^{48}Ca $2\beta^-$ decay 2016Ar19,2002Bb03,2000Br63

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Parent: ^{48}Ca: E=0.0; $J^\pi=0^+$; $T_{1/2}=2.9\times10^{19}$ y *+42−11*; Q($2\beta^-$)=4268.08 *8*; %$2\beta^-$ decay=74 *26*

^{48}Ca-$T_{1/2}$: From ^{48}Ca Adopted Levels. $T_{1/2}(2\beta^-)=2.5\times10^{19}$ y *+39−10* estimated by evaluator from partial $T_{1/2}(2\beta^-)$'s to g.s., 984, 2421, and 2997. Other: $T_{1/2}(2\nu2\beta^-)=2.87\times10^{19}$ y *51* (2004Ra26; from analysis of Gamow-Teller strengths in ^{48}Ti(d,2p) and ^{48}Ca(p,n).) and 3.55×10^{19} y *75* (2006Fr03, preliminary; from analysis of Gamow-Teller strengths in ^{48}Ti(d,2p) and ^{48}Ca(^{3}He,t).); $T_{1/2}(2\nu$, g.s. to g.s.)$=4.44\times10^{19}$ y *+49−40*(stat) *29*(syst) reported from a NEMO3 experiment in a thesis (2008KiZL).

^{48}Ca-Q($2\beta^-$): From 2021Wa16.

^{48}Ca-%$2\beta^-$ decay: symmetrized value of 78% *+22−30* from Adopted Levels of ^{48}Ca.

2016Ar19: measured $2\nu2\beta^-$-decay halflife with NEMO-3 in the Modane underground laboratory. $T_{1/2}(2\nu2\beta^-)=6.4\times10^{19}$ y *+7−6*(stat) *+12−9*(syst), $T_{1/2}(0\nu2\beta^-)>2.0\times10^{22}$ y (90% C.L). Results from 2016Ar19 should supersede all previous results from NEMO-3 in 2012Si23 and 2011Ba55,

2002Bb03,2002Ba33: source was a powder of $^{48}CaCO_3$ (73% ^{48}Ca) at Modane Underground Laboratory. Measured Eγ, Iγ with low-background 400 cm^3 HPGe with a passive shield of 6 cm lead, 10 cm of OFHC copper, and 15 cm of ordinary lead. 2002Bb03 repeat the measurement by 2002Ba33 since large impurities were found in the latter. Results in 2002Bb03 supersede those in 2002Ba33. $T_{1/2}(\beta^-)>1.6\times10^{20}$ y, $>2.5\times10^{20}$ y, $>1.9\times10^{20}$ y for single β^- decay to g.s., 131 and 152 levels, respectively; $T_{1/2}(2\beta^-)>1.8\times10^{20}$ y, $>1.5\times10^{20}$ y, $>1.5\times10^{20}$ y for $2\beta^-$ decay to 984, 2421, and 2297 levels, respectively, all with 90% C.L.

2000Br63,2000Br44: 3.5 g *1* of ^{48}Ca sources in 8 squares with mixture of 80% $CaCO_3$ and 20% polyvinyl (77.8% ^{48}Ca) at Modane Underground Laboratory. Measured $\beta\beta$-coincidences with TGV (Telescope Germanium Vertical; 16 HPGe detectors, 20-cm Cu thick shielding, airtight box), $\beta\gamma$ discrimination for 8700-h run. $T_{1/2}(2\nu2\beta^-)=4.2\times10^{19}$ y *+33−13*, $T_{1/2}(0\nu2\beta^-)>1.5\times10^{21}$ y (90% C.L.).

2012Si23,2010Si06: measured $2\nu2\beta^-$-decay halflife with NEMO-3 in the Modane underground laboratory. See also 2011TrZW, 2009KoZY, 2008KoZV of the same measurement. $T_{1/2}(2\nu2\beta^-)=4.4\times10^{19}$ y *+5−4*(stat) *4*(syst).

2011Ba55: measured $0\nu2\beta^-$-decay halflife with NEMO-3 in the Modane underground laboratory. $T_{1/2}(0\nu2\beta^-)>1.3\times10^{22}$ y (90% C.L).

2005Zd02: pilot study on use of enriched $^{48}CaWO_4$ crystal scintillators to measure ^{48}Ca $T_{1/2}(0\nu2\beta^-)$. Scintillation properties (energy resolution, α/β ratio, and pulse-shape discrimination ability) and radiopurity of $^{48}CaWO_4$ scintillators studied. Preliminary result using a small non-enriched crystal was $T_{1/2}(0\nu2\beta^-)>6\times10^{19}$ y for a 1374 h measuring time. Estimated sensitivity for ≈100 kG $^{48}CaWO_4$ crystals is $T_{1/2}(0\nu2\beta^-)>1.0\times10^{27}$ y.

2002Be36: measured $\gamma\gamma$-coin with NaI(Tl) detectors at INFN. $T_{1/2}(2\nu2\beta^-)>1.2\times10^{18}$ y (90% C.L.).

2008Um05,2004Og01,2003Og05: measured γ spectra with a CaF_2 scintillation detector system (ELEGANT VI) at the underground laboratory (Oto Cosmo Observatory). $T_{1/2}(0\nu2\beta^-)>5.8\times10^{22}$ y (90% C.L.). Result from 2008Um05 supersedes their previous result in 2004Og01. See also 2000OgZW and 2000OgZX.

