Adopted Levels, Gammas

Q(β^-)=1.656×10^4 *10*; S(n)=580 *90*; S(p)=2.667×10^4 *23*; Q(α)=−1.984×10^4 *19* 2017Wa10

The mass excess adopted by (2012Wa38) is 32.41 MeV *10*. See also 1986Vi09, 1987Gi05, 1988Wo09, 1991Or01.

Halo nucleus:

The ^{19}C nucleus has been suggested as a 1-neutron halo nucleus based on measurements of various reaction cross sections and momentum distributions of breakup products. See discussions in:

1989Sa10: E(^{19}C)=45.12 MeV/nucleon, Cu target, $\sigma_{reaction}$=2.7 b *15*.

1995Ba28: E(^{19}C)≈77.2 MeV/nucleon, Be target, FWHM(^{18}C parallel momentum dist)$_{lab}$=44 MeV/c *6*.

1996Ma25: E(^{19}C)=30.3 MeV/nucleon, Ta target, σ_{1n}=2.5 b *4*, $\sigma_{charge\ changing}$=0.595 b *10*, FWHM(n angular momentum dist)=42 MeV/c.

1998Ba28: E(^{19}C)≈88 MeV/nucleon, Be and Ta targets, $\sigma(Be)_{1n}$=105 mb *17* and FWHM(^{18}C parallel momentum dist)=42 MeV/c *4*. $\sigma(Ta)_{1n}$=1.1 b *4* and FWHM(^{18}C parallel momentum dist)=41 MeV/c *3*.

1998Ba87: E(^{19}C)≈910 MeV/nucleon, carbon target, FWHM(^{18}C parallel momentum dist)=69 MeV/c *3*. See (1999Sm01) who suggest the momentum distributions at different energies are affected by the low-lying excited state.

2001Co06: E(^{19}C)≈910 MeV/nucleon, C and Pb targets, $\sigma(C)_{1n}$=233 mb *51* and $\sigma(Pb)_{1n}$=1967 mb *334*. Evaluated relationship between S_{1n} and the S_{1n} separation energy. See also (2000Co31).

2001Oz03: E(^{19}C)=960 MeV/nucleon, carbon target, $\sigma_{interaction}$=1231 mb *28*, analyzed relation of σ_i to effective matter radius.

2009Na39: E(^{19}C)=240 MeV/nucleon, carbon and lead targets, $\sigma(C)_{1n}$=132 mb *4* and $\sigma(Pb)_{1n}$=969 mb *34*. Deduced σ_{1n}(Coulomb)=690 mb 70.

2016To10: E=307 MeV/nucleon, carbon target, $\sigma_{interaction}$=1.125±0.025(stat)±0.013(sys) b; find $R^{matter}_{rms}=3.10^{+0.05}_{-0.03}$ fm.

2001Ma08, 2001Ma21: E(^{19}C)≈50 MeV/nucleon, ^{9}Be target surrounded by 11 NaI detectors, σ_{1n}=264 mb *80* on ^{9}Be, σ_{1n}=1.35 b *18* on Au. Deduced (56 *9*)% of 1n-removal events populate $^{18}C_{g.s.}$ and measured a narrow $^{18}C_{g.s.}$ parallel momentum distribution by gateing on events not in coincidence with γ rays. By considering the relationship between the parallel momentum distribution width and S_n they deduce S_n≈650 keV *150*. Their analysis is found consistent only if Jπ(^{19}C)=1/2$^+$.

2010Ta04: E(^{19}C)=40 MeV/nucleon, ^{1}H liquid hydrogen target, σ_R=754 mb *22*, using the transmission method.

Analyses of the ^{19}C nuclear halo properties are given in: (1995Gu07, 1998Ri02, 1999Sm01, 2000Ka36, 2002Ka34, 2005Na09, 2013Lu02); discussion on mainly heavy carbon nuclide halos is given in (2000Be58, 2009Ch45, 2011Fo18); and broader discussion on halo nuclei including ^{19}C (1992La13, 1996Sh13, 1999La04, 2000Gu04, 2000Oz03, 2001Le21, 2001Lo20, 2003Li24, 2003Li31, 2004Ne16, 2010Gu15, 2011Al11, 2013Sh05, 2013Sh17, 2015Ha20, 2016Ya05). See also (1997Or03).

Theoretical analysis:

General theoretical analysis of the ^{19}C structure properties is given in (2000Ba24, 2008Ka39, 2014La02); analysis of the carbon isotopes is given in (1996Re19, 1997Ka25, 1998Sh16, 2000De35, 2003Sa50, 2003Su09, 2003Th06, 2004Su23, 2004Ta31, 2006Le33, 2006Ta28, 2007Ma53, 2007Sa50, 2009Um05); and broader analyses of light nuclear properties including ^{19}C are given in (1987Sa15, 1993Po11, 1996Su24, 1997Ba54, 1997Ho04, 2002Gu10, 2002Ka73, 2002Me12, 2003Le34, 2004La24, 2004Sa58, 2004Th11, 2005Sa63, 2006Ko02, 2007Do20, 2010Co05, 2012Yu07, 2013Sh05, 2014Ja14, 2015Sh21).

