^{35}Ca $\varepsilon+\beta^+$ decay (25.7 ms) 1999Tr04,1985Ay01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Lijie Sun and Jun Chen	NDS 211,1 (2026)	30-Sep-2025

Parent: ^{35}Ca: E=0; J^π=1/2$^+$; $T_{1/2}$=25.7 ms *2*; Q($\varepsilon+\beta^+$)=1.595×10^4 *11*; %$\varepsilon+\beta^+$ decay=100

^{35}Ca-J^π,$T_{1/2}$: From the Adopted Levels of ^{35}Ca.

^{35}Ca-Q($\varepsilon+\beta^+$): 15950 *105* deduced by evaluators from mass excesses of 4777 *105* for ^{35}Ca measured by 2023La09 and −11172.9 *5* for ^{35}K from 2021Wa16. Q(ε) from 2021Wa16: 16360 *200* (syst).

1999Tr04, 1998Le45: A secondary ^{35}Ca beam at 0.3 ions/s and 98% purity was produced via the projectile fragmentation of a 95-MeV/nucleon ^{40}Ca^{20+} primary beam impinging on a rotating ^{nat}Ni target, selected using ΔE-ToF by the GANIL LISE3 spectrometer, and implanted into a 500−μm thick silicon detector sandwiched between two 500−μm thick silicon detectors for detecting β^+ particles. 3.5×10^4 ^{35}Ca ions were stopped at a depth of 300 μm with FWHM=70 μm (setting 1) and 2.5×10^4 ^{35}Ca ions were stopped at a depth of 450 μm (setting 2). $\varepsilon+\beta^+$-delayed protons were detected by the implantation detector. γ rays were detected by three Ge detectors and two NaI detectors. Measured E_p, I_p, Eγ, Iγ, E_{2p}, I_{2p}, βp-coin, pγ-coin. Built the decay scheme consisting of 1p-emitting states in ^{35}K, a 2p-emitting state (T=5/2 IAS) in ^{35}K, 1p daughter states in ^{34}Ar, and a 2p daughter state in ^{33}Cl. Deduced decay branching ratios, B(GT) and B(F), and parent ^{35}Ca $T_{1/2}$ from implant-decay correlations.

1985Ay01: ^{35}Ca isotope discovery. ^{35}Ca was produced by bombarding a natural calcium target using a 135-MeV ^{3}He beam from the 88-inch Cyclotron at Lawrence Berkeley Laboratory. Recoiling products were slowed down, transported, and collected on a slowly rotating catcher wheel. The $\varepsilon+\beta^+$-delayed protons were detected using Si detector telescopes. Measured E_p, I_p, pp-coin. Built the decay scheme consisting of a 2p-emitting state (T=5/2 IAS) in ^{35}K, sequential 2p intermediate states in ^{34}Ar, and 2p daughter states in ^{33}Cl. Deduced ^{35}Ca $T_{1/2}$ and ^{35}Ca mass using the known members of A=35, T=5/2 sextuplets IMME.

Theoretical studies involving ^{35}Ca decay: 2003Sm02, 1991De26, 1990Br26.

The decay scheme is considered relatively complete as all observed individual I(1p) and I(2p) add up to almost 100% in 1999Tr04.

^{35}K Levels

E(level)†	J^π#	$T_{1/2}$#	Comments
0	3/2$^+$	175 ms *2*	
1553 *5*	(1/2)$^+$		$E(p0)_{lab}$=1427 *5*, proton line 1 in 1999Tr04.
3781 *26*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=3592 *25*, proton line 5 in 1999Tr04.
4018 *37*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=3822 *36*, proton line 6 in 1999Tr04.
4520‡			$E(p1)_{lab}$=1909-2647, proton group 2 in 1999Tr04, corresponding to E(level)=4140-4900.
4788 *49*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=4570 *48*, proton line 9 in 1999Tr04.
4982 *13*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=4754 *38*, proton line 10 in 1999Tr04, corresponding to E(level)=4977 *39*. $E(p1)_{lab}$=2727 *13*, proton line 3 in 1999Tr04, corresponding to E(level)=4982 *13*. E(level): weighted average of the two E(level) values of 4977 *39* (p0) and 4982 *13* (p1).
5249 *73*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=5018 *71*, proton line 11 in 1999Tr04.
5493‡			$E(p1)_{lab}$=2947-3500, proton group 4 in 1999Tr04, corresponding to E(level)=5208-5778.
5533 *49*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=5294 *48*, proton line 12 in 1999Tr04.
5710 *49*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=5466 *48*, proton line 13 in 1999Tr04.
5716‡			$E(p2)_{lab}$=1909-2647, proton group 2 in 1999Tr04, corresponding to E(level)=5336-6096.
5865 *38*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=5616 *37*, proton line 14 in 1999Tr04.
6089 *62*	1/2$^+$,3/2$^+$		$E(p0)_{lab}$=5834 *60*, proton line 15 in 1999Tr04.
6302‡			$E(p3)_{lab}$=1909-2647, proton group 2 in 1999Tr04, corresponding to E(level)=5922-6681.
6335 *73*	1/2$^+$,3/2$^+$		$E(p1)_{lab}$=4041 *71*, proton line 7 in 1999Tr04.
6585‡			$E(p0)_{lab}$=5983-6649, proton group 16 in 1999Tr04, corresponding to E(level)=6243-6928.
7813‡			$E(p0)_{lab}$=7131-7887, proton group 18 in 1999Tr04, corresponding to E(level)=7424-8203.
9168 *23*	1/2$^+$		T=5/2 E(level): weighted average of the three E(level) values of 9144 *92* (p0), 9157 *23* (p1), and 9186 *27* (2p0). J^π,T: isobaric analog state of 1/2$^+$ ^{35}Ca g.s. (1985Ay01,1999Tr04). $E(p0)_{lab}$=8802 *89*, proton line 19 in 1999Tr04, corresponding to E(level)=9144 *92*. $E(p1)_{lab}$=6783 *22*, proton line 17 in 1999Tr04, corresponding to E(level)=9157 *23*. $E(2p0)_{lab}$=4305 *26*, proton line 8 in 1999Tr04, corresponding to E(level)=9186 *27* with

