Coulomb excitation **2013Ga23,2012GaZV**

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Sukhjeet Singh	ENSDF	08-Mar-2022

2013Ga23, 2012GaZV: Beam=^{224}Ra, E=631.68 MeV (for ^{60}Ni target), 633.92 MeV (for ^{112}Cd and ^{120}Sn targets) produced by bombardment of thick Uranium carbide target by 1.4 GeV protons from CERN PS booster facility. Ions of ^{224}Ra were accelerated in REX-ISOLDE. Targets: 2.1 mg/cm^2 thick ^{60}Ni, 2.0 mg/cm^2 thick ^{112}Cd, 2.0 mg/cm^2 thick ^{120}Sn. Measured Eγ, Iγ, (particle)γ coin using MINIBALL array of 24 HPGe detectors, each with six-fold segmentation and arranged in eight triple clusters. Scattered particles (beam and target recoils) were detected in a highly segmented Si detector. Measured yields of γ rays for two ranges of recoil angles of the target nucleus: 23.10°−39.87° and 39.30°−53.23° for ^{60}Ni target; 23.94°−40.32° and 40.43°−54.32° for ^{112}Cd and ^{120}Sn targets. Data analyzed using GOSIA computer code, by providing known lifetimes and branching ratios for low-lying levels as input parameters to this code. A total of 23 free parameters (16 matrix elements as stated in 2012GaZV) for each combination of target and recoil angle range) were determined from 57 independent data points. Deduced E1, E2, E3 matrix elements, and intrinsic quadrupole and octupole moments. Evidence for strong octupole deformation, stronger than in ^{220}Rn.

^{224}Ra Levels

Data are from 2013Ga23, except when stated otherwise.
Magnitude of matrix elements are listed, sign is unknown. Units are in eb$^{L/2}$, where L=multipole order.
Q_1, Q_2 and Q_3 are intrinsic dipole, quadrupole and octupole moments, respectively, and are from 2012GaZV with some also listed in 2013Ga23.

E(level)[†]	J$^\pi$	T$_{1/2}$	Comments
0.0[#]	0$^+$		
84.4[#] *2*	2$^+$		Q_2=6.32 *10* in eb units. β_2=0.154 (2012GaZV). E2 matrix element (from g.s.,0$^+$)=1.99 *3*.
216.0[@] *2*	1$^-$		Dipole moment Q_1<0.002, <0019 in eb$^{1/2}$ units. Octupole moment Q_3=3.20 *30* in eb$^{3/2}$ units. E1 matrix element (from g.s.,0$^+$)<0.0018. E1 matrix element (from 85,2$^+$)<0.003. E3 matrix element (from 85,2$^+$)=1.37 *14*.
250.5[#] *4*	4$^+$		Q_2=6.23 *11* in eb units. E2 matrix element (from 85,2$^+$)=3.15 *6*.
290.5[@] *3*	3$^-$		Octupole moment Q_3=2.52 *9* in eb$^{3/2}$ units. Octupole moment Q_3<8.0 in eb$^{3/2}$ units. Q_2=5.40 *30* in eb units. Dipole moment Q_1=0.00030 *6* in eb$^{1/2}$ units. β_3=0.097 (2012GaZV). E1 matrix element (from 85,2$^+$)=0.0026 *5*. E2 matrix element (from 216,1$^-$)=2.30 *11*. E3 matrix element (from g.s.,0$^+$)=0.940 *30*. E3 matrix element (from 85,2$^+$)<4.00.
432.7[@] *4*	5$^-$		Q_2=7.1 *11* in eb units. Octupole moment Q_3=2.40 *30* in eb$^{3/2}$ units. Dipole moment Q_1=0.00026 *8* in eb$^{1/2}$ units. E1 matrix element (from 251,4$^+$)=0.0030 *10*. E2 matrix element (from 291,3$^-$)=4.10 *60*. E3 matrix element (from 241,2$^+$)=1.41 *19*.
478.9[#] *4*	6$^+$	52.7[‡] ps *42*	Q_2=6.30 *20* in eb units. E2 matrix element (from 251,4$^+$)=4.05 *15*.

