Adopted Levels

S(p)=−2.5×10^{3} *1* 2023Ch46,2021Wa16

The evaluator deduces the mass excess ΔM=44.8 MeV *1* from S_p=−2.5 MeV *1*.

The ^{9}N nucleus is not mentioned in the most recent AME analysis (2021Wa16).

Theoretical works:

1974Ir04, (also Irvine et al., Annals of Physics **102** 129 (1976)): The structure of p-shell nuclei was analyzed using a two-body Hamiltonian model. A J^π=1/2$^-$ ground state was predicted with a binding energy of about 14 MeV. In addition the first excited J^π=3/2$^-$ state was predicted at around E_x≈5 MeV, and higher-lying multiplet of states was also predicted.

1975Be31: An energy-density model was developed based on single-particle wave-functions and occupation numbers, pairing effects, Coulomb energies and other nuclear properties. The ^{9}N ground state was predicted to be unstable against 1-proton decay with a binding energy of 24.8 MeV.

1982Ng01: A modified-oscillator shell model formalism was developed to study the binding energies and other properties of p-shell nuclei. The ground-state binding energy was predicted as 13.1 MeV with a nuclear radius of r=2.154 fm.

1983AnZQ: An atomic mass formula was developed using an approach that added shell terms to a model that fit the gross shape of the mass surface. A mass excess of 50.8 MeV (B.E.≈17.1 MeV) was predicted for ^{9}N.

2000Po32: Developed a model to predict exotic nuclide masses based on known masses for mirror nuclei. Estimates a mass excess around 46.5 MeV (B.E.≈21.4 MeV).

In (2023Ch46), strong evidence supporting the observation of a ^{9}N resonance is presented. While the data can be described with either a single peak or with two peaks, the data are best represented with a two-peak fit; however a unique solution is difficult to establish. A complex-energy Gamow shell model (GSM) prediction is used to guide the interpretation. The ground and first-excited states are expected as J^π=1/2$^+$ and 1/2$^-$ states, respectively; the authors explored a reasonable solution where the parameters of the J^π=1/2$^-$ first-excited state were fixed by values from the GSM and the ground-state parameters were deduced from a fit. Other solutions were explored as well; recommended experimental level-energy values are given in Table S1 of the supplemental materials.

The authors also describe a classification scheme that characterizes bound, antibound, decaying and capturing resonant states based on their location in the complex-*k* plane. In their analysis, they find the ^{9}N ground state is most likely a broad resonance state, however they cannot rule out a description where the ground state is a subthreshold resonance.

^{9}N Levels

Cross Reference (XREF) Flags

A ^{9}Be(^{13}O,^{9}N)

E(level)	J^π †	$Q_{1p}=E_{c.m.}(p+^{8}C_{g.s.})$ ‡	XREF	Comments
0	1/2$^+$	2.5 *1*	A	%p=100
2.1 *1*	1/2$^-$	4.6 *1*	A	%p=100

† From Gamow shell-model prediction.

‡ The decays proceed by $^{9}N \rightarrow p+^{8}C_{g.s.} \rightarrow 3p+^{6}Be_{g.s.} \rightarrow 5p+^{4}He$.

$^{9}Be(^{13}O,^{9}N)$ 2023Ch46

2023Ch46: XUNDL file compiled by TUNL (2023).

The authors report first evidence for a state in ^{9}N. The observation is obtained from analysis of ^{13}O+^{9}Be data that has produced results on other particle-unbound states in, for example, ^{10}B, ^{11}C, ^{11}O, $^{13,14}F$, ^{16}F and ^{18}Na.

In the present case, a beam of ≈60 MeV/nucleon ^{13}O ions from the NSCL/A1900 fragment separator was purified in the Radio Frequency Fragment Separator before impinging on a 1 mm thick ^{9}Be target (see supplemental material and prior reports such as (2023Ch22)). Fragmentation reactions populated the short-lived ^{9}N nucleus, which proton decayed before exiting the target. The complete kinematics of the charged-particle reaction products were measured using the HiRA array, which comprised a set of 14 64 mm × 64 mm position sensitive ΔE-E telescopes that covered the forward direction of the outgoing beam (θ_{lab}≈2.1° to 12.4°). We assume the telescopes were arranged in vertical towers with a 2-3-4-3-2 configuration where the central tower had a gap between the upper and lower two telescopes to permit the beam a downstream exit at θ=0°, as in past experiments.