^{19}C Levels

Cross Reference (XREF) Flags

A	^{1}H(^{19}C,p′γ)	G	^{9}Be(^{40}Ar,^{19}C)	M	^{181}Ta(^{48}Ca,^{19}C)
B	^{1}H(^{19}C,^{18}Cn)	H	^{9}Be(^{48}Ca,^{19}C)	N	^{181}Ta(^{40}Ar,^{19}C)
C	^{1}H(^{19}C,X)	I	^{12}C(^{19}C,X)	O	^{208}Pb(^{19}C,^{19}C)
D	^{1}H(^{20}C,^{19}Cγ)	J	^{12}C(^{22}Ne,^{19}C)	P	Th(p,^{19}C)
E	^{9}Be(^{20}N,^{19}Cγ)	K	^{12}C(^{25}Ne,^{19}Cγ)	Q	U(p,^{19}C)
F	^{9}Be(^{22}N,^{19}C)	L	^{19}B β^- decay	R	^{241}Pu(n,F) E=thermal

E(level)	J$^\pi$	$T_{1/2}$	XREF	Comments
0	(1/2$^+$)	46.3 ms *40*	ABCDEFGHIJK MNOPQR	%β^-=100; %β^-n=47 *3*; %β^-2n=7 *3* $T_{1/2}$: from the weighted average of 49 ms *4* (1988Du09: see also preliminary value 30 ms *10* in 1988DuZT), 45.5 ms *40* (1995Oz02) and 44.1 ms *42* (Reeder et al., Int. Conf. on Nucl. Data for Science and Technology, May 9-13, 1994, Gatlinburg, Tennessee: see also 44

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{19}C Levels (continued)

E(level)	J$^\pi$	$T_{1/2}$	XREF	Comments
				ms *4* in the unpublished private communications of (2008ReZZ)/(1995ReZZ) and 45.5 ms *40* (1994RaZW)). Also see 46.2 ms *40* in (2015Bi05). J$^\pi$: from analysis of breakup fragment momentum distributions in 2001Ma08. Decay: Studies of the β-delayed neutron emission have been carried out in (1991Re02: $\beta^-n=\beta_{1n}+2(\beta_{2n})+3(\beta_{3n})...=(53\ 26)\%$), (1995ReZZ/2008ReZZ: $\beta^-n=(66\ 9)\%$), and (1988Du09: $\beta_{1n}=(47\ 3)\%$ and $\beta_{2n}=(7\ 3)\%$. Analysis of β-γ coincidences indicate the β_{1n} decay populates ^{19}N*(6400,6508,7025), which subsequently neutron decay to ^{18}B*(115,587) see (1995Oz02). There is evidence for additional branches that β-2n decay to ^{17}B with β-2n=(7 *3*)% (1988Du09).
209 *2*	(3/2$^+$)	1.34 ns *10*	A DE K	E(level): from (2015Wh02). See also 2005El07: 197 keV *6*, 2015Va09: 198 keV *10*, and 2008St18: 201 keV *15*. $T_{1/2}$: Analysis of the spectra using lineshape and recoil-distance techniques indicate T_{mean}=198 ns *10* and 190 ns *10* values, respectively (2015Wh02). Additional systematic uncertainties give final uncertainties of T_{mean}=198 ns *12* and 190 ns *13* for the two methods, respectively. The authors give a recommended value T_{mean}=194 ns *15*. J$^\pi$: from 2015Wh02, based on the B(M1) value; E2 components are excluded and neglected.
282? *5*			A	E(level): from Eγ=72 keV *4* to E_x=209 keV *2*. The Jπ of this state had initially been suggested as 5/2$^+$ based on expectations from shell model analysis. In this case β_2=0.29 *3*; deduced from integrated experimental cross section for this state from 0°−1.7° and distorted wave analysis (2005El07). However, subsequent observations and discussion in (2011Oz01, 2012Ko38, 2013Th06) support the notion that the first Jπ=5/2$^+$ state must be unbound. Cross section: 4.2 mb *5* in (p,p′).
653 *95*	(5/2$^+$)	<100 keV	F	%n≈100 E(level): deduced from E(^{18}C+n)=76 keV *14* and S(n)=577 keV *94*.
1.46×10^3 *10*	5/2$^+$	0.29 MeV *2*	B	%n≈100 E(level): deduced from E(^{18}C+n)=880 keV *10* and S(n)=577 keV *94*.

