University of Pennsylvania
ScholarlyCommons

Department of Physics Papers | Department of Physics

8-27-2007

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

H Terry Fortune
University of Pennsylvania, fortune@physics.upenn.edu

Rubby Sherr
Princeton University

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.

© 2007 The American Physical Society
http://dx.doi.org/10.1103/PhysRevLett.99.089201

This paper is posted at ScholarlyCommons. http://repository.upenn.edu/physics_papers/145
For more information, please contact repository@pobox.upenn.edu.

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

Disciplines
Physical Sciences and Mathematics | Physics

Comments
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.

© 2007 The American Physical Society
http://dx.doi.org/10.1103/PhysRevLett.99.089201

This journal article is available at ScholarlyCommons: http://repository.upenn.edu/physics_papers/145

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 $\Gamma_{\rm expt} = C^2 S \Gamma_{\rm SP}$, 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 $^{13}N(\text{g.s.}) \times (sd)^2_{0+}$, 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}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 $\Gamma = S\Gamma_{\rm SP}$, where now $\Gamma_{\rm SP}$ 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			
J^π	E_x	Width		Ref. [1]		Present	
		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.

H. T. Fortune
Department of Physics and Astronomy
University of Pennsylvania
Philadelphia, Pennsylvania, 19104, USA

R. Sherr
Department of Physics
Princeton University
Princeton, New Jersey 08544, USA

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

[1] L. Canton, G. Pisent, J. P. Svenne, K. Amos, and S. Karataglidis, Phys. Rev. Lett. **96**, 072502 (2006).
[2] S. Truong and H. T. Fortune, Phys. Rev. C **28**, 977 (1983).
[3] J. D. Goss, P. L. Jolivette, C. P. Browne, S. E. Darden, H. R. Weller, and R. A. Blue, Phys. Rev. C **12**, 1730 (1975).
[4] H. T. Fortune, M. E. Cobern, S. Mordechai, G. E. Moore, S. LaFrance, and R. Middleton, Phys. Rev. Lett. **40**, 1236 (1978).
[5] F. Ajzenberg-Selove, Nucl. Phys. **A523**, 1 (1991).

 © 2007 The American Physical Society