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^{35}Ca ε+β^+ decay (25.7 ms) 1999Tr04,1985Ay01 (continued)

^{35}K Levels (continued)

E(level)[†]	J^{π}[#]	$T_{1/2}$[#]	Comments
			S(2p)(^{35}K)=4747.5 *6* (2021Wa16) and adding a +7−keV correction for the difference in the recoil effect between 1p and 2p emissions (1999Tr04). Others: E(2p0)$_{lab}$=4089 *30*, E(2p0)$_{c.m.}$=4311 *40* (1985Ay01), corresponding to E(level)=9059 *41* in ^{35}K with S(2p)(^{35}K)=4747.5 *6* (2021Wa16). 1985Ay01 observed E(2p1)$_{lab}$=3287 *30* and proposed both 2p0 and 2p1 proceed via a sequential decay mechanism with the first proton E(p)$_{lab}$=2213 keV, corresponding to an intermediate state in ^{34}Ar at 6807 keV. However, 2p1 has been ruled out in 1999Tr04 due to the nonobservation of expected pγ coincidences. 1999Tr04 also states that the observed ratio I(2p0)/I(p)=0.98 *9* agrees with the calculated branching ratio I(2p)/I(p)=1 for the IAS (1991De26).

† Evaluators deduced E(level)(^{35}K)=E(p)$_{lab}$×[m(p)+m(^{34}Ar)]/m(^{34}Ar)+S(p)(^{35}K)+E(level)(^{34}Ar), with S(p)(^{35}K)=83.6 *5* (2021Wa16), E(level)(^{34}Ar) from 2012Ni10, and E(p)$_{lab}$ from 1999Tr04. For a ^{35}K proton-emitting level with multiple proton branches, evaluators take the weighted average for E(level)(^{35}K) values deduced from each proton branch. 1999Tr04 used S(p)(^{35}K)=78 *20* from 1993Au07, which causes a small difference between the original E(level)(^{35}K) in 1999Tr04 and the deduced E(level)(^{35}K) here.

‡ Unresolved proton-emitting levels corresponding to a group of unresolved protons populating one daughter state in ^{34}Ar, which are not included in the Adopted Levels.

\# From the Adopted Levels.

ε,β^+ radiations

av Eβ: Additional information 1.