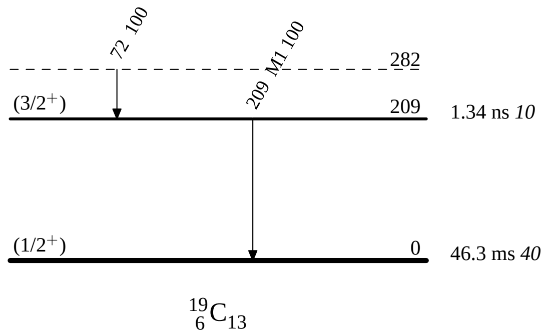
γ(^{19}C)

E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.	Comments
209	(3/2$^+$)	209 *2*	100	0	(1/2$^+$)	M1	B(M1)↓=0.00321 *25* (2015Wh02); B(M1)(W.u.)=0.00179 *14* (2015Wh02)
282?		72 *4*	100	209	(3/2$^+$)		

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^1H(^{19}C,p'\gamma)$ 2005El07

Beam=^{19}C, target=liquid H_2.

2005El07: A beam of 49.4 MeV/nucleon ^{19}C ions, produced in fragmentation of a 110 MeV/nucleon ^{22}Ne beam on a ^{9}Be target at the RIKEN/RIPS facility, was momentum and mass analyzed before impinging in a 3 cm diameter cryogenic hydrogen target that had an areal density of 190 mg/cm^2.

The scattered ^{19}C particles were detected in a ΔE-ΔE-ΔE-E telescope that covered θ<1.7°, while γ-rays were detected using the DALI2 array of 158 NaI(Tl) scintillators. Eγ, Iγ, $\gamma\gamma$, particle-γ coin were measured.

2005Ka26: The authors searched for evidence of an isomeric state with E_x<300 keV and $T_{1/2}$<500 ns, as predicted by shell model calculations.

A coctail beam, including ^{19}C and ^{17}B, was produced by fragmenting a ^{22}Ne beam on a ^{9}Be target at RIKEN. Beam particles were identified from analysis of ΔE, time-of-flight and beam rigidity. The beam impinged on a liquid hydrogen target that was surrounded by NaI γ-ray detectors; results for prompt transitions are reported in (2005El07). After the target, the beam was stopped in a ΔE-ΔE-ΔE-E telescope that was surrounded by thin plastic scintillators (for identification of β decay events) and an array of segmented HPGe clover detectors that were intended to observed delayed de-excitations from isomeric states populated in the reaction. Several transitions related to β-decay of daughters and granddaughters were identified. No definitive evidence in support of an isomeric state was found.

The authors commented on the level of confidence for non-observation over various transition energy ranges, and over various lifetime ranges. Finally, various combinations of Jπ values were considered for the ground state and a supposed isomeric state.

See also analysis in (2008Ka39).

^{19}C Levels

E(level)‡	J$^\pi$†	Comments
0.0	1/2$^+$	Configuration=$d^4_{5/2}\otimes s_{1/2}$ (2001Ma08).
197? *6*	(3/2$^+$)	Configuration of state suggested as mixture of $d^5_{5/2}$, $d^5_{5/2}\otimes s^2_{1/2}$ and $d^4_{5/2}\otimes s_{1/2}$ configurations (2001Ma08).
269? *8*	(5/2$^+$)	β_2=0.29 *3*; deduced from integrated experimental cross section for this state from 0°−1.7° and distorted wave analysis (2005El07). Cross section: 4.2 mb *5* in (p,p′).

† Tentative assignments to excited states based upon systematics of transition strengths combined with considerations of g.s. configuration and half-lives of the excited states.

‡ From 2005El07.

γ(^{19}C)

Neither of the observed transitions in ^{19}C from 2005El07 corresponds to a 5/2→1/2 γ ray as it would imply a long lifetime for each level and would make the observation of the transitions impossible with the setup described above.

E$_\gamma$†‡	I$_\gamma$‡	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Comments
72 *4*	100 *13*	269?	(5/2$^+$)	197?	(3/2$^+$)	
197 *6*	89 *12*	197?	(3/2$^+$)	0.0	1/2$^+$	E$_\gamma$: Assignment to (1/2$^+$) state based upon retarded feature of the 3/2→1/2 transition and the prompt nature of the observed γ rays. (2005El07).

† Quoted uncertainties are from statistical error and Doppler correction.

‡ From 2005El07.

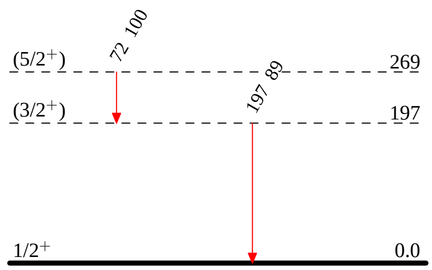
^{1}H(^{19}C,p′γ) 2005El07

Level Scheme

Intensities: Relative I_γ

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



$^{19}_{6}C_{13}$

^{1}H(^{19}C,^{18}Cn) 2008Sa03

2008Sa03:
Beam=^{19}C, target=liquid hydrogen.

