7-6-2012

Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”

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

Recommended Citation

Fortune, H. T. (2012). Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”. Retrieved from https://repository.upenn.edu/physics_papers/251

Fortune, H. T. (2012). Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”. *Physical Review C 86*(2), 019801. doi: 10.1103/PhysRevC.86.019801

Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”

Abstract

A recent paper [Phys. Rev. C 83, 057304 (2011)] used knockout from ^{12}Be to populate two states near 3.9 MeV in ^{11}Be and observed their neutron decay—but treated the two as a single state. The authors used a branching ratio for the upper state from an experiment that also did not separate the two states. Thus, their energy for ^{11}Be(3.96 MeV) and the spectroscopic factor connecting it to ^{12}Be(gs) are questionable.

Disciplines

Physical Sciences and Mathematics | Physics

Comments

Fortune, H. T. (2012). Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”. *Physical Review C 86*(2), 019801. doi: 10.1103/PhysRevC.86.019801

PHYSICAL REVIEW C **86**, 019801 (2012)

Comment on “Neutron knockout of ^{12}Be populating neutron-unbound states in ^{11}Be”

H. T. Fortune

Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, Pennsylvania, 19104, USA

(Received 31 May 2011; revised manuscript received 5 April 2012; published 6 July 2012)

A recent paper [Phys. Rev. C **83**, 057304 (2011)] used knockout from ^{12}Be to populate two states near 3.9 MeV in ^{11}Be and observed their neutron decay—but treated the two as a single state. The authors used a branching ratio for the upper state from an experiment that also did not separate the two states. Thus, their energy for ^{11}Be(3.96 MeV) and the spectroscopic factor connecting it to ^{12}Be(gs) are questionable.

DOI: 10.1103/PhysRevC.86.019801 PACS number(s): 29.38.−c, 29.30.Hs, 21.10.Pc, 21.60.Cs

The ^{10}Be (t,p) [1] and ^{9}Be(t,p) [2] reactions first demonstrated the predominance of the $(sd)^2$ configuration in ^{12}Be(gs) and in several of the states in ^{11}Be. Peters *et al.* [3] looked at low-energy neutron decay of ^{11}Be states formed in neutron removal from ^{12}Be and claimed to have extracted a spectroscopic factor for the 3.95-MeV $3/2^-$ state. Two states exist here—$5/2^-$ at 3.888 MeV and $3/2^-$ at 3.955 MeV. The authors took the $3/2^-$ branching ratio (BR) from an experiment [4] that clearly did not resolve the $3/2^-$ and $5/2^-$ states, rather than from an experiment [5] that did. They dismiss the possibility that the $5/2^-$ could have made an appreciable contribution in Ref. [4]. But the $L = 2$ $2n$ cluster spectroscopic factor for the $5/2^-$ state is 0.121 [6], not exactly negligible and comparable to that for the first $3/2^-$, and larger than half the value of the $L = 0$ S for the latter. In the ^{9}Be(t,p) reaction [2], the 3.888-MeV $5/2^-$ state was about half as strong as the 3.955-MeV $3/2^-$ state. And the heavy-ion $2n$ stripping reaction used by Ref. [4] probably favors $L = 2$ over $L = 0$ more than does (t,p).

Reference [3] states that Ref. [30] (Ref. [7] in this Comment) “selectively populated the 3.887 and 3.949 MeV states by two proton and two neutron transfer reactions, respectively.” The actual energies in that paper are 3.90(3) and 3.95(3) MeV. As those energies result from two different experiments, the uncertainties are probably independent so that the energy difference in those two *peaks* is 50(42) keV. In the ^{9}Be(t,p) reaction [2], the energy difference in the two *states* is 67.0(1.4) keV, so one (or both) of the heavy-ion reactions could easily be populating both states. The $3/2^-$ should be quite weak in $2p$ pickup from ^{13}C because it contains a large $(sd)^2$ neutron amplitude [2] that is absent in ^{13}C(gs). In both reactions, the angular distribution is observed [7] to have a pure $L = 2$ shape. In ^{13}C(^{12}C,^{14}O), the selection rules require $L = 2$ for both states, whereas, in ^{9}Be(^{16}O,^{14}O), the $5/2^-$ is required to have $L = 2$, but the $3/2^-$ can be reached via either $L = 0$ or 2. In the (t,p) reaction, some $L = 0$ is observed [2,8]. The observation of $L = 2$ dominance in the heavy-ion reaction would seem to indicate that the $(5/2^-)/(3/2^-)$ ratio is larger in Ref. [30] (Ref. [7] in this Comment) than in Ref. [2]. I expect that a good resolution ^{9}Be(^{16}O,^{14}O) experiment will find appreciable population of the 3.888-MeV $5/2^-$ state. This is the reaction whose BR was used by Peters *et al.*

Reference [3] repeatedly refers to the $5/2^-$ state as having an excitation energy of 3.887 MeV. They also repeatedly refer to it as having a neutron decay energy of 14 keV. Of course, an excitation energy of 3.887 MeV corresponds to a neutron decay energy of 18 keV. The excitation energy of 3.888(1) in Ref. [2] would have $E_{\mathrm{n}} = 19(1)$ keV. Reference [3] states “This 14 keV decay channel was also observed in Ref. [30].” I find no mention of a “14 keV decay channel” in that paper. Reference [3] states “The nonobservation of the 3.887-MeV state, decaying preferentially to the 2^+ state in ^{10}Be by 14 keV, indicates that this state is not strongly populated by simple neutron removal from ^{12}Be *or two-neutron transfer [their Ref. [25]* (Ref. [