

$^{40}\text{Ca}(\text{d},\alpha\gamma)$ [2007Pr03](#),[1975Co09](#),[1973Ha56](#)

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Full Evaluation	Jun Chen	NDS 152, 1 (2018)	30-Sep-2017

- [2007Pr03](#): E=4.5 MeV deuteron beam was produced from the ESTU tandem accelerator. Target was $220 \mu\text{g}/\text{cm}^2$ ^{40}Ca on a $1\text{mg}/\text{cm}^2$ Ni backing. α particles were detected with the SCARY array of Solar cells and γ rays were detected with an array of eight Clover detectors. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ -coin, $\alpha\gamma$ -coin, Doppler-shift attenuation. Deduced levels, lifetimes. Comparisons with shell-model calculations.
- [1975Co09](#) (also thesis by [1974CoYC](#) and [1974LoZM](#)): E=7.84-16.0 MeV deuteron beam was produced from the University of Notre Dame FN tandem Van de Graaff accelerator. Target was self-supporting Ca. α particles were detected with an annular silicon surface-barrier detectors and γ rays were detected with a Ge(Li) detector. Measured $E\gamma$, $\alpha\gamma$ -coin, Doppler-shift attenuation. Deduced levels, lifetimes. Comparisons with available data. [1975Co09](#) also report data on $^{40}\text{Ca}(\text{d},\alpha)$ and $^{36}\text{Ar}(^3\text{He},p\gamma)$.
- [1973Ha56](#): E=4.421 MeV deuteron beam was produced from the Groningen 5-MV Van de Graaff accelerator. Target was $320 \mu\text{g}/\text{cm}^2$ natural Ca on a $1200 \mu\text{g}/\text{cm}^2$ nickel backing. α particles were detected with an annular surface-barrier silicon detector and γ rays were detected with a Ge(Li) detector. Measured $E\gamma$, $\alpha\gamma$ -coin, Doppler-shift attenuation. Deduced levels, lifetimes.
- [1972Ha15](#) (from the same group as [1973Ha56](#)): E=4.421, 5.080 MeV; measured $E\gamma$, $I\gamma$, $\alpha\gamma(\theta)$. Deduced levels, J, π , γ -ray branchings.

 ^{38}K Levels

E(level) [†]	J π @	T _{1/2} ^{&}	Comments
0	3 ⁺		
130.6 4	0 ⁺		
458.6 4	1 ⁺	>2.8 ps	J π : 1 from $328\gamma(\theta)$; 1 ⁻ gives an unacceptable solution based on substate population (1972Ha15).
			T _{1/2} : from 1973Ha56 .
1698.0 5	1 ⁺	52 fs 10	J π : 1 from $1567\gamma(\theta)$; 1 ⁻ gives an unacceptable solution based on substate population (1972Ha15).
			T _{1/2} : weighted average of 76 fs 20 (2007Pr03), 57 fs 24 (1975Co09) and 45 fs 10 (1973Ha56).
2401.2 4	2 ⁺	63 fs 15	J π : 1,2 from $1942\gamma(\theta)$; J=1 is rejected by $2271\gamma(\theta)$ (1972Ha15).
			T _{1/2} : weighted average of 66 fs 15 (2007Pr03), 53 fs 35 (1975Co09) and 62 fs 17 (1973Ha56).
2613.1 4	3 ⁻	6 ps +5-2	T _{1/2} : from 1973Ha56 . Other: >1.8 ps (1975Co09).
2645.8 5	(4) ⁻	>8.3 ps	T _{1/2} : from 1973Ha56 . Other: >2.3 ps (1975Co09).
2828.2 6	1 ⁻	0.22 ps 5	T _{1/2} : weighted average of 317 fs 44 (2007Pr03), 142 fs +45-38 (1975Co09) and 194 fs 49 (1973Ha56).
2869.5 5	2 ⁻	3.1 ps 8	T _{1/2} : from 1973Ha56 . Other: >1.2 ps (1975Co09).
2993.1 5	0 ⁻	114 fs 30	J π : 0,1 from $\gamma(\theta)$ (1972Ha15).
			T _{1/2} : weighted average of 90 fs 28 (2007Pr03) and 152 fs 35 (1973Ha56).
3315.5 9	(1 ⁺ ,2 ⁻ ,3 ⁺)	1.70 ps 29	J π : 1,2,3 from $3315\gamma(\theta)$ (1972Ha15).
			T _{1/2} : from 1973Ha56 .
3341.5 8	1 ⁺	<38 fs	J π : 1 ⁺ from $\gamma(\theta)$ (1972Ha15).
			T _{1/2} : from 1973Ha56 . Other: <73 fs (1975Co09).
3418.4 16	(6) ⁻		E(level): level not in 1975Co09 .
3430.4 8	2 ⁺	<0.12 ps	T _{1/2} : from 1975Co09 .
3443?			E(level): level from 1973Ha56 and 1972Ha15 considered as uncertain (evaluator).
3614.2 [‡] 7	(3,5) ⁻	0.5 ps +6-2	T _{1/2} : from 1975Co09 .
3668.2 6	3 ⁺	91 fs 35	J π : 1,3 from $\gamma(\theta)$ (1972Ha15).
			T _{1/2} : weighted average of 111 fs 35 (2007Pr03) and 66 fs 38 (1975Co09). Other: <104 fs (1973Ha56).
			γ 's to g.s., 2613 and 2646 shown by 1973Ha56 and 1972Ha15 are, instead, from 3688 level according to 1975Co09 .
3688.6 5	(3)	0.28 ps +11-8	T _{1/2} : from 1975Co09 . Other: <104 fs (1973Ha56).
3703.8 5	(1 ⁺ ,2,3 ⁺)	>0.76 ps	T _{1/2} : from 1975Co09 .
3813.3 [‡] 8	2 ⁻		