A E=70 MeV/nucleon ^{19}C beam was produced at the RIKEN/RIPS facility by fragmenting a 110 MeV/nucleon ^{22}Ne in a thick target. The beam impinged on a 3 cm diameter cryogenic hydrogen target with 120 mg/cm^2 areal density. The γ-rays from reactions in the target were detected using 48 NaI(Tl) scintillators while charged particles were detected with a plastic counter hodoscope. Neutrons, from ^{19}C breakup, were detected using a neutron hodoscope consisting of two walls of plastic scintillator array.

The inclusive ^{18}C+n and exclusive ^{18}C+n+γ[^{18}C*(2$^+$)=1.58 MeV] spectra were analyzed. A resonance at E(rel)=0.88 MeV *1* with Γ=290 keV *20* was observed in the inclusive spectrum, but absent in the exclusive γ-ray coincidence events; evidence the state decays to $^{18}C_{g.s.}$. In addition, the angular distribution of the resonance was analyzed and compared with DWBA calculations.

See analysis in (2016La20), which suggests strong dynamic excitation of the ^{18}C core is required to find agreement in σ magnitude for the Jπ=5/2$^+$ ($E_x \approx$1.46 MeV) state. See also (2011Cr02).

2011Oz01: The cross section for 1-n removal from 40 MeV/nucleon ^{19}C on protons in a liquid hydrogen target (204 mg/cm^2) was measured at the RIKEN/RIPS facility along with the parallel momentum distribution of ^{18}C fragments. In addition, the 160 NaI(Tl) element DALI2 array surrounded the reaction target and measured deexcitation γ-rays correlated with breakup fragments. The cross section σ_{1n}=101 mb *11* is measured along with a ^{18}C fragment parallel momentum distribution width of FWHM=83 MeV/c *12*.

^{19}C Levels

E(level)†	J$^\pi$	Γ (MeV)	σ (mb)#	Comments
0	1/2$^+$			
1.46×10^3 *10*	5/2$^+$‡	0.29 MeV *2*	8.6 *4*	Resonance energy(c.m.)=880 keV *10* (g.s. in ^{18}C). J$^\pi$: from DWBA analysis of angular distribution.

† Excitation energy=resonance energy+S(n)+excitation energy of the daughter nucleus ^{18}C.
‡ From comparison of $\sigma(\theta)$ distributions with DWBA calculations for ^{19}C(p,p′) reaction.
# Experimental cross-sections.

^{1}H(^{19}C,X) 2011Ya13

Charge changing cross sections and total reaction cross sections for 40 MeV/nucleon ^{19}C+^{1}H reactions were measured at the RIKEN/RIPS facility. The σ_R=754 mb *22* was measured, along with various cross sections to specific elements.

^{19}C Levels

E(level)
0

^{1}H(^{20}C,^{19}Cγ) 2015Va09

2015Va09: The authors studied the low-lying structure of ^{19}C using the ^{1}H(^{20}C,^{19}C) reaction to populate levels that de-excited via γ-ray transitions. A single transition was observed and compared with theoretical estimates suggesting decay from a Jπ=3/2^{+} state to the 1/2^{+} ground state.

A cocktail beam that included a ^{20}C component was produced by fragmenting a E(^{40}Ar)=63 MeV/nucleon beam in a 0.2 mm thick ^{181}Ta target. The beam was purified in the RIKEN/RIPS fragment separator and transported to a 190 mg/cm^{2} liquid hydrogen target. The beam, which was identified via time-of-flight (ToF) using a thin plastic scintillator that was near the target, had an energy of around 50 MeV/nucleon at the center of the target. The heavy ejectiles within θ_{lab}<6.5° were identified using ΔE vs. E and ΔE vs ToF analysis. De-excitation γ-rays in coincidence with ^{19}C ejectiles were detected using the 160 DALI2 NaI scintillators arranged in a ball-like configuration that covered angles between θ_{lab}=15°−160°. A GEANT4 simulation indicated 54% efficiency at 200 keV.

The Doppler corrected spectrum indicated a transition corresponding to E$_{\gamma}$=198 keV *10*, which agrees with prior observations. The cross section σ=4.54 mb *76* was deduced. This cross section is in line with expectations from direct feeding of a Jπ=3/2^{+} state in the one-neutron removal reaction, but it is not in agreement with expectations if the reaction would feed a bound Jπ=5/2^{+} state that cascades through the 3/2^{+} state (yielding an order of magnitude higher predicted cross section).

Further discussion focuses on the high degree of certainty for excluding a higher-lying bound Jπ=5/2^{+} state in ^{19}C.