E(decay)	E(level)	Iβ^+[#]	Iε[#]	Log *ft*	I($\varepsilon+\beta^+$)[†#]	Comments
(6.78×10^3 *11*)	9168	8.4 *4*	0.0056 *9*	3.3 *1*	8.4 *4*	av Eβ=2671 *54*; εK=6.02×10^{-4} *89*; εL=5.66×10^{-5} *84*; εM+=9.5×10^{-6} *13* I($\varepsilon+\beta^+$): %I(p0)=0.41 *6*, %I(p1)=3.8 *2*, %I(2p0)=4.2 *3*.
(8.14×10^3 *11*)	7813	1.1 *2*	4.0×10^{-4} *9*	4.6	1.1[‡] *2*	av Eβ=3335; εK=3.27×10^{-4} *44*; εL=3.07×10^{-5} *42*; εM+=5.13×10^{-6} *63*
(9.37×10^3 *11*)	6585	1.08 *17*	2.5×10^{-4} *5*	4.9	1.08[‡] *17*	av Eβ=3933; εK=2.07×10^{-4} *27*; εL=1.95×10^{-5} *25*; εM+=3.24×10^{-6} *37*
(9.62×10^3 *13*)	6335	2.9 *3*	6.1×10^{-4} *10*	4.6 *1*	2.9 *3*	av Eβ=4056 *64*; εK=1.90×10^{-4} *26*; εL=1.79×10^{-5} *24*; εM+=2.99×10^{-6} *36*
(9.65×10^3 *11*)	6302	2.0 *7*	4×10^{-4} *2*	4.7	2.0[‡] *7*	av Eβ=4076; εK=1.88×10^{-4} *24*; εL=1.77×10^{-5} *22*; εM+=2.95×10^{-6} *34*
(9.86×10^3 *13*)	6089	1.39 *19*	2.7×10^{-4} *5*	4.9 *1*	1.39 *19*	av Eβ=4179 *64*; εK=1.76×10^{-4} *23*; εL=1.65×10^{-5} *22*; εM+=2.75×10^{-6} *32*
(1.009×10^4 *12*)	5865	1.42 *17*	2.6×10^{-4} *5*	5.0 *1*	1.42 *17*	av Eβ=4287 *59*; εK=1.63×10^{-4} *21*; εL=1.54×10^{-5} *19*; εM+=2.56×10^{-6} *29*
(1.023×10^4 *11*)	5716	1.0 *4*	1.7×10^{-4} *7*	5.2	1.0[‡] *4*	av Eβ=4361; εK=1.56×10^{-4} *19*; εL=1.47×10^{-5} *18*; εM+=2.45×10^{-6} *27*
(1.024×10^4 *12*)	5710	0.61 *15*	1.1×10^{-4} *3*	5.4 *+2−1*	0.61 *15*	av Eβ=4366 *59*; εK=1.56×10^{-4} *20*; εL=1.46×10^{-5} *19*; εM+=2.44×10^{-6} *28*
(1.042×10^4 *12*)	5533	0.72 *18*	1.2×10^{-4} *3*	5.4 *+2−1*	0.72 *18*	av Eβ=4454 *59*; εK=1.48×10^{-4} *19*; εL=1.39×10^{-5} *18*; εM+=2.32×10^{-6} *26*
(1.046×10^4 *11*)	5493	2.2 *3*	3.6×10^{-4} *7*	4.9	2.2[‡] *3*	av Eβ=4474; εK=1.46×10^{-4} *18*; εL=1.37×10^{-5} *17*; εM+=2.28×10^{-6} *25*

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^{35}Ca $\varepsilon+\beta^+$ decay (25.7 ms) 1999Tr04,1985Ay01 (continued)

ϵ,β^+ radiations (continued)

E(decay)	E(level)	$I\beta^+$ #	$I\varepsilon$#	Log *ft*	$I(\varepsilon+\beta^+)$†#	Comments
(1.070×10^4 *13*)	5249	3.9 *3*	5.9×10^{-4} *9*	4.7 *1*	3.9 *3*	av Eβ=4592 *64*; εK=1.36×10^{-4} *18*; εL=1.28×10^{-5} *16*; εM+=2.13×10^{-6} *25*
(1.097×10^4 *11*)	4982	10.1 *7*	0.0014 *2*	4.32 *6*	10.1 *7*	av Eβ=4725 *54*; εK=1.26×10^{-4} *15*; εL=1.18×10^{-5} *14*; εM+=1.97×10^{-6} *22* $I(\varepsilon+\beta^+)$: %I(p0)=4.2 *4*, %I(p1)=6.0 *5*.
(1.116×10^4 *12*)	4788	2.9 *3*	3.8×10^{-4} *6*	4.9 *1*	2.9 *3*	av Eβ=4819 *59*; εK=1.19×10^{-4} *15*; εL=1.12×10^{-5} *14*; εM+=1.86×10^{-6} *21*
(1.143×10^4 *11*)	4520	5.4 *9*	7×10^{-4} *2*	4.7	5.4‡ *9*	av Eβ=4952; εK=1.11×10^{-4} *13*; εL=1.04×10^{-5} *12*; εM+=1.74×10^{-6} *19*
(1.193×10^4 *12*)	4018	3.8 *3*	4.1×10^{-4} *6*	4.9 *1*	3.8 *3*	av Eβ=5198 *59*; εK=9.7×10^{-5} *12*; εL=9.1×10^{-6} *11*; εM+=1.52×10^{-6} *16*
(1.217×10^4 *11*)	3781	3.0 *3*	3.0×10^{-4} *5*	5.1 *1*	3.0 *3*	av Eβ=5316 *54*; εK=9.1×10^{-5} *11*; εL=8.6×10^{-6} *10*; εM+=1.43×10^{-6} *15*
(1.440×10^4 *11*)	1553	48.2 *13*	0.0030 *4*	4.26 *3*	48.2 *13*	av Eβ=6417 *54*; εK=5.52×10^{-5} *62*; εL=5.19×10^{-6} *58*; εM+=8.66×10^{-7} *88*

† Deduced from the I(p) values in 1999Tr04 multiplied by 0.994. The original %ΣI(1p)=96.4 *18* and %ΣI(2p)=4.2 *3* in 1999Tr04 lead to %ΣI(1p)+%ΣI(2p)=100.6. The evaluators perform a renormalization of 100.6 to 100, which yields the factor of 0.994. The original I(p) in 1999Tr04 was determined from the number of observed proton events and the total number of implants, with simulated proton-detection efficiencies.

‡ Feeding to a group of unresolved levels in ^{35}K. The corresponding Log *ft* values are displayed without uncertainties.

Absolute intensity per 100 decays.