

Adopted Levels

| Type | Author | History | Citation | Literature Cutoff Date |
|-----------------|--|---------|------------------|------------------------|
| Full Evaluation | J. H. Kelley, C. G. Sheu and J. E. Purcell | | NDS 198,1 (2024) | 1-Aug-2024 |

$S(p) = -2730$ *syst* [2021Wa16](#)

$\Delta S(p) = 500$ (syst, [2021Wa16](#)).

$S_{2p} = -3090$ 500 (sys.) ([2021Wa16](#)).

The ^{13}F nucleus is unbound to proton emission. A resonance is observed in ([2021Ch19](#)); however, since this resonance is reported at a higher energy than expected for the ground state, it is believed to correspond to an excited state. See also ([2023Th03](#)).

In ([2013Ti01](#)), the Kelson-Garvey mass systematics ([1966Ga25](#)) are improved to provide reliable predictions of the masses of proton-rich nuclei based on analysis of their neutron-rich mirror nuclei. For ^{13}F , the predicted binding energy $E_{\text{bind}} = 53.666$ MeV *16* and mass excess $\Delta M = 43.386$ MeV *16* are based on comparison with ^{13}Be .

In ([2012Fo22](#)) a potential model is developed that is informed by $^{12,13}\text{Be}$ and ^{12}O properties. The expected $J^\pi = 1/2^+$ ground state is predicted near the resonance energy $E_p = 2.4$ MeV with $\Gamma \approx 0.6$ MeV, relative to $^{12}\text{O}_{\text{g.s.}}$. The $J^\pi = 5/2^+$ excited state is predicted near $E_p \approx 5$ MeV with $\Gamma \approx 0.35$ MeV. The analysis is updated in ([2013Fo22](#)) with similar results.

See ([1993Po11](#)) for earlier shell-model analysis of ground-state binding energies, including ^{13}F .

 ^{13}F LevelsCross Reference (XREF) Flags

A $^9\text{Be}(^{13}\text{O}, ^{13}\text{F})$

| E(level) [†] | J^π | Γ | E_T (MeV) [‡] | XREF | Comments |
|-----------------------|---------------------|-------------|--------------------------|----------|---|
| x | (5/2 ⁺) | 1.01 MeV 27 | 7.06 9 | A | %p=100 Analysis of the invariant-mass spectrum is consistent with sequential proton decay via $^{12}\text{O}(0:0_1^+, 2.2 \text{ MeV}; 2_1^+, 4.8 \text{ MeV}; 2_2^+)$ with intensities of 40% <i>16</i> , 28% <i>18</i> and 32% <i>16</i> , respectively. |

[†] The authors suggest the $J^\pi = 5/2^+$ excited state has been observed. The $1/2^+$ g.s. is expected ≈ 3 MeV lower in energy.

[‡] $^{10}\text{C}+3p$ Invariant Mass.

$^9\text{Be}(^{13}\text{O}, ^{13}\text{F})$ 2021Ch19

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2021Ch19: XUNDL dataset compiled by TUNL (2021).

The authors analyzed the excitation spectra of particle-unbound nuclides produced in ^{13}O reactions on a ^9Be target. The first observation of a ^{13}F resonance, produced via charge-exchange reactions, was reported.

A beam of 69.5 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 ^9Be target. ^{13}F nuclides were produced and decayed in-flight via

$^{13}\text{F} \rightarrow \text{p} + ^{12}\text{O} \rightarrow 3\text{p} + ^{10}\text{C}$ reactions. All decay products were detected using the HiRA High-Resolution position sensitive ΔE -E telescope array, which covered the polar angles $\theta_{\text{lab}} = 2.1^\circ$ to 12.4° . The invariant-mass spectrum, E_{T} , was deduced by analyzing the momenta of the $3\text{p} + ^{10}\text{C}$ decay products. As in the past study of ^{11}O (2020We08), structures in the excitation spectrum are enhanced by analyzing events where ^{10}C is ejected perpendicular to the beam direction in the ^{13}F center-of-mass system.

The invariant-mass spectrum is dominated by a $\Gamma \approx 1$ MeV peak around $E_{\text{T}} \approx 7$ MeV that sits on top of a broad smooth background.

For perspective, (2012Fo22) predicts a $J^\pi = 1/2^+$ ground state at around $E_{\text{T}} = 4$ MeV and a $J^\pi = 5/2^+$ first excited state near $E_{\text{T}} = 7$ MeV. No evidence is seen for a lower energy resonance; the authors suggest the lower state may have a broad width that prevents its observation in the present measurement. Comparison with the mirror ^{13}Be nucleus ground state provides ambiguous results for the measured $1/2^+$ width, leaving uncertainty on the expectation for ^{13}F .

A Monte Carlo simulation was developed to interpret the observed features, since the level structures of ^{12}O and ^{10}C are convoluted in the spectrum. Involvement of the $^{10}\text{C}^*(3353 \text{ keV})$ first excited state is generally inconsistent with the observed invariant-mass spectrum so the analysis is limited to final population of $^{10}\text{C}_{\text{g.s.}}$. Hence the analysis focused on branching ratios for sequential decay of a $(5/2^+)$ ^{13}F resonance through ^{12}O states that subsequently 2p decay via processes described in (2019We11), and the total decay energy was assumed to be carried in the $3\text{p} + ^{10}\text{C}$ kinetic energies.

Sequential decays via low-lying ^{12}O states are considered in the Monte Carlo simulation. See the text for discussion and comparison of expectations based on the mirror ^{13}Be nucleus. The branching ratios to the $J^\pi = 0_1^+$ and 2_1^+ and 2_2^+ ^{12}O states are found as 40% 16, 28% 18 and 32% 16, respectively. An alternate and reasonable fit to the data assumed zero contribution from the 2_2^+ state; in this case the relative ratios for the 0_1^+ and 2_1^+ states remained consistent with the initial three-level fit.

 ^{13}F Levels

| $E(\text{level})^\dagger$ | J^π | Γ | $E_{\text{T}} (\text{MeV})^\ddagger$ | Comments |
|---------------------------|-----------|-------------|--------------------------------------|--|
| x | $(5/2^+)$ | 1.01 MeV 27 | 7.06 9 | Analysis of the invariant-mass spectrum is consistent with sequential proton decay via $^{12}\text{O}(0:0_1^+, 2.2 \text{ MeV}:2_1^+, 4.8 \text{ MeV}:2_2^+)$ with intensities of 40% 16, 28% 18 and 32% 16, respectively. |

† The authors suggest the $J^\pi = 5/2^+$ excited state has been observed. The $1/2^+$ g.s. is expected 3 MeV lower in energy.

‡ Invariant Mass.