^{19}C Levels

E(level)	J$^{\pi}$	Comments
0	1/2^{+}	J$^{\pi}$: from 2001Ma08.
198 *10*	3/2^{+}	

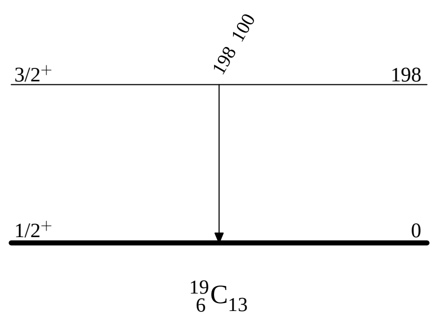
γ(^{19}C)

E$_{i}$(level)	J$^{\pi}_{i}$	E$_{\gamma}$	I$_{\gamma}$	E$_{f}$	J$^{\pi}_{f}$
198	3/2^{+}	198 *10*	100	0	1/2^{+}

^{1}H(^{20}C,^{19}Cγ) 2015Va09

Level Scheme

Intensities: % photon branching from each level



^{9}Be(^{20}N,^{19}Cγ) 2015Wh02

2015Wh02: The authors studied the magnetic response of the halo nucleus ^{19}C by measuring the lifetime of the first excited state and deducing the B(M1) transition strength.

A beam of E(^{20}N)=74 MeV/nucleon ions (Δp/p=2%), produced by fragmentation of ^{22}Ne in a thick ^{9}Be target at the NSCL, impinged on a 370 mg/cm^2 ^{9}Be target that sometimes induced single proton knock-out reactions populating ^{19}C*(209). The heavy ^{19}C recoil was detected using the S800 focal plane detectors, while de-excitation γ-rays were detected using seven elements of the GRETINA array. The Doppler-shift of the de-excitation γ-rays was measured in two configurations: first with only the ^{9}Be reaction target (v/c=0.36) located 13 cm upstream with respect to the center of the array and second with the reaction target at 15.5 cm upstream with respect to the center of the array and a 1527 mg/cm^2 thick Ta degrader located 5 cm downstream from the reaction target (v/c=0.32). In this arrangement, the GRETINA detectors were located at θ_{lab}=40° and θ_{lab}=65°.

^{19}C Levels

E(level)	J$^\pi$	T$_{1/2}$	Comments
0	1/2$^+$		J$^\pi$: from 2001Ma08.
209 *2*	(3/2$^+$)	1.34 ns *10*	T$_{1/2}$: Analysis of the spectra using lineshape and recoil-distance techniques indicate T$_{mean}$=198 ns *10* and 190 ns *10* values, respectively (2015Wh02). Additional systematic uncertainties give final uncertainties of T$_{mean}$=198 ns *12* and 190 ns *13* for the two methods, respectively. The authors give a recommended value T$_{mean}$=194 ns *15*. J$^\pi$: from 2015Wh02, based on the B(M1) value; E2 components are excluded and neglected.

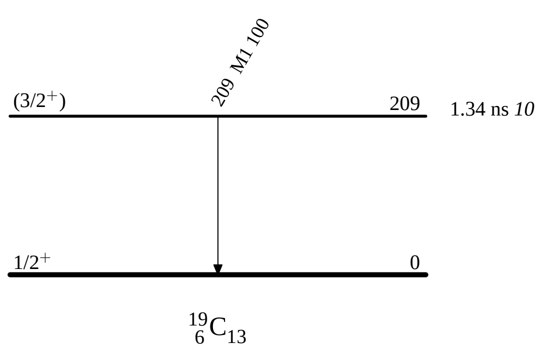
γ(^{19}C)

E$_i$(level)	J$^\pi_i$	E$_\gamma$	I$_\gamma$	E$_f$	J$^\pi_f$	Mult.	Comments
209	(3/2$^+$)	209 *2*	100	0	1/2$^+$	M1	B(M1)↓=0.00321 *25* (2015Wh02); B(M1)(W.u.)=0.00179 *14* (2015Wh02)

^{9}Be(^{20}N,^{19}Cγ) 2015Wh02

Level Scheme

Intensities: % photon branching from each level



^{9}Be(^{22}N,^{19}C) 2013Th06

1995Oz02: ^{9}Be(^{22}N,^{19}C) was used to produce ^{19}C. The beam was implanted in a plastic scintillator and β-delayed neutrons were measured corresponding to three neutron decay transitions. Analysis of the decay rate gives the lifetime $T_{1/2}$=45.5 ms *40*. In total, eight neutron groups were observed in the neutron energy spectrum, three from ^{19}C and five from ^{19}N delayed neutrons and other beam contaminants. The total P_{1n}=(47 *3*)%. Shell model calculations used by the authors predict Jπ=1/2^{+}, but 3/2^{+} and 5/2^{+} states were predicted nearby and could not be ruled out.

2013Th06: Neutron decay spectroscopy was used to analyze the ^{18}C+n pairs produced when a ^{22}N beam was fragmented on a target.

