Adopted Levels

$Q(\beta^-)=23.32\times10^3$ *7*; S(n)=50 *32* 2021Wa16

$S_{2n}=-160$ keV *10* (2024An11).

Q-values are computed using S_{2n} from (2024An11) and other mass values from (2021Wa16).

1973Bo30,1974Bo05: Spallation products from 4.8 Gev proton bombardment of natural uranium targets at the LBNL Bevatron were identified via ΔE-E and time-of-flight techniques. The particle stability of ^{14}Be and ^{17}B isotopes was confirmed, but there was some uncertainty about ^{13}Be because of a relatively high background. It was later found to be particle unbound. The first observation of ^{13}Li resonance structure was at GSI using the ALADIN-LAND setup (2008Ak03).

In early theoretical work, a $J^\pi=3/2^-$ ground state (1985Po10 and 1996Ch38) was predicted to be unbound to ^{11}Li+2n decay by 3.34 MeV (1985Po10). The lowest excited states with $J^\pi=7/2^-$ and $1/2^-$ were also predicted by (1985Po10) to lie at E_x=1.42 and 2.09 MeV, respectively. See also (2018Fo07).

^{13}Li Levels

Cross Reference (XREF) Flags

A ^{1}H(^{14}Be,2p)
B ^{9}Be(^{14}Be,^{13}Li)

E(level)[a]	J^π	Γ	$E_{c.m.}(^{11}Li+2n)$(MeV)	XREF	Comments
0	$3/2^-$	125 keV *+60−40*	0.16 *1*	AB	%2n=100 E(level): From (2024An11). J^π,Γ: From (2013Ko03). J^π: Analysis of the T and Y Jacobi systems find emission of a strongly correlated $^1s_0$ n-n pair with dineutron character and indicate $J^\pi=3/2^-$, which is the J^π of ^{11}Li.
0.29×10^3 *6*			0.45 *6*	A	E(level): From (2024An11). Decays to $^{11}Li_{g.s.}$+2n.
1.31×10^3 *31*		2 MeV *1*	1.47 *31*	A	%2n=100 E(level),Γ: From (2008Ak03). Decays to $^{11}Li_{g.s.}$+2n.
2.6×10^3 *2*			2.8 *2*	A	E(level): From (2024An11). Decays mainly to $^{11}Li_{g.s.}$+2n, but evidence is also found for sequential branches to $^{12}Li_{g.s.}$+n and $^{12}Li^*$(0.4 MeV)+n.

[a] From $E_{c.m.}(^{11}Li+2n)+S_{2n}$, where $S_{2n}=-160$ keV *10* from (2024An11).

$^{1}H(^{14}Be,2p)$ 2024An11,2008Ak03,2010Jo07

2008Ak03:XUNDL dataset compiled by ANL, 2008.

First observation of ^{13}Li nuclide as neutron-unbound resonance was achieved using the ALADIN-LAND setup.

A beam of E(^{14}Be)=304 MeV/nucleon ions, from the GSI/FRS facility, impinged on a 50 mm long cylindrical liquid-hydrogen target with an effective thickness of 350 mg/cm^2 that was placed at the ALADIN large-gap dipole magnet target position. Residual lithium ions resulting from 1-proton knockout reactions from the ^{14}Be were momentum analyzed using position-sensitive multi-wire proportional counters and the ALADIN dipole while the coincident neutrons were momentum analyzed using the large area neutron detector LAND array.

A peak at $E_{res}(^{11}Li+2n)$=1.47 MeV *31* was observed in the ^{11}Li+2n relative energy spectrum.

2010Jo07: A re-analysis of the (2008Ak03) ^{11}Li+n+n data was carried out by using a sophisticated model to evaluate the three-body correlations. In this re-analysis, the data indicated a similar structure to that observed for ^{10}He: where a $J^\pi=0^+$ ground state and $J^\pi=2^+$ excited state are favored. In the case of ^{13}Li, the authors interpreted the data as a broad $J^\pi=3/2^-$ ground state at E_{res}=1.47 MeV comprising s-wave neutrons coupled with the $J^\pi=3/2^-$ ^{11}Li core. In addition, they suggested an unresolved group of broad and overlapping excited states whose structure yields $J^\pi=1/2^-$, $3/2^-$, $5/2^-$ and $7/2^-$; these unobserved excited states are understood as a 2^+ coupling with the $J^\pi=3/2^-$ ^{11}Li core.

