^{208}Pb(α,α'),(α,$\alpha'\gamma$),(α,α'n)

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. J. Martin	NDS 108,1583 (2007)	1-Jun-2007

1967Al14 E=42 MeV.
1975De07 E=34.6 MeV, FWHM=17 keV.
1976De14 E=35 MeV. Measured gammas.
1976Gi10 E=104 MeV.
1976Ru02 E=79 MeV, FWHM=85 keV.
1977Yo05 E=96 MeV, θ=3°−8°.
1978Mo04 E=48 MeV.
1978Mo10 E=96, 115 MeV, FWHM=150 to 200 keV.
1979Ey02 E=104 MeV. Studied α'-γ coincidences In (α,α'nγ).
1979Ha46,1977Ha08 E=120 MeV, FWHM=120-150 keV, θ=12° to 23°.
1980Be50 E=152 MeV, FWHM≈150 keV, θ=5°−25°.
1980Dj02 E=218 MeV, θ=3°−7°.
1980Li11 E=23.5 MeV.
1980Mo18,1980Mo16 E=172 MeV, FWHM=ΔE/E=1×10^{-3}.
1981Ba45 E=24,27 MeV, FWHM≈40 keV.
1981De17 E=48 MeV, FWHM=35 keV.
1981St25 E=104 MEV.STUDIED (α,α'n). FWHM=220 keV for α'S.
1981Yo04 E=99,117,129 MeV, θ=0°−8°.
1982Mo27 E=172 MeV, θ=3°−5°.
1982Ya02 E=83.8,89.0,118.7 MeV, θ=1.6°−7.5°.
1983Co02 E=104 MeV.
1983Mo17 E=172 MeV, θ=1.5°−8°.
1984Bo39 E=340,480 MeV.
1984Ey01 E=104 MeV, FWHM≈100. Studied (α,α'n).
1985Mo09 See 1983Mo17.
1987Br09 E=120 MeV. Studied (α,α'n).
1988Va17 See 1987Br09.
1989Po01 E=120 MeV. Studied (α,$\alpha'\gamma$).
1992Fu01 E=70 MeV, FWHM=27 keV.
1992Po02 E=120 MeV. Studied (α,$\alpha'\gamma$).
1995AtZZ E=40.4 MeV. FWHM=11 keV.
1997Da11 E=200 MeV, FWHM≈130 keV. Supersedes 1996Da12.
1997VaZT E=40 MeV, FWHM=8-10 keV.
Additional information 1.
2001Cl01 E=240 MeV. See 2004Yo02.
2003Uc01 E=400 MeV, FWHM=200 keV, θ=0° to 13°.
2004Ga09 See 2004Uc01.
2004Lu04 E=240 MeV. See 2004Yo02.
2004Uc01 E=386 MeV, FWHM=200 keV, θ=0° to 13.5°.
2004Yo02 E=240 MeV.
2005Hu10 E=200 MeV. See 2003Hu13 and 2004Hu04. No new data.
2007Hu02 E=200 MeV. Studied (α,α'n).
Others: 1965Sa04, 1970Br07, 1974Ce03, 1974Gr08.
1976De14 measured gammas. All other references are to inelastic particle scattering. 1976De14 report g.s. transitions from the 4086, 4842, 5292, and 5512 levels. These transitions are not measured directly, but are inferred from $\alpha\gamma$ coincidence data.
%EWSR=%energy−weighted sum rule.

2001Va04 E=40 MeV, FWHM=8-10 keV. Authors Give σ Only. The Energies Are Given In 1997VaZT

2003Hu13 E=200 MeV. Studied (α,α'p). FWHM=400 keV For Excitation Energies In ^{208}Pb And 600 keV For Excitation Energies In ^{207}Tl

2004Hu04 E=200 MeV. Studied (α,α'p) (see 2003Hu13) And (α,α'n). FWHM=1-1.5 MeV For Excitation Energies In ^{207}Pb

