8-27-2007

Comment on "Predicting Narrow States in the Spectrum of a Nucleus beyond the Proton Drip Line"

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Suggested Citation:
H.T. Fortune and R. Sherr. (2007). Comment on "Predicting Narrow States in the Spectrum of a Nucleus beyond the Proton Drip Line". *Physical Review Letters* **99**. 089201.

http://dx.doi.org/10.1103/PhysRevLett.99.089201

Comment on "Predicting Narrow States in the Spectrum of a Nucleus beyond the Proton Drip Line"

A recent Letter [1] presented calculations of several resonances in $^{14}C + n$ and $^{14}O + p$, including three negative-parity states, for which they used the structure of a $0p_{1/2}$ nucleon coupled to 0_2^+ and 2_2^+ core states in ^{14}C and ^{14}O. These negative-parity states in ^{15}C are nearly pure $(sd)^2$ neutrons coupled to the ground state (g.s.) of ^{13}C, with the pair of neutrons having $J = 0$ or 2, as has been suggested [2] by the reaction $^{13}C(t, p)$. This configuration has a large overlap with that of Ref. [1], but there appears to be a problem with the widths in both ^{15}C and ^{15}F and with the energy shifts between ^{15}C and ^{15}F.

In Ref. [1], the $1/2^-$ state at 3.10 MeV in ^{15}C has a calculated width of 2 keV, but its experimental width is 42 keV [3]. This width can come only from neutron decay to ^{14}C(g.s.). A width of 42 keV, combined with an $\ell = 1$ single-particle (SP) width of 1.3 MeV results in a spectroscopic factor S of 0.033, where we have used the relationship $\Gamma_{expt} = C^2 S \Gamma_{SP}$, with $C^2 = 1$ here. The SP width, and hence S, can be sensitive to the details of the SP calculation. However, here we are primarily interested in the ratio $\Gamma(^{15}F)/\Gamma(^{15}C)$ for mirror states, and that ratio is very insensitive to those details.

For the mirror state in ^{15}F, we can compute its energy using the configuration $^{13}N(g.s.) \times (sd)^2_{0+}$, with the mixture of s^2 and d^2 from [4]. The result is $E_p = 4.63$ MeV, not very close to 5.49 MeV in Ref. [1]. With good isospin, the spectroscopic factor in ^{15}F is the same as in ^{15}C, so we can compute the expected width of this $1/2^-$ state in ^{15}F from the expression $\Gamma = S\Gamma_{SP}$, where now Γ_{SP} is the $\ell = 1$ SP width for proton decay. Our calculated value for this SP width for a state at our calculated energy is about 1.6 MeV, so that we expect $\Gamma(^{15}F, 1/2^-) \approx 55$ keV, significantly larger than the width of 5 keV in Ref. [1]. If the state is at the energy computed in Ref. [1], its width would be ≥ 65 keV. These values are summarized in Table I.

The $5/2^-$ and $3/2^-$ energies in ^{15}C are 4.22 and 4.66 MeV, respectively. The $3/2^-$ state has considerable width—perhaps (by inspection of the spectrum in [2]) as much as 100–150 keV, similar to the calculated width of 90 keV in Ref. [1]. With the configuration of $(sd)^2_{2+}$ coupled to the ^{13}C (or ^{13}N) g.s., we get energies in ^{15}F of $E_p = 5.92$ and 6.30 MeV, for $5/2^-$ and $3/2^-$, respectively. Reference [1] has these two states at 6.88 and 7.25 MeV. Their width for the $3/2^-$ state in ^{15}F is 40 keV. It is very difficult to understand how the width in ^{15}F could be less than in ^{15}C. From their n width in ^{15}C, we estimate a $3/2^-$ width in ^{15}F of about 180 keV for a state at our energy and about 200 keV if at their energy. If the width in ^{15}C is 150 keV, these change to 300 and 325 keV. These are also listed in Table I.

We have not found an estimate of the experimental neutron width of the $5/2^-$ state in ^{15}C, for which the compilation [5] gives ≤ 14 keV. Reference [1] lists 2 keV for the calculated value of this quantity. If this value is correct, the width of the mirror state in ^{15}F would be 6 keV if it is at our energy, 10 keV if at the energy of Ref. [1].

In addition, a second $1/2^-$ state in ^{15}C at 5.87 MeV, with a width of about 100 keV, is within the range of energies considered by Ref. [1].

We agree with Ref. [1] that narrow resonances are to be expected in $^{14}C + n$ and $^{14}O + p$ in the energy range discussed, but it would appear that the energies and widths of the negative-parity resonances will be considerably different from the ones calculated in Ref. [1].

TABLE I. Energies (MeV) and widths (keV) of three lowest negative-parity states in ^{15}C and ^{15}F.

	^{15}C			^{15}F			
		Width		Ref. [1]		Present	
J^π	E_x	Ref. [1]	Other	E_p	Γ	E_p	Γ
$1/2^-$	3.10[a]	2	42[b]	5.49	5	4.63	55[c]
$5/2^-$	4.22[d]	2	≤ 14[a]	6.88	10	5.92	6[e]
$3/2^-$	4.66[d]	90	100–150[f]	7.25	40	6.30	180[g]

[a]Ref. [5].
[b]Ref. [3].
[c]If E_p is 5.49 MeV, Γ is ≥ 65 keV.
[d]Ref. [2].
[e]This value is for $\Gamma(^{15}C) = 2$ keV and $E_p = 5.92$ MeV. If E_p is 6.88 MeV, we get $\Gamma = 10$ keV.
[f]By inspection of the spectrum of Ref. [2].
[g]Using $\Gamma(^{15}C) = 90$ keV. If E_p is 7.25 MeV, Γ is ≥ 200 keV. If $\Gamma(^{15}C)$ is 150 keV, Γ is 300–325 keV.

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Received 20 September 2006; published 24 August 2007
DOI: 10.1103/PhysRevLett.99.089201
PACS numbers: 24.10.−i, 25.40.Dn, 25.40.Ny, 27.20.+n

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