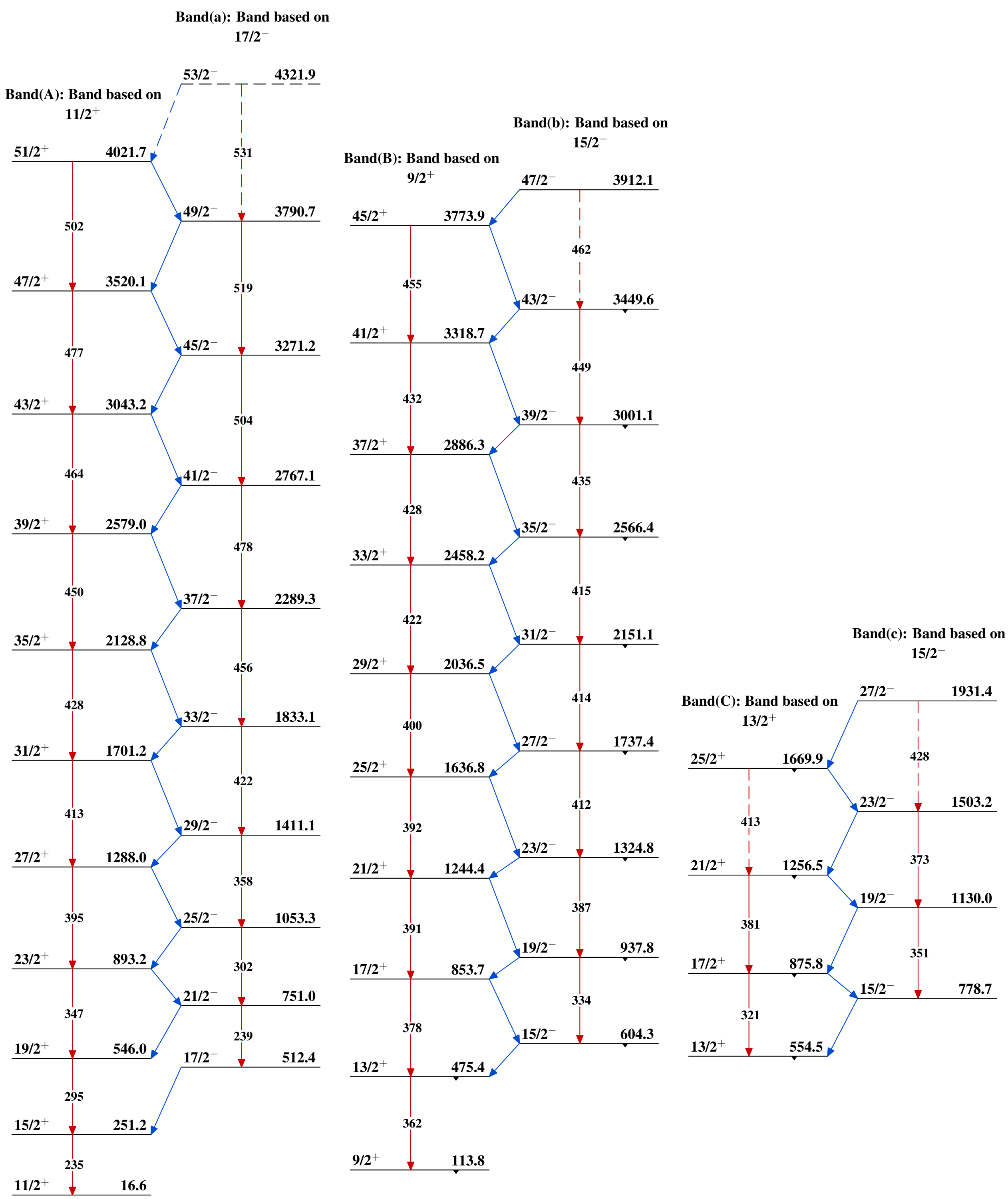
Level Scheme (continued)

Intensities: Relative I_γ



$^{219}_{88}Ra_{131}$

$^{208}Pb(^{14}C,3n\gamma)$ E=68 MeV 2017He15



$^{219}_{88}Ra_{131}$