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$^{40}\text{Ca}(\text{d},\alpha\gamma)$ **2007Pr03,1975Co09,1973Ha56 (continued)** ^{38}K Levels (continued)

E(level) [†]	J ^π [@]	T _{1/2} ^{&}	Comments
3856.2 20	1 ⁺	<83 fs	T _{1/2} : from 1973Ha56.
3931.1 7	2 ⁻		
3978.9 10	1 ⁺	<40 fs	T _{1/2} : from 1973Ha56.
4331.0 [#] 15		0.24 ps +49-17	T _{1/2} : from 1975Co09.
4700.5 [‡] 10			

[†] From a least-squares fit to γ -ray energies, unless otherwise noted.

[‡] Level from 2007Pr03.

[#] Level from 1975Co09.

[@] From Adopted Levels. The assignments made in this dataset from $\gamma(\theta)$ data for spin and substate population data for parity of 1972Ha15 are given under comments.

[&] From DSAM method.

 $\gamma(^{38}\text{K})$

E _i (level)	J _i ^π	E _γ [†]	I _γ ^b	E _f	J _f ^π	Mult. ^c	δ ^c	Comments
458.6	1 ⁺	327.9 2	100.0 3	130.6	0 ⁺	M1		E _γ : weighted average of 327.7 4 (1975Co09) and 328.0 2 (1973Ha56). Other: 329.1 2 (2007Pr03).
1698.0	1 ⁺	458.4 ^{&a} 4 1567.4 2	1.5 3 100	0 130.6	3 ⁺ 0 ⁺	M1		E _γ : weighted average of 1568.3 5 (1975Co09) and 1567.4 1 (1973Ha56). Other: 1568.0 4 (2007Pr03). I _γ : from 1972Ha15.
2401.2	2 ⁺	704.4 ^{&ad} 8 1942.5 1	<6 100 2	1698.0 458.6	1 ⁺ 1 ⁺	D+Q	+0.077 12	E _γ : weighted average of 1943.3 10 (1975Co09) and 1942.5 1 (1973Ha56). Other: 1944.3 5 (2007Pr03). I _γ : from 1972Ha15. Other: 100 3 from 2007Pr03.
		2270.6 [‡] 9	9 2	130.6	0 ⁺			E _γ : other: 2273.1 14 (2007Pr03). I _γ : weighted average of 8 2 (1972Ha15) and 10 3 (2007Pr03).
		2401.7 ^{&ad} 3	<4	0	3 ⁺			E _γ : quoted value reduced 2 keV from 2403.7 3 (2007Pr03).
2613.1	3 ⁻	2612.9 [‡] 4	100	0	3 ⁺			E _γ : other: 2616.6 4 (2007Pr03). A ₂ =+0.282 17, A ₄ =+0.01 3 (1972Ha15).
2645.8	(4) ⁻	2646.3 [‡] 7	100	0	3 ⁺			E _γ : other: 2649.6 4 (2007Pr03).
2828.2	1 ⁻	425.6 [#] 8	10.5 5	2401.2	2 ⁺			E _γ : other: 426.3 4 (2007Pr03). I _γ : other: 22 6 (1972Ha15).
		2698.3 6	100.0 5	130.6	0 ⁺			E _γ : weighted average of 2698.7 12 (1975Co09) and 2698.2 6 (1973Ha56). Other: 2700.3 8 (2007Pr03).
2869.5	2 ⁻	467.6 [#] 6	31.4 5	2401.2	2 ⁺			I _γ : other: 100 6 (1972Ha15). E _γ : other: 468.2 3 (2007Pr03). I _γ : other: 24 9 (1972Ha15).
		1171.9 [#] 7	17 1	1698.0	1 ⁺			E _γ : other: 1172.1 8 (2007Pr03). I _γ : other: 15 9 (1972Ha15).
		2411.6 17	57.8 7	458.6	1 ⁺			E _γ : weighted average of 2412.0 20 (1975Co09)

