^{48}Ca(γ,γ'),(pol γ,γ') 2002Ha13,2014De04

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2002Ha13: Bremsstrahlung (ΔE(e)≈150 keV) was produced from the S-DALINAC at Darmstadt. Target was 2977 mg 82.7% enriched ^{48}Ca. γ rays were detected with two HPGe detectors (90° detector shielded with BGO scintillators. Measured Eγ, Iγ, $\gamma\gamma(\theta)$ (at 90° and 130°), yields. Deduced levels, J, π, widths, transition strengths, lifetimes. Comparisons with available data. See also 2000Ha34, 2000Zi04, 2001Ba66, 2004Ha51, and 2005Zi04.

The summed E1 strength and electric polarizability between 5 and 10 MeV in ^{48}Ca are ≈10 times larger than in ^{40}Ca; the E1 strength in ^{48}Ca exhausts ≈0.3% of the energy-weighted sum rule; the summed B(E2) strengths are approximately equal for the two nuclides. See 2002Ha13 for a discussion of the possible sources of E1 strength. Also, see 2002Ha13 for a discussion of the E2 strengths and their distributions in these two nuclides.

1999Ot02 in a study of ^{40,48}Ca(^{86}Kr,^{86}Kr′) E=60 MeV/nucleon found no significant difference in the dipole response of ^{40}Ca and ^{48}Ca and obtained a total %EWSR=6.7 *33*. This is in sharp contrast to these results. However, 2002Ha13 note that analysis of heavy-ion scattering is model-dependent while their analysis is not and that their results exhibit high resolution resolving single excitations and have a low detection limit.

2014De04: E=6.6-9.51 MeV linearly polarized photons from the HIγS facility at TUNL. Measured γ asymmetries. Deduced J, π. 2014De04 also re-analyzed $\gamma(\theta)$ data in 2002Ha13 and determined the total B(E1)↑ from the work of 2002Ha13 to be 80×10^{-5} e^{2}b *8* from 56×10^{-5} e^{2}b *4* reported in 2002Ha13. 2014De04 also report data on (α,$\alpha'\gamma$).

^{48}Ca Levels

In obtaining Γ_γ previously unobserved dipole transitions were assumed by 2002Ha13 to be E1 since previous (e,e′) measurements (1979Gr09,1980St17) did not show any significant M1 strength below 10 MeV.

B(E1),B(E2): see 2002Ha13 for B(E1)↑ and B(E2)↑ values derived from $\Gamma_{\gamma0}$′s.

E(level)	J$^\pi$†	T$_{1/2}$@	Comments
0.0	0$^+$		
3831.5 *2*	2$^+$	35 fs *3*	$\Gamma_{\gamma0}$=0.013 eV *1*
4695.4 *3*	1	32.6 fs *+25−22*	$\Gamma_{\gamma0}$=0.014 eV *1*
6612.2 *1*	1$^-$‡	1.87 fs *14*	$\Gamma_{\gamma0}$=0.24 eV *1*
7298.5 *2*	1$^-$‡&	0.201 fs *14*	$\Gamma_{\gamma0}$=2.24 eV *13*
7655.7 *2*	1$^-$‡&	1.87 fs *7*	$\Gamma_{\gamma0}$=0.21 eV *1*
7915.4 *9*	2$^+$	22 fs *+4−3*	$\Gamma_{\gamma0}$=0.021 eV *3*
8027.6 *4*	2$^+$	11.4 fs *12*	$\Gamma_{\gamma0}$=0.040 eV *4*
8386.1 *5*	1$^-$‡	0.159 fs *21*	$\Gamma_{\gamma0}$=2.82 eV *25*; $\Gamma_{\gamma1}$=0.261 eV *18*
8517.9 *8*			T$_{1/2}$: 4.6 fs *8* if E1 or 11.4 fs *28* if E2 excitation. $\Gamma_{\gamma0}$: 0.098 eV *17* if E1 or 0.04 eV *1* if E2 excitation.
8883.5 *5*	1$^-$#	0.42 fs *14*	$\Gamma_{\gamma0}$=1.16 eV *1*; $\Gamma_{\gamma1}$=0.048 eV *13*
9033.9 *4*	1$^-$‡	0.242 fs *14*	$\Gamma_{\gamma0}$=1.85 eV *24*; $\Gamma_{\gamma1}$=0.043 eV *18*
9295.3 *2*	1$^-$#	0.236 fs *14*	$\Gamma_{\gamma0}$=1.95 eV *12*
9472.8 *8*	1$^-$‡	0.250 fs *21*	$\Gamma_{\gamma0}$=1.81 eV *15*
9545.7 *2*	1$^-$‡	0.139 fs *7*	$\Gamma_{\gamma0}$=3.27 eV *21*

† Spin from $\gamma(\theta)$ in 2002Ha13 and parity from Adopted Levels for excited states, unless otherwise noted.

‡ Spin and parity confirmed by γ asymmetry in 2014De04.

Previous J=2 assignment by 2002Ha13 from $\gamma(\theta)$ is determined to be 1$^-$ from re-analysis of $\gamma(\theta)$ data in 2002Ha13 and additional γ asymmetry measurements by 2014De04.

@ From $\Gamma_{\gamma0}$ assuming $\Gamma_{\gamma0}/\Gamma$=1 when deexcitation pattern is unknown.

& Possible candidates for a two-phonon quadrupole-octupole state. The 7299 state is preferred from systematics (2002Ha13).

^{48}Ca(γ,γ′),(pol γ,γ′) 2002Ha13,2014De04 (continued)

γ(^{48}Ca)

E_i(level)	J^π_i	E_γ[†]	Γ_γ/Γ[†]	E_f	J^π_f	Mult.[‡]	Comments
3831.5	2^+	3831.3 *2*	1.0	0.0	0^+		
4695.4	1	4695.2 *3*	1.0	0.0	0^+	D	
6612.2	1^-	6611.7 *1*	1.0	0.0	0^+	E1	
7298.5	1^-	7297.9 *2*	1.0	0.0	0^+	E1	
7655.7	1^-	7655.0 *2*	1.0	0.0	0^+	E1	
7915.4	2^+	7914.7 *9*	1.0	0.0	0^+	E2	
8027.6	2^+	8026.9 *4*	1.0	0.0	0^+	E2	
8386.1	1^-	4554 *9*	0.090 *3*	3831.5	2^+	D[#]	
		8385.3 *5*	0.91 *8*	0.0	0^+	E1	
8517.9		8517.1 *8*	1.0	0.0	0^+		
8883.5	1^-	5050.6 *9*	0.040 *10*	3831.5	2^+	D	
		8882.6 *5*	1.0 *3*	0.0	0^+	E1	
9033.9	1^-	5200.9 *15*	0.022 *9*	3831.5	2^+	D[#]	
		9033.0 *4*	1.0 *4*	0.0	0^+	E1	
9295.3	1^-	9294.3	1.0	0.0	0^+	E1	Mult.: other: Q from 2002Ha13.
9472.8	1^-	9471.8 *8*	1.0	0.0	0^+	E1	
9545.7	1^-	9544.7 *2*	1.0	0.0	0^+	E1	

† From 2002Ha13, unless otherwise noted. Eγ values are derived from excitation energies and Γ_γ/Γ=1.0 are assumed by 2002Ha13 to obtain $T_{1/2}$ where there is only a single transition.

‡ From γ(θ) in 2002Ha13, γ asymmetry in 2014De04 and comparison to RUL.

δ=0 assumed by 2002Ha13.

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Level Scheme

Intensities: Γ_γ/Γ