^{208}Pb Levels

E(level)†‡#@	$T_{1/2}$	L&	β_L b	Comments
0.0				
2614.3 *4*	15.4 ps *12*	3		B(E3)↑=0.66 *5* (1980Li11) $T_{1/2}$: from B(E3). L: L=3 also reported by 1992Fu01, 1981De17, 1979Ha46, 1976Ru02. β_L: 0.106 (1981Ba45), 0.103 (1980Mo18), 0.117 (1979Ha46), 0.113 *9* (1978Mo10), 0.118 *9* (1976Ru02), 0.097 *2* (1976Gi10), 0.122 *7* (1967Al14). %EWSR=17.5 *10* (1980Be50), 21.0 (1992Fu01).
3198.3 *5*		5	0.0712	L: L=5 also reported by 1979Ha46, 1976Ru02. β_L: others: 0.048 (1980Mo18), 0.049 (1979Ha46), 0.062 *4* (1976Ru02), 0.068 *4* (1967Al14).
3707.8 *9*		5	0.0347	L: L=5 also reported by 1979Ha46, 1976Ru02. β_L: others: 0.024 (1980Mo18), 0.032 (1979Ha46), 0.038 *3* (1976Ru02).
3960.0 *15*				
4037.7 *8*		7	0.0346	
4050 *2*				
4086.0 *15*		2	0.0547	L: L=2 also reported by 1992Fu01, 1979Ha46, 1976Ru02. β_L: others: 0.053 (1980Mo18), 0.049 (1979Ha46), 0.051 (1976Ru02), 0.051 *4* (1967Al14).
4125.7 *8*				
4181 *2*				
4255.2 *15*				
4293.4 *15*				
4322.3 *8*		4	0.0630	L: L=4 also reported by 1979Ha46. β_L: others: 0.063 (1980Mo18), 0.060 (1979Ha46), 0.072 *4* (1967Al14).
4423.1 *8*		6	0.0226	L: L=6 also reported by 1979Ha46. β_L: other: 0.044 (1979Ha46).
4479.1 *15*				
4610.7 *8*		8	0.0267	
4679 *2*				
4698.3 *8*		3	0.0377	L: other: L=3 also reported by 1992Fu01. %EWSR<2.8 (1992Fu01).
4715 *5*				
4841.3 *8*		1		L: from 1981De17, 1979Ha46. β_L: σ(5291 level)/σ(4841 level)=0.9 *1* (1975De07), 1.1 (1997VaZT). %EWSR=4.9 *3* (1992Po02 from reanalysis of data of 1980Ch22 In (γ,γ')).
4856 *3*				
4868 *3*				
4895.0 *8*		10	0.0108	
4937.0 *8*		3	0.0153	L: L=3 also reported by 1992Fu01. %EWSR=0.6 (1992Fu01).
4950 *2*				
4974.0 *8*		3	0.0226	L: L=3 also reported by 1992Fu01.
5038.1 *8*				
5073.7 *15*		10	0.0207	
5084.0 *15*		3	0.0107	
5095 *2*				
5215.9 *8*				
5243.0 *8*		3	0.0196	L: L=3 also reported by 1992Fu01. 1979Ha46 report L=2,(4). %EWSR=0.6 (1992Fu01).
5291.6 *8*		1		L: L=1 also reported by 1992Po02, 1981De17. β_L: σ(5291 level)/σ(4841 level)=0.9 *1* (1975De07). %EWSR=0.88 *18* (1992Po02).
5348.0 *8*		3	0.0310	L: L=3 also reported by 1992Fu01, 1979Ha46. %EWSR=2.1 (1992Fu01).