The 5p+α invariant-mass spectrum was analyzed and found with no prominent narrow structures. However, since ^{9}N is expected to 1-proton decay to $^{8}C_{g.s.}$, the 4p+α sub-events were analyzed and a ^{8}C peak was found at the expected energy, confirming a decay mode via ^{8}C. *Note:* ^{8}C is known to decay sequentially by two 2-proton decays having an intermediate state involving $^{6}Be_{g.s.}$; ^{8}C→2p(2.11 MeV)+[$^{6}Be_{g.s.}$→2p(1.37 MeV)+^{4}He]. With the 4p+α participants comprising the $^{8}C_{g.s.}$ isolated, the p+$^{8}C_{g.s.}$ invariant-mass spectrum was analyzed, and it revealed a broad structure around what the authors call Q_{5p}≈5-9 MeV; this implies proton decays in the region of $E_{c.m.}$(p+$^{8}C_{g.s.}$)=Q_{1p}≈1.5-5.5 MeV.

A single-peak R-matrix analysis of the data assuming an *s*-wave pole found Q_{1p}=1.22 MeV *16* and Γ=2.59 MeV *23*. Similarly, a single *p*-wave pole results with a resonance having with Q_{1p}=2.01 MeV *16* and Γ=2.28 MeV *23*. However, for either case, the magnitude of the background is smaller than expected (2023Ch47); so neither case is favored.

The case for a two-peak fit appears rather unconstrained. A complex-energy Gamow shell model (GSM) prediction was utilized to provide some guidance; extensive discussion is included in the text and supplemental materials. States with J^{π}=1/2^{+} and 1/2^{-} are expected; in addition the ground state parity inversion reported in ^{11}Be is expected. The analysis explored a solution where the parameters of the higher-lying J^{π}=1/2^{-} state were fixed to match the GSM prediction of $E_{c.m.}$(p+$^{8}C_{g.s.}$)=Q_{1p}=4.60 MeV (Deduced from Q_{5p}=8.08 MeV in Table S1) and Γ=1.35 MeV (Table S1). Then the parameters of the J^{π}=1/2^{+} ground state were obtained from a fit yielding $E_{c.m.}$=Q_{1p}=2.75 MeV *21* and Γ=0.58 MeV *44*; the GSM predicted Q_{1p}=2.08 MeV and Γ=1.74 MeV. In this case the background is in line with expectations. This is a reasonable and favorable solution, but insufficient data exist to constrain a unique solution. For comparison, a different two-peak fit was shown where the width of the J^{π}=1/2^{-} state was decreased by half in comparison with the GSM prediction. In this case the 1/2^{+} became broader and its location changed as well.

The authors give recommended experimental values in the supplimental materials where Q_{5p}=6 MeV *1* and 8.1 MeV *1* are given for the 1/2^{+} and 1/2^{-} states, respectively; using Q_{4p}=(2.11 MeV+1.37 MeV) for $^{8}C_{g.s.}$, this implies $E_{c.m.}$(p+$^{8}C_{g.s.}$)=Q_{1p}=2.5 MeV *1* for the ground state and 4.6 MeV *1* for the 1/2^{-} state. The widths were not indicated, but values of a few hundred keV up to a couple MeV could be suggested. The authors indicated the $^{9}N_{g.s.}$ is likely a broad resonant state, as described in their classification scheme.

^{9}N Levels

E(level)	J^{π} †	Q_{1p}=$E_{c.m.}$(p+$^{8}C_{g.s.}$) ‡
0	1/2^{+}	2.5 *1*
2.1 *1*	1/2^{-}	4.6 *1*

† From Gamow shell-model prediction.

‡ The decays proceed by ^{9}N→p+$^{8}C_{g.s.}$→3p+$^{6}Be_{g.s.}$→5p+^{4}He.

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