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$^{40}\text{Ca}(\text{d},\alpha\gamma)$ 2007Pr03,1975Co09,1973Ha56 (continued) $\gamma(^{38}\text{K})$ (continued)

$E_i(\text{level})$	J_i^π	$E_\gamma^\dagger$	I_γ^b	E_f	J_f^π	Mult. ^c	δ^c	Comments
								and 2411.3 17 (1973Ha56). Other: 2413.1 5 (2007Pr03).
2869.5	2 ⁻	2870.1 9	100 1	0	3 ⁺			I_γ : other: 78 13 (1972Ha15). E_γ : weighted average of 2871.0 20 (1975Co09) and 2869.9 9 (1973Ha56). Other: 2872.7 4 (2007Pr03).
2993.1	0 ⁻	2534.4 [‡] 3	100	458.6	1 ⁺			I_γ : other: 100 9 (1972Ha15). $\gamma(\theta)$ is isotropic (1972Ha15).
3315.5	(1 ⁺ ,2 ⁻ ,3 ⁺)	914.7 12	100 7	2401.2	2 ⁺			E_γ : other: 2536.4 7 (2007Pr03). E_γ : unweighted average of 915.9 4 (1975Co09) and 913.5 2 (1973Ha56). Other: 914.2 3 (2007Pr03).
		3314.9 12	82 7	0	3 ⁺			I_γ : from 1972Ha15. E_γ : weighted average of 3320 4 (1975Co09) and 3314.6 9 (1973Ha56). I_γ : from 1972Ha15.
3341.5	1 ⁺	3210.7 [‡] 7	100	130.6	0 ⁺			
3418.4	(6) ⁻	772.6 [‡] 15	100 18	2645.8	(4) ⁻			E_γ : other: 774.1 4 (2007Pr03). I_γ : from 1972Ha15.
		3419 ^{‡d}	82 18	0	3 ⁺			E_γ : γ not reported by 2007Pr03. I_γ : from 1972Ha15.
3430.4	2 ⁺	1029.1 [#] 7		2401.2	2 ⁺			
		3431 [#] 4		0	3 ⁺			
3443?		1042 ^{‡d}	100	2401.2	2 ⁺			
3614.2	(3,5) ⁻	968.4 ^{&a} 4		2645.8	(4) ⁻			
3668.2	3 ⁺	1267.0 [‡] 4		2401.2	2 ⁺	D(+Q)	+0.02 4	E_γ : other: 1267.0 8 (2007Pr03).
3688.6	(3)	1042.9 ^{&} 3	100 20	2645.8	(4) ⁻			
		1075.3 ^{&} 7	46 15	2613.1	3 ⁻			
		3557 [‡]		130.6	0 ⁺			E_γ : γ not reported by 2007Pr03.
3703.8	(1 ⁺ ,2,3 ⁺)	1302.6 ^{&} 3		2401.2	2 ⁺			
3813.3	2 ⁻	1412.1 ^{&a} 7		2401.2	2 ⁺			
3856.2	1 ⁺	3725.4 ^{‡@} 19		130.6	0 ⁺			
3931.1	2 ⁻	1318.0 ^{&} 5		2613.1	3 ⁻			
3978.9	1 ⁺	3520 [#]		458.6	1 ⁺			
		3848.5 ^{‡@} 21		130.6	0 ⁺			
4331.0		400 [#]		3931.1	2 ⁻			
4700.5		1086.3 ^{&a} 7		3614.2	(3,5) ⁻			

[†] From weighted average of 1975Co09 and 1973Ha56, unless otherwise noted. Corresponding values from 2007Pr03 are systematically higher by about 1 keV at low energies to as much as 2-3 keV at higher energies. The precision is comparable in different studies.

[‡] From 1973Ha56 (and/or 1972Ha15).

[#] From 1975Co09.

[@] Placement from 1975Co09, 1973Ha56 placed this as g.s. transition.

[&] From 2007Pr03, but quoted E_γ reduced by 1 keV to account for systematic differences between values from 2007Pr03 and corresponding values from 1975Co09 and 1973Ha56. The original values from 2007Pr03 are given under comments.

^a γ reported in 2007Pr03 only.

^b From 2007Pr03, unless otherwise noted.

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${}^{40}\text{Ca}(\text{d},\alpha\gamma)$ [2007Pr03,1975Co09,1973Ha56](#) (continued)

$\gamma({}^{38}\text{K})$ (continued)

^c From $\gamma(\theta)$ data and substate population data in [1972Ha15](#). For many transitions [1972Ha15](#) give multiple values of mixing ratios depending on the spin choice, these are not listed here.

^d Placement of transition in the level scheme is uncertain.

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Legend

Level Scheme

Intensities: Relative photon branching from each level

-----► γ Decay (Uncertain)