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^{208}Pb(α,α'),($\alpha,\alpha'\gamma$),(α,α'n) (continued)

^{208}Pb Levels (continued)

E(level)†‡#@	L&	β_L b	Comments
5369 *2*			
5386 *2*			
5482.8 *15*	5	0.0382	L: L=5 also reported by 1992Fu01.
5490 *2*			
5512.1 *8*	1		L: from $\alpha'\gamma(\theta)$ of 1992Po02. 1981De17 also report L=1. %EWSR=5.2 *11* (1992Po02).
5516.6 *7*	3	0.0758	E(level): from 1995AtZZ. %EWSR<2.0 (1992Fu01).
5544 *2*	7	0.0216	
5563.7 *15*	2	0.0210	
5640.8 *8*			
5656.5 *15*			
5665.0 *15*	5	0.0172	
5690.8 *8*	4	0.0363	L: L=4 also reported by 1992Fu01.
5718.4 *8*	7	0.0184	
5814.5 *8*	3	0.0277	
5835 *2*			
5872.1 *15*	3	0.0139	L: L=3 also reported by 1992Fu01. %EWSR=0.2 (1992Fu01).
5888 *2*			
5973 *4*			
5995.4 *15*	6	0.0297	
6010.9 *15*	3	0.0353	
6054 *2*			
6087.6 *8*			
6195.6 *8*			
6241 *2*			
6264.4 *15*	1[a]		L: from 1992Po02 based on $\alpha'\gamma(\theta)$.
6279 *3*			
6318 *2*			
6370	1[a]		E(level): reported only by 1992Po02 and interpreted As an isoscalar dipole state. L: from 1992Po02 based on $\alpha'\gamma(\theta)$.
6427.5 *8*			
6452.8 *8*			
6488.3 *8*			
6539.4 *15*			
6555 *2*			
6614.3 *15*			
6629 *2*			
6659 *2*			
6687.4 *8*			L: 1979Ha46 report L=5 for E(level)=6810 *40*.
6702 *2*			
6717 *2*			E(level): 1992Po02 report a peak At 6720 which they interpret As an isoscalar dipole state with %EWSR=0.53 *11*.
7060	1		E(level): reported only by 1992Po02 and interpreted As an isoscalar dipole state with %EWSR=0.57 *12*. L: from 1992Po02 based on $\alpha'\gamma(\theta)$ In ($\alpha,\alpha'\gamma$).
7200			E(level),L: reported only by 1978Mo04. Not discussed, but shown In the authors′ spectrum and labeled with $J^\pi=4^+$.
7280	1		E(level): reported only by 1992Po02 and interpreted As an isoscalar dipole state with %EWSR=0.35 *9*. L: from 1992Po02 based on $\alpha'\gamma(\theta)$ In ($\alpha,\alpha'\gamma$).
7400	4		E(level),L: reported only by 1980Mo18. β_4=0.033, %EWSR=2.7 (1980Mo18).
8100	4		E(level),L: reported only by 1980Mo18. β_4=0.030, %EWSR=2.5 (1980Mo18).

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^{208}Pb(α,α'),($\alpha,\alpha'\gamma$),(α,α'n) (continued)

^{208}Pb Levels (continued)