2024An11: A cocktail beam comprising ^{11}Li (70%), ^{12}Be (2.5%) and ^{14}Be (9%) components was produced at the RIKEN/RIBF facility. The beams, with energies of E=246, 340 and 265 MeV/nucleon, respectively, impinged on a 15 cm thick solid hydrogen target that was surrounded by the MINOS time-projection chamber (TPC). In the ^{13}Li study, the reaction vertex position was determined from the TPC analysis of the two reaction protons. The ^{13}Li products decayed instantly, and the invariant mass of the system was determined using the momentum of the two neutrons, analyzed using two 16-element hodoscopes from the NEBULA arrays, and the momentum of the ^{11}Li remnant that was measured using the SAMURAI spectrometer.

The invariant mass spectrum is dominated by a peak at E(^{11}Li+2n)=0.160 keV with strong indications of a higher peak at 450 keV. The spectrum is featureless at higher energies, but the region was analyzed assuming two additional peaks: first was a peak at E(^{11}Li+2n)=1.47 MeV (consistent with the group reported by (2008Ak03)), and second with a peak at E(^{11}Li+2n)=2.8 MeV. The experimental method was found unreliable for determining resonance widths.

The four resonance regions were then analyzed to identify whether the states decay directly to $^{11}Li_{g.s.}$+2n or sequentially via $^{12}Li+n\rightarrow{}^{11}Li+2n$. The lower states are found to decay directly to $^{11}Li_{g.s.}$+2n, while the E(^{11}Li+2n)=2.8 MeV state is found to decay dominantly to ^{11}Li+2n with smaller branches to ^{12}Li+n. In their Figure 3, the decay arrow thicknesses are intended to indicate relative decay intensities.

^{13}Li Levels

E(level)[a]	J^π	Γ	$E_{c.m.}(^{11}Li+2n)$(MeV)[b]	Comments
0			0.16 *1*	Decays to $^{11}Li_{g.s.}$+2n.
0.29×10^3 *6*			0.45 *6*	Decays to $^{11}Li_{g.s.}$+2n.
1.31×10^3 *31*	(3/2$^-$)	2.1 MeV *11*	1.47 *31*	Decays to $^{11}Li_{g.s.}$+2n. Γ: From (2010Jo07); see also Γ=2 MeV *1* from (2008Ak03). J^π: The $J^\pi=3/2^-$ spin deduced by (2010Jo07) for the E_{res}=1.47 MeV state is complicated by the subsequent observations of (2013Ko03) where a lower-lying E_{res}=120 keV state is identified with $J^\pi=3/2^-$ character.
2.6×10^3 *2*			2.8 *2*	Decays mainly to $^{11}Li_{g.s.}$+2n; evidence is also found for additional branches to $^{12}Li_{g.s.}$+n and $^{12}Li^*$(0.4 MeV)+n.

[a] From $E_{c.m.}(^{11}Li+2n)+S_{2n}$, where $S_{2n}=-160$ keV *10* from (2024An11).

[b] From (2024An11), except for the $E_{c.m.}(^{11}Li+2n)$=1.47 MeV state, which is from (2008Ak03).

^{9}Be(^{14}Be,^{13}Li) 2013Ko03

2013Ko03: XUNDL dataset compiled by TUNL, 2013.

A beam of 53.6 MeV/nucleon ^{14}Be ions was produced using the NSCL/A1900 fragment separator. The beam impinged on a 477 mg/cm^2 Be target where 1-proton removal reactions produced ^{13}Li nuclei that decayed to ^{11}Li+2n. The MONA+sweeper magnet system detected the 2 neutrons and ^{11}Li ions, respectively.

Data were analyzed to obtain the ^{11}Li+2n relative energy spectrum; a causality cut was included that minimized contributions from the double scatter of a single neutron. The results were compared with a Monte Carlo simulation that was used to evaluate the device acceptances and energy dependent efficiencies, etc.

A peak at E_{res}=120 keV *+60−80* with Γ=125 keV *+60−40* was observed. ^{13}Li is bound to one neutron emission, but unbound to 2n emission. Analysis of the Y and T Jacobi systems indicates that the emitted pair of neutrons have a strong dineutron character; this implies J^{π}=3/2$^-$.

^{13}Li Levels

E(level)	J^{π}	Γ	$E_{c.m.}$(^{11}Li+2n)(MeV)	Comments
0	3/2$^-$	125 keV *+60−40*	0.120 *+60−80*	

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