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

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A recent Letter [1] presented calculations of several resonances in $^{14}\text{C} + n$ and $^{14}\text{O} + p$, including three negative-parity states, for which they used the structure of a $0p_{1/2}$ nucleon coupled to $0_1^-$ and $2_1^+$ core states in $^{14}\text{C}$ and $^{14}\text{O}$. These negative-parity states in $^{15}\text{C}$ are nearly pure $(sd)^2$ neutrons coupled to the ground state (g.s.) of $^{13}\text{C}$, with the pair of neutrons having $J = 0$ or 2, as has been suggested [2] by the reaction $^{13}\text{C}(t, p)$. This configuration has a large overlap with that of Ref. [1], but there appears to be a problem with the widths in both $^{15}\text{C}$ and $^{15}\text{F}$ and with the energy shifts between $^{15}\text{C}$ and $^{15}\text{F}$.

In Ref. [1], the $1/2^-$ state at 3.10 MeV in $^{15}\text{C}$ has a calculated width of 2 keV, but its experimental width is 42 keV [3]. This width can come only from neutron decay to $^{14}\text{C}$(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 $\Gamma^{\text{exp}} = S^2 \Gamma^\text{SP}$, with $S^2 = 1$ 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 $\Gamma(15\text{F})/\Gamma(15\text{C})$ for mirror states, and that ratio is very insensitive to those details.

For the mirror state in $^{15}\text{F}$, we can compute its energy using the configuration $^{13}\text{N}(\text{g.s.}) \times (sd)^2_{0^+}$, 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 $^{15}\text{F}$ is the same as in $^{15}\text{C}$, so we can compute the expected width of this $1/2^-$ state in $^{15}\text{F}$ from the expression $\Gamma = S\Gamma^\text{SP}$, where now $S\Gamma^\text{SP}$ is the $\ell = 1$ SP width for proton decay. Our calculated width for this SP width for a state at our calculated energy is about 1.6 MeV, so that we expect $\Gamma(15\text{F}, 1/2^-) \approx 55$ 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 $\approx 65$ keV. These values are summarized in Table I.

The $5/2^-$ and $3/2^-$ energies in $^{15}\text{C}$ 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 $^{13}\text{C}$ (or $^{13}\text{N}$) g.s., we get energies in $^{15}\text{F}$ 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 $^{15}\text{F}$ is 40 keV. It is very difficult to understand how the width in $^{15}\text{F}$ could be less than in $^{15}\text{C}$. From their $n$ width in $^{15}\text{C}$, we estimate a $3/2^-$ width in $^{15}\text{F}$ of about 180 keV for a state at our energy and about 200 keV if at their energy. If the width in $^{15}\text{C}$ 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 $^{15}\text{C}$, for which the compilation [5] gives $\leq 14$ 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 $^{15}\text{F}$ 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 $^{15}\text{C}$ 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 $^{14}\text{C} + n$ and $^{14}\text{O} + p$ 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>
<thead>
<tr>
<th>$J^\pi$</th>
<th>$E_\pi$ (MeV)</th>
<th>$^{15}\text{C}$ Width</th>
<th>$^{15}\text{F}$ Width</th>
<th>$^{15}\text{C}$ Present</th>
<th>$^{15}\text{F}$ Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/2^-$</td>
<td>3.10$^a$</td>
<td>2</td>
<td>42$^b$</td>
<td>5.49</td>
<td>5</td>
</tr>
<tr>
<td>$5/2^-$</td>
<td>4.22$^d$</td>
<td>2</td>
<td>$\approx 14^e$</td>
<td>6.88</td>
<td>10</td>
</tr>
<tr>
<td>$3/2^-$</td>
<td>4.66$^d$</td>
<td>90</td>
<td>100–150$^f$</td>
<td>7.25</td>
<td>40</td>
</tr>
</tbody>
</table>

$^a$Ref. [5].  
$^b$Ref. [3].  
$^c$If $E_p$ is 5.49 MeV, $\Gamma$ is $\approx 65$ keV.  
$^d$Ref. [2].  
$^e$This value is for $\Gamma(15\text{C}) = 2$ 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 $\Gamma(15\text{C}) = 90$ keV. If $E_p$ is 7.25 MeV, $\Gamma$ is $\approx 200$ keV. If $\Gamma(15\text{C})$ is 150 keV, $\Gamma$ is 300–525 keV.

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