A beam of 68 MeV/nucleon ^{22}N ions, produced by fragmenting a ^{48}Ca beam on a thick ^{9}Be target at the NSCL, impinged on a 481 mg/cm^{2} ^{9}Be reaction target. The resulting ^{18}C+n products were momentum analyzed using both a large-gap superconducting dipole magnet and the MoNA array.

A single resonance is observed with E_{rel}=76 keV *14* and $\Gamma \leq$100 keV; this corresponds to E_x=653 keV *95*. The width was dominated by the $\approx$100 keV experimental resolution.

Significant discussion on the spin-parity of the state is given. Results from prior measurements are given as support for assuming Jπ=5/2^{+} (2011Oz01,2012Ko38), and for removing the previously suggested Jπ=5/2^{+} assignment from the E_x=270 keV resonance reported in (2005El07). Particular comments are given to explain the present lack of sensitivity to the E_x=1.46 MeV, Jπ=5/2 state observed in 2008Sa03.

^{19}C Levels

E(level)	J^{π}	Γ	Comments
0	(1/2^{+},3/2^{+})	45.5 ms *40*	J^{π}: from shell model predictions (1995Oz02).
653 *95*	(5/2^{+})	<100 keV	E(level): deduced from E(^{18}C+n)=76 keV *14* and S(n)=577 keV *94* (from http://amdc.in2p3.fr/masstables/Ame2003/rct2.mas03). Rounded value of S(n) is 580 keV *90* in published 2012Wa38.

^{9}Be(^{40}Ar,^{19}C) 2000Oz01,2012Kw02

2000Oz01: Production yields for fragmentation of 1 GeV/nucleon ^{40}Ar projectiles on a berylium target were measured. Cross sections of roughly 1.00×10^{-7} b were deduced.

2012Kw02: Production yields for fragmentation of 120 MeV/nucleon ^{40}Ar projectiles on berylium, nickel and tantalum targets were measured. Cross sections of roughly 2×10^{-5} mb were deduced.

See also 2002Ji08.

^{19}C Levels

E(level)
0

^{9}Be(^{48}Ca,^{19}C) 1981St23

1981St23: Production yields for fragmentation of 213 GeV/nucleon ^{48}Ca projectiles on a berylium target were measured at the Bevalac using a 0° magnetic spectrometer. The neutron-rich fragments were focused on a stack of Lexan plastic track detectors; analysis of the tracks provided the range, charge and magnetic deflection of the produced isotopes. A charge resolution of 0.2 was obtained along with a mass resolution of approximately ≤0.2 u.

The analysis showed clear indications of ^{18}C, ^{19}C, ^{20}C. Ambiguous results on ^{21}C are found. This work is credited with the discover of ^{20}C and ^{27}F. For ^{19}C, the cross section of roughly 0.8 μb was deduced.

^{19}C Levels

E(level)
0

^{12}C(^{19}C,X) 2012Ko38

2012Ko38: The cross section for 1-n removal from 243 MeV/nucleon ^{19}C on a carbon target was measured at the RIKEN/ZDS (zero degree spectrometer), along with the parallel momentum distribution of ^{18}C fragments. The σ=163 mb *12* is deduced. The discussion analyzes the momentum distribution shape by assuming various ^{18}C states are populated in the breakup, and is consistent consistent with Jπ=1/2^{+} for the ground state.

^{19}C Levels

E(level)	J^π
0	(1/2^{+})

$^{12}C(^{22}Ne,^{19}C)$ 1988Du09

1988Du09: ^{19}C was produced by fragmentation of a 60 MeV/n ^{22}Ne beam impinging on either a tantalum or a carbon target and was selected using the LISE spectrometer. The ^{19}C ions were implanted into a 7 mm thick plastic scintillator. Following the decay, β-particles were detected by a plastic scintillator while the delayed neutrons were detected through the Gd(n,γ) reaction in a 4π neutron ball that surrounded the implantation target. $T_{1/2}$=49 ms *4*, P_{0n}=0.46 *3*, P_{1n}=0.47 *3* and P_{2n}=0.07 *2* were measured.

^{19}C Levels

E(level)	$T_{1/2}$
0	49 ms *4*

$^{12}C(^{25}Ne,^{19}C\gamma)$ 2004St10,2008St18

2004St10,2004ST29,2008ST18: The authors populated ^{19}C using a cocktail beam of neutron-rich nuclides [^{25}Ne, ^{26}Ne, ^{27}Na, ^{28}Na, ^{29}Mg, and ^{30}Mg] that were produced by fragmenting an initial 77.5 MeV/nucleon ^{36}S beam at the GANIL/SISSI beamline. The cocktail beam was selected using the ALPHA spectrometer and focused on a carbon target that was coupled to a plastic scintillator.

Eγ, $\gamma\gamma$, γ(fragment) coincidences were measured using 74 BaF_2 detectors that surrounded the target with 4π and the SPEG spectrometer. The ^{19}C were identified using time-of-flight, energy loss and focal-plane position information. A single γ-ray transition is observed. Results are compared with shell-model calculations for analysis of Jπ values.