E(level)†‡#@	L&	Comments
10.9×10^3 *3*	2	configuration: isoscalar giant quadrupole resonance. E(level): from 2004Yo02. Others (MeV):10.9 *3* (1987Br09), 10.9 *2* (1984Bo39), 10.9 *3* (1980Mo18), 10.9 *3* (1980Be50), 10.9 *3* (1979Mo13), 10.9 *3* (1979Ha46). Γ (MeV):3.0 *3* (2004Yo02), 3.1 *3* (1987Br09), 2.8 *3* (1984Bo39), 2.6 *3* (1980Mo18), 2.4 *4* (1980Be50), 2.6 *3* (1979Mo13), 3.0 *3* (1979Ha46). %EWSR=100 *13* (2004Yo02), 120-170 (1987Br09), 81 *10* At E=340 MeV, 93 *10* At E=480 MeV (1984Bo39), 70 (1980Mo18), 77 *15* (1980Be50), 145 *30* (1979Ha46). When other L components are included, %EWSR= 59 (L=2) + 5 (L=3) + 16 (L=4) + 16 (L=6) (1983Mo17,1985Mo09), 115 *20* (L=2) + 21 *7* (L=4) (1982Ya02), and 100 (L=2) + 20 (L=4) (best fit 1979Ha46). L: L=2 is dominant (1977Yo05); however, an L=4 component from a hexadecapole background has been observed (see for example 1982Ya02, 1980Mo18, 1979Ha46). 1979Ey02 report $\alpha'\gamma(\theta)$ consistent with L=2, but 1981St25 report a strong population of the 13/2$^+$ In ^{207}Pb from their (α,α'n) work, requiring higher multipole components, L=4 and 6. See also 1984Ey01, who suggest that the E2 EWSR strength should Be lowered by about 50%.
12500	4	reported only by 1983Mo17 (also given In 1985Mo09). Γ=3.6 MeV, %EWSR=14.
13.3×10^3 *3*	1	configuration: low-energy component of the isoscalar giant dipole resonance (2004Yo02, 2004Uc01). E(level): from 2004Yo02. Other(MeV):13.0 *1* (2004Uc01). See also earlier reports from these groups given In their references. 2004Ga09 reports E=12.7 *2*, but appears to Be the same work As 2004Uc01. Γ(MeV): 5.7 *5* (2004Yo02), 1.1 *4* (2004Uc01). See also earlier reports from these groups given In their references. %EWSR=24 *15* (2004Yo02), 7.0 *4* (2004Uc01. The uncertainty is statistical only).
13.96×10^3 *20*	0	configuration: isoscalar giant monopole resonance (2004Uc01, 2004Yo02). From the observation of γ decay to the g.s. In ($\alpha,\alpha'\gamma$) In the energy interval 12.3 to 15.8 MeV, 1989Po01 determine that the isovector giant dipole contribution to the resonance cross section In (α,α') can Be estimated to Be No more than 12% 4. E(level): from 2004Yo02. See also earlier reports from this group given In their references. Others (MeV):13.4 *2* (2004Uc01), 13.9 *3* (1987Br09), 13.9 *2* (1984Bo39), 13.5 *3* (1982Ya02), 13.8 *3* (1980Mo18), 13.5 *2* (1980Dj02), 13.9 *4* (1980Be50), 13.9 *3* (1979Ha46). L: from 2004Yo02, 2004Uc01. 1983Mo17 report small contributions from L=2, 4, and 6. From $\alpha'\gamma(\theta)$, 1979Ey02 show that L=0 is dominant, but some contribution from higher multipoles is required (≈30-40%, mainly even L). From the strong feeding of the 13/2$^+$ level In ^{207}Pb from their (α,α'n) work, 1984Ey01 conclude that there must Be an L=6 contribution to the resonance cross section. Γ(MeV):2.88 *20* (2004Yo02), 4.0 *4* (2004Uc01), 2.4 *3* (1987Br09), 2.0 *3* (1984Bo39), 3.0 *3* (1982Ya02), 2.6 *3* (1980Mo18), 3.2 *4* (1980Be50), 2.5 *4* (1979Ha46). %EWSR=99 *15* (2004Yo02), 104 *9* (2004Uc01. Uncertainty is statistical only), 85 *20* (1987Br09). For the L ≠ 0 components, 1983Mo17 report %EWSR=14, 9.5, and 6 for L=2, 4, and 6, respectively, 1982Ya02 report %EWSR=20 *15*, 28 *13*, and 27 *8* for L=2 At E=84 MeV, 89 MeV, and 119 MeV, respectively, and 1979Ha46 report %EWSR=50 *16* if L=2, or 17 *4* if L=4. from α'-neutron coincidence studies, 1984Ey01 obtain a value of 15-20% for the direct neutron decay of the resonance to levels In ^{207}Pb.
16000?	6	reported only by 1983Mo17 (also given In 1985Mo09). Not confirmed by 1986Ad02. Γ=2.9 MeV, %EWSR=15.
19.6×10^3 *5*		configuration: high-energy giant octupole resonance (2004Yo02, 1997Da11). L=3 is established In (p,p′) and (^{3}He,^{3}He′). E(level): from 2004Yo02. Others: 19.7 *5* (1997Da11), 18.7 *7* (1983Mo17), 17.5 *8* (1980Mo16). Γ(MeV)=7.4 *6* (2004Yo02), 5.0 *9* (1983Mo17), 4.8 *8* (1980Mo16). %EWSR=70 *14* (2004Yo02), 60 *20* (1980Mo16).
22.1×10^3 *3*	1	configuration: high-energy component of the isoscalar giant dipole resonance (2004Hu04, 2004Uc01, 2004Yo02, 1997Da11, 1980Mo16). E(level): from 2004Hu04. Others (MeV): 21.5 *10* from (α,α'p), and 21.2 *7* from (α,α'n) (2007Hu02), 22.2 *3* (2004Yo02), 22.7 *2* (2004Uc01) 22.4 *5* (1997Da11), 21.3 *8* (1980Mo16). L: from 2004Hu04. L=1 also determined by several earlier authors. Γ(MeV): 3.8 *8* (2004Hu04), 9.4 *4* (2004Yo02), 11.9 *4* (2004Uc01), 3.0 *5* (1997Da11), 5.9 *8* (1980Mo16). %EWSR=158 *43* (2004Hu04), 88 *15* (2004Yo02), 111 *6* (2004Uc01). 2004Uc01 point out that the