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Coulomb excitation 2013Ga23,2012GaZV (continued)

^{224}Ra Levels (continued)

E(level)[†]	Jπ	$T_{1/2}$	Comments
640.6[@] *4*	7^-		Dipole moment Q_1<0.010 in $eb^{1/2}$ units. E1 matrix element (from 480,6^+)<0.010.
754.5[#] *5*	8^+	20.8[‡] ps *+49−55*	Q_2=6.6 *8* in eb units. E2 matrix element (from 480,6^+)=5.00 *60*.
905.9[@] *5*	9^-		
965.49[&] *24*	2^+		Q_2=0.73 *12* in eb units. E2 matrix element (from g.s.,0^+)=0.23 *4*.
1067.1[#] *6*	10^+		

[†] From least-squares fit to Eγ values, assuming 0.3 keV uncertainty for each γ-ray energy.
[‡] Deduced in 2012GaZV from relevant matrix elements, assuming 100% E2 decay from each level. Note that 8^+ level decays also by a weak 113.8 keV, E1 transition.
[#] Band(A): g.s. band.
[@] Band(B): Octupole band.
[&] Band(C): γ band.

γ(^{224}Ra)

B(E1)(W.u.), B(E2)(W.u.) and B(E3)(W.u.) values are from 2013Ga23, deduced from measured matrix elements.

Eγ	Iγ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[#]	Comments
74.4		290.5	3^-	216.0	1^-	(E2)	38.5	B(E2)(W.u.)=93 *9*
84.4	53 *3*	84.4	2^+	0.0	0^+	E2	21.2	B(E2)(W.u.)=98 *3*
113.8		754.5	8^+	640.6	7^-	[E1]	0.351	
131.6	1.46 *13*	216.0	1^-	84.4	2^+	E1	0.247	B(E1)(W.u.)<1.3×10^{-4} B(E3)(W.u.)=210 *40* Iγ(131.6)/Iγ(216.0)=0.48 *5*.
142.0	0.44 *10*	432.7	5^-	290.5	3^-	E2	2.18	B(E2)(W.u.)=190 *60* E_γ: from 2012GaZV, listed as 142.6 in 2013Ga23.
151.5		905.9	9^-	754.5	8^+	[E1]	0.176	
161.7		640.6	7^-	478.9	6^+	[E1]	0.150	B(E1)(W.u.)<3×10^{-4}
166.4	81.5 *19*	250.5	4^+	84.4	2^+	E2	1.164	B(E2)(W.u.)=137 *5*
182.3	0.78 *9*	432.7	5^-	250.5	4^+	E1	0.1126	B(E1)(W.u.)=4×10^{-5} *+3−2* Iγ(182.3)/Iγ(142.0)=1.8 *4*.
205.9	2.49 *17*	290.5	3^-	84.4	2^+	E1	0.0842	B(E1)(W.u.)=3.9×10^{-5} *+17−14* B(E3)(W.u.)<600
207.7	0.38 *15*	640.6	7^-	432.7	5^-	[E2]	0.511	E_γ: from Figure 2 in 2013Ga23 and Figure 4.11 in 2012GaZV; 207.6 in Table B.2 in 2012GaZV.
216.0	3.03 *12*	216.0	1^-	0.0	0^+	E1	0.075	B(E1)(W.u.)<5×10^{-5}
228.5	13.6 *4*	478.9	6^+	250.5	4^+	[E2]	0.366	B(E2)(W.u.)=156 *12* E_γ: from 2012GaZV, listed as 228.4 in 2013Ga23.
265.3	0.18 *6*	905.9	9^-	640.6	7^-	[E2]	0.223	
275.7	1.26 *9*	754.5	8^+	478.9	6^+	[E2]	0.197	B(E2)(W.u.)=180 *60*
(290.5)		290.5	3^-	0.0	0^+	[E3]	1.084	B(E3)(W.u.)=42 *3*
312.6	0.09 *5*	1067.1	10^+	754.5	8^+	[E2]	0.1345	
(348.5)		432.7	5^-	84.4	2^+	[E3]	0.508	B(E3)(W.u.)=61 *17*
881.1	0.41 *8*	965.49	2^+	84.4	2^+			
965.5	0.36 *9*	965.49	2^+	0.0	0^+	(E2)	0.0096	B(E2)(W.u.)=1.3 *5* Mult.: Coulomb excitation of 965 level suggests mult=E2.