1996Ba80,1996Bb01: measured $1e^-$ and $2e^-$; tunnel at Hoover Dam under a minimum of 72 meters of rock; UC Irvine time projection chamber with 2β source as the central electrode in a magnetic field. 42.2 g of CaO_3 (18.5 mg/cm^2 total thickness with substrate and binder) and 10.3 CaO_3 (5.4 mg/cm^2) sources enriched to 73% ^{48}Ca. 2440 h exposure for thick source and 4001 h exposure for thin source. 14.0 *47* 2β events from one analysis of the thin source data resulted in $T_{1/2}(2\nu2\beta^-)=4.3\times10^{19}$ y *+24−11* with systematic uncertainty of 1.4×10^{19} y based on the difference between two different analyses of the thin source and detector efficiency. See 1996Ba80 for more details on the analysis, results from the thick target, and an alternate but consistent with the one adopted by 1996Ba80.

1991SaZQ: measured I($2\beta^-$). Natural CaF_2 crystals containing a total of 0.32 grams of ^{48}Ca in Kamioka underground laboratory; 1314 hours.

1991Yo05: measured I($2\beta^-$). Natural CaF_2 crystals containing a total of 43.0 grams of 48Ca in coal mine; 7588.5 hours.

1986Al05: reanalyzed the ^{48}Ca β^- decay data of 1985Al17 to obtain a lower limit on $T_{1/2}$ for ^{48}Ca 0^+ to ^{48}Ti 2297,2^+ $2\beta^-$ decay transition. The 2014γ-983γ coincidence would be the signature for this decay.

1970Ba61: 10.6-grams $^{48}CaF_2$ source in a deep salt mine. Measured I($2\beta^-$) with a streamer chamber triggered by two scintillation counters. Deduced $T_{1/2}$. Data were reanalyzed by 1989Ba05.

Others: 2009SaZR, 2009Ki19.

^{48}Ca is a particularly attractive candidate for a 2β-decay search. The β^- decay of ^{48}Ca to ^{48}Sc is suppressed due to the angular momentum conservation law (J^π(^{48}Ca, g.s.)$=0^+$ and J^π(^{48}Sc,g.s.)$=6^+$) and the $2\beta^-$ decay has the largest available energy release

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for all 2β candidates ($Q(2\beta^-)$=4.274 MeV *4*) that is higher than most of the radioactive backgrounds. Therefore, the large space factor compensates for a relatively small nuclear matrix element. See 1993Mo36 for a review of $2\beta^-$ decay searches. Others: see the Nuclear Science References File for theoretical studies, compilations, and reviews. See 1990Al19 for a measurement of $\sigma(\theta)$ from the ^{48}Ti(n,p) reaction at E=198 MeV and its possible implications on ^{48}Ca $2\beta^-$ decay.

^{48}Ti Levels

E(level)†	J$^\pi$†	$T_{1/2}$†	Comments
0.0	0^+	stable	$T_{1/2}(2\nu2\beta^-)=5.6\times10^{19}$ y *+14−11*, from weighted average of 6.4×10^{19} y *+7−6*(stat) *+12−9*(syst) (2016Ar19), 4.3×10^{19} y *+24−11* (1996Ba80, syst $\Delta T_{1/2}=1.4\times10^{19}$ y), and 4.2×10^{19} y *+33−13* (2000Br63) for decay to this state; syst $\Delta T_{1/2}$ added in quadrature before averaging. Note that 4.2×10^{19} y *+22−11* from 2006BaZZ is from the average of the latter two. Other: $>3.6\times10^{19}$ y (1970Ba61). Theory: 1.3×10^{19} y$\le T_{1/2}(2\nu2\beta^-)\le6.0\times10^{19}$ y (1998Su19). $T_{1/2}(0\nu2\beta^-)\ge5.8\times10^{22}$ y for decay to this state (2008Um05, 90% C.L.). Others: $>2.0\times10^{22}$ y (2016Ar19, 90% C.L.), $>1.5\times10^{21}$ y (2000Br63, 90% C.L.), $>1.1\times10^{21}$ y (1989Ba05), $>9.5\times10^{21}$ y (1991Yo05, 76% C.L.), and $>1.6\times10^{19}$ y (1991SaZQ). Theory: 1.3×10^{25} y$\le T_{1/2}(0\nu2\beta^-)\le4.0\times10^{25}$ y (1998Su19).
(983.5)	2^+		$T_{1/2}(2\beta^-)>1.8\times10^{20}$ y for decay to this state (2002Bb03, 90% C.L.). Other: $T_{1/2}(0\nu2\beta^-)>1.0\times10^{21}$ y (1970Ba61). Theory: $T_{1/2}(2\nu2\beta^-)=5.0\times10^{26}$ y (1984Ha60).
(2421.1)	2^+		$T_{1/2}(2\beta^-)>1.5\times10^{20}$ y for decay to this state (2002Bb03, 90% C.L.). Theory: $T_{1/2}(2\nu2\beta^-)=3.6\times10^{26}$ y (1984Ha60).
(2997.3)	0^+		$T_{1/2}(2\beta^-)>1.5\times10^{20}$ y for decay to this state (2002Bb03, 90% C.L.). Other: $T_{1/2}(0\nu2\beta^-)>8\times10^{18}$ y (1986Al05, 95% C.L.).

† From Adopted Levels. Energies are rounded values.

$\gamma(^{48}Ti)$

E_γ†	E_i(level)	J_i^π	E_f	J_f^π
(983.5)	(983.5)	2^+	0.0	0^+
(2013.8)	(2997.3)	0^+	983.5?	2^+

† Rounded values from Adopted Gammas.

Legend

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Decay Scheme