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^{208}Pb(α,α'),($\alpha,\alpha'\gamma$),(α,α'n) (continued)

^{208}Pb Levels (continued)

E(level)†‡#@	L&	Comments
		uncertainty is statistical only and that the systematic uncertainty could Be large. See also 1985Mo09, 1984Bo39, 1983Mo17.
		from α-proton and α-neutron coincidence work, 2004Hu04 determine branching for direct proton decay to the $2s_{1/2}$ + $2d_{3/2}$ states and $1h_{11/2}$ + $2d_{5/2}$ final states In ^{207}Tl of 2.3% 11 and 1.2% 7, respectively. The value for direct neutron decay to final states In ^{207}Pb with excitation energies from 0 to 6 MeV is 23% 5. See also 2007Hu02.
26.9×10^3 *7*	2	E(level),L: from 2004Hu04. Also reported In 2003Hu13. Γ=6.0 *13* MeV (2004Hu04, 2003Hu13). configuration: suggested As an overtone of the isoscalar giant quadrupole resonance (2004Hu04, 2003Hu13).

† From 1997VaZT, except where noted otherwise. Cross-sections, but No energies, are given In 2001Va04. In addition to the levels given here, 1979Ha46 report complex structure At 6370, 6580, 6810 (L=5), 7290, 7520, and 8340 (L=4).

‡ In addition to the giant resonances with L=0, 1, 2, and 3, 1983Mo17 suggests the possibility of an L=4 resonance At 12.5 MeV with Γ=3.6 MeV and %EWSR=14, and an L=6 resonance At 16.0 MeV with Γ=2.9 MeV and %EWSR=15.

No peak observed At 19 MeV with strength comparable to that implied by data of 1979Do01 In (^{16}O,^{16}O′) (1980Mo18). 1982Mo27 report the possible existence of L=5 excitation In the region E=15-17 MeV. See also 1984Bo39. 1984Bo39 report some isoscalar dipole strengths, fragmented between 26 and 35 MeV with main component centered around 29 MeV, with %EWSR=34 *+36−14* At E=340 MeV and 55 *+65−30* At E=480 MeV.

@ 1979Ey02 report fine structure At≈8.3,≈8.8,≈9.4-9.7,≈10.25,≈10.7,≈11.25,≈12-12.3,≈12.7 and≈13.7-14.2 MeV with Γ≈400 keV.

& From 1995AtZZ, except where noted otherwise. Others: 1992Fu01, 1981De17, 1979Ha46, 1976Ru02.

[a] %EWSR=2.2 *5* (1992Po02) for the 6264+6370 levels.

[b] Values are β_L from 1995AtZZ. This reference has the most complete set of values. Other values are given In comments. 1967Al14, 1976Ru02, 1978Mo10, and 1979Ha46 quote $(\beta_L R)^2$. For comparison purposes, these have been converted by the evaluator to β_L values using R=7.11. 1981De17 give In graphical form the strength In % of the energy-weighted sum rule for the L=1 levels. They note that the dipole strength is localized At≈5500. 1979Ha46 compute isoscalar transition rates for several states.