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Coulomb excitation 2013Ga23,2012GaZV (continued)

$\gamma(^{224}Ra)$ (continued)

† From 2012GaZV for "total statistics, (particle)-γ data. Listed intensities are divided by a factor of 1000 by the compiler. Values are also given in 2012GaZV for individual six experiments.
‡ From Adopted Gammas unless otherwise stated.
# From BrIcc computer code.

Coulomb excitation 2013Ga23,2012GaZV

Level Scheme

Intensities: Relative I_γ

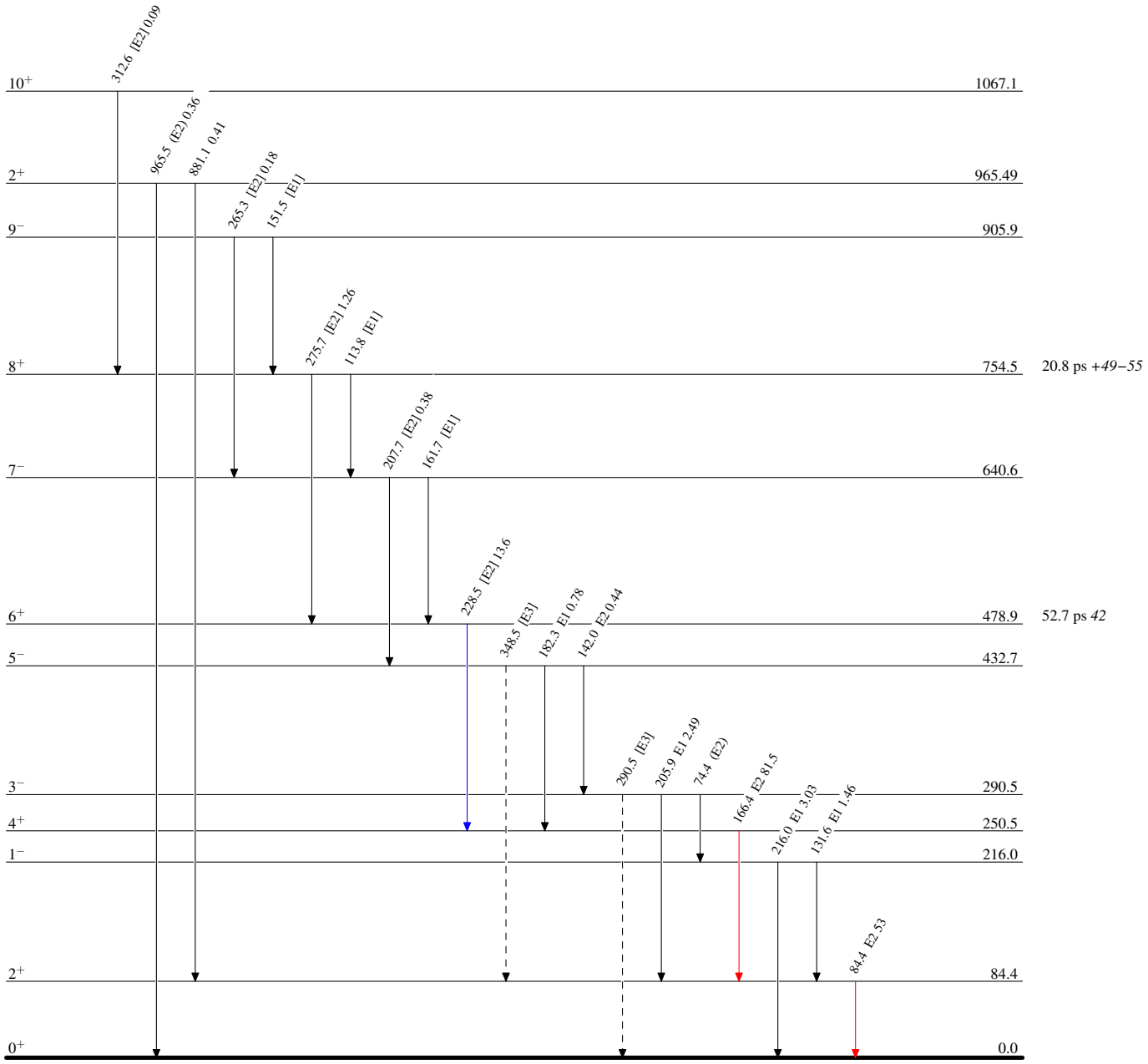
Legend

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

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

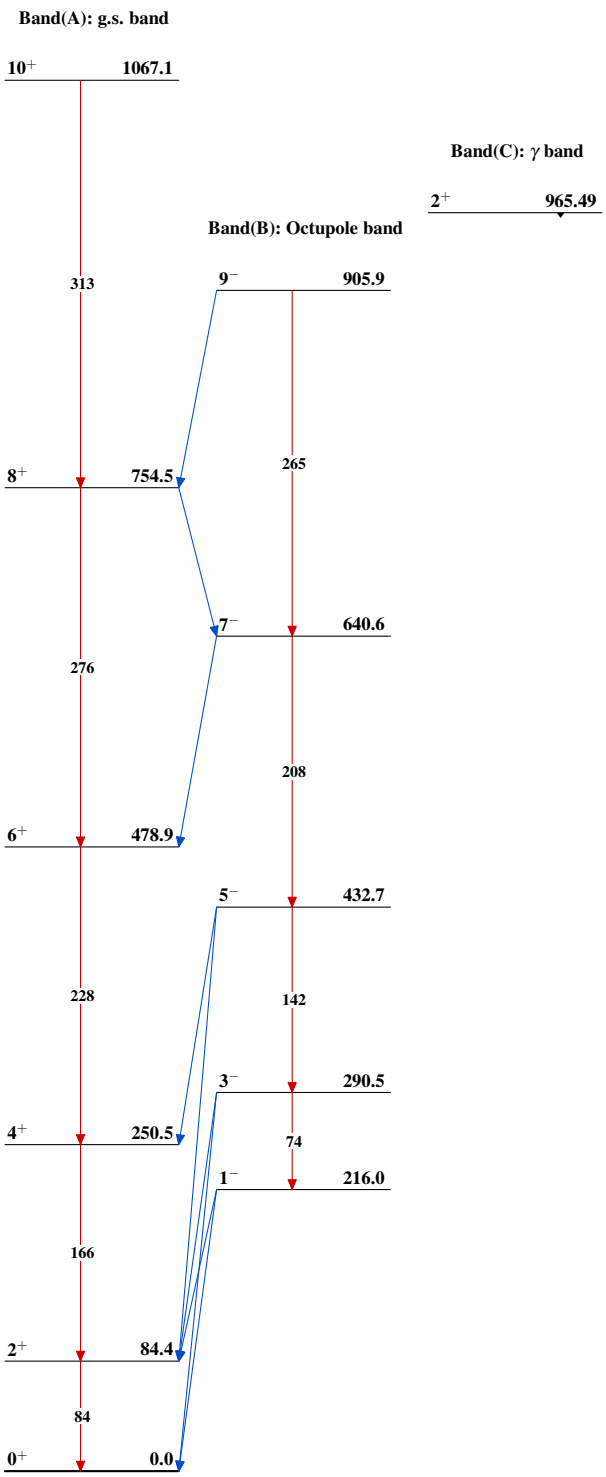
$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)



$^{224}_{88}Ra_{136}$

Coulomb excitation 2013Ga23,2012GaZV



$^{224}_{88}Ra_{136}$