All data are from 2008St18.

^{19}C Levels

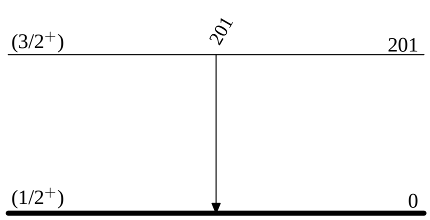
E(level)	J^π	Comments
0	$(1/2^+)$	J^π: from Adopted Levels of ^{19}C in ENSDF database.
201 *15*	$(3/2^+)$	J^π: $3/2^+$ or $5/2^+$ from shell-model predictions; the latter would require 201γ to be E2 and corresponding half-life≈1 μs for 201 level.

$\gamma(^{19}C)$

E_γ	E_i(level)	J^π_i	E_f	J^π_f
201 *15*	201	$(3/2^+)$	0	$(1/2^+)$

$^{12}C(^{25}Ne,^{19}C\gamma)$ 2004St10,2008St18

Level Scheme



$^{19}_{6}C_{13}$

^{19}B β^- decay 1998Yo06,2003Yo02

Parent: ^{19}B: E=0; J^π=(3/2$^-$); $T_{1/2}$=2.92 ms *13*; Q(β^-)=26.37×10^3 *41*; %β^- decay=100.0
^{19}B-$T_{1/2}$: from 2003Yo02.
^{19}B-Q(β^-): from 2012Wa38.

1998Yo06: A beam of ^{19}B was produced by fragmentation of a 95 MeV/A ^{40}Ar beam on a ^{181}Ta target. ^{19}B was selected using the RIKEN Projectile-fragment Separator (RIPS) and was implanted into a 12 mm thick plastic scintillator stopper. The β-decays were observed during the 100 ms beam-off period. The active stopper detected β-rays and a neutron detector array, consisting of 14 liquid scintillation counters covering about 80% of 4π detected delayed neutrons. The efficiency of the neutron array was 30% by comparison of a measurement of β-delayed neutrons of ^{15}B, which has a known delayed neutron emission probability of 100%.

A preliminary value of $T_{1/2}$=3.3 ms *2* was deduced from the least-squares fits to the data, and P_n=125% *32* was determined from the ratio of the number of detected neutrons to that of β-rays. P_n is more than 100% which implies the existence of significant multineutron emissions in the decay, reflecting its large Q_β value (26.5 MeV) compared with the multineutron separation energies of daughter nucleus ^{19}C (S_{1n}=160 keV, S_{2n}=4.4 MeV,.....).

2003Yo02: The authors reevaluated the preliminary values $T_{1/2}$ and P_n reported in 1998Yo06. The new experiment was performed using RIPS at RIKEN Accelerator Research Facility as was in 1998Yo06. A beam of ^{19}B was produced by the projectile-fragmentation reaction of a 95 MeV/*u* ^{40}Ar beam on a 670 mg/cm^2 ^{nat}Ta target. The values of $T_{1/2}$ and P_{in} were determined by fitting a set of decay curves altogether to remove possible complication and inconsistency. The method of maximum likelihood was applied for deducing $T_{1/2}$ and P_{in}. The neutron detection efficiencies were treated carefully, the total detection efficiencies of direct and scattered neutrons are 31.5 % *3* and 4.7% *+2-6*, respectively. The new values of $T_{1/2}$=2.92 ms *13*, P_{1n}=71.8% *+83-91* and P_{2n}=16.0% *+56-48* were determined with a better precision. P_{3n} was not determined because of the limited statistics. In the text it is unclear if the 1998Yo06 "preliminary" data are included in the 2003Yo02 analysis; we assume that it is and use the 2003Yo02 result to avoid possible data correlations.

1999Re16: A low statistics determination of $T_{1/2}$=4.5 ms *15* was given.

In Summary, the decay to ^{19}C levels is not measured. Only the P_{1n}=71.8% *+83-91* to ^{18}C and P_{2n}=16.0% *+56-48* to ^{17}C were determined.

^{19}C Levels

E(level)	Comments
581+x	E(level): group of neutron-decaying levels above S(n)(^{19}C)=581 keV.
4763+y	E(level): group of 2 neutron-decaying levels above S(2n)(^{19}C)=4763 keV.

β^- radiations

E(decay)	E(level)	Iβ^-†	Log *ft*	Comments
(1.1×10^4‡ *11*)	4763+y	16.0 *56*	5.02 *16*	Iβ^-: total β^-2n decay branch β^-_{2n}=16.0% *+56-48*.
(1.3×10^4‡ *13*)	581+x	71.8 *91*	4.74 *7*	Iβ^-: total β^-n decay branch β^-_{1n}=71.8% *+83-91*.

† Absolute intensity per 100 decays.
‡ Estimated for a range of levels.

^{181}Ta(^{48}Ca,^{19}C) 1991Or01

1991Or01: The authors measured the masses of several nuclides, produced in the fragmentation of 55 MeV/nucleon ^{48}Ca ions on a 330 mg/cm^2 ^{nat}Ta target at GANIL, by measuring their time-of-flight over a roughly 80 meter flight path. The nuclides were detected and identified in the SPEG spectrometer focal plane. A mass resolution near 3×10^{-4} was achieved.

The mass excess ΔM=33.07 MeV *24* was deduced.

^{19}C Levels

E(level)
0

^{181}Ta(^{40}Ar,^{19}C) 1987Gi05

1987Gi05: The authors measured the masses of several nuclides, produced in the fragmentation of 60 MeV/nucleon ^{40}Ar ions on a 350 mg/cm^2 ^{nat}Ta target at GANIL, by measuring their time-of-flight over a roughly 80 meter flight path. The nuclides were detected and identified in the SPEG spectrometer focal plane. A mass resolution near 5×10^{-4} was achieved.

The mass excess ΔM=32.95 MeV *42* was deduced.

^{19}C Levels

E(level)
0

^{208}Pb(^{19}C,^{19}C) 1999Na27

1999Na27: The Coulomb dissociation of 67 MeV/nucleon ^{19}C on ^{208}Pb was measured in a study of the low-lying E1 strength distribution at the RIKEN/RIPS facility. Complete kinematics of the ^{18}C+n dissociation products were measured and analyzed. The Coulomb dissociation cross section 1.19 b *11* was deduced after subtraction the nuclear component (obtained from a ^{12}C target) from the total cross section obtained with the Pb target. This corresponds to an E1 atrength of 0.71 e^2fm^2. Analysis of the ^{18}C+n distributions indicates S_n=530 keV *130*, and gives a clear indication of $J\pi=1/2^+$ for the ground state (compared to $5/2^+$ suggested in other analyses).

See also analysis in (2000Ba24, 2004Su23, 2004Ta31, 2005Na09).

^{19}C Levels

E(level)	J^π
0	$1/2^+$

Th(p,^{19}C) 1988Wo09

1986Vi09, 1988Wo09: Mass measurements of several neutron-rich light nuclei were carried out using an improved fitting technique for deducing nuclear mass values from measurements of time-of-flight (ToF) through the LANL/TOFI spectrometer; the ToF through the spectrometer depends on the mass-to-charge ratio and is independent of ion velocity.

The rare isotope species were produced by proton spallation reactions on a Th target. Typical flight times of 500 ns, with timing uncertainties near 180 ps yielded typical mass-to-charge resolutions of 3.6×10^{-4} from analysis of multiple runs that involved multiple charge states.

A mass excess of 32.77 MeV *12* was deduced in (1988Wo09), which compares with 32.30 MeV *24* which was previously deduced in (1986Vi09).

1991Re02, 1991ReZZ, 2008ReZZ: Spallation products from 800 MeV proton bombardment of a ^{232}Th target were captured by a transport line with a mass-to-charge filter and transfered to the TOFI spectrometer at LAMPF. The beamline was separately tuned to transport a number of different nuclides. The ions were implanted in a Si detector, and identification by standard techniques was implemented. The β-delayed neutrons were detected in a polyethylene moderated ^{3}He counter; half-lifes and β-delayed neutron probabilities were deduced from analysis of of the number of implanted ions (per beam pulse) and the rate of β-delayed neutrons detected in the zero-threshold counter. The β-delayed neutron probabilities=$\beta^{-}n=\beta_{1n}+2(\beta_{2n})+3(\beta_{3n})$...=(1991Re02: (53 *26*)%), (1995ReZZ/2008ReZZ: (66 *9*)%) were deduced.

Lifetimes of $T_{1/2}$=44.1 ms *42* (Reeder et al., Int. Conf. on Nucl. Data for Science and Technology, May 9-13, 1994, Gatlinburg, Tennessee: and 44 ms *4* in the unpublished private communications of (2008ReZZ)/(1995ReZZ) were deduced.

^{19}C Levels

E(level)	$T_{1/2}$
0	44.1 ms *42*

U(p,^{19}C) 1974Bo05

1974Bo05: Spallation yield cross sections, on a uranium target, were measured at the Bevatron using 4.8 GeV protons. Reaction products were identified using ΔE, E and time-of-flight determinations. A production cross section of ≈5 μb was measured. This result confirmed a the earlier first observation of ^{19}C by Raisbeck et al. that had been published only as a conference proceedings.

^{19}C Levels

E(level)
0

^{241}Pu(n,F) E=thermal 1999Ko26

1999Ko26: Light fission products, including ^{11}Li, ^{14}Be and ^{19}C, were identified and characterized in neutron induced fission events on ^{241}Pu.

^{19}C Levels

E(level)	σ(yield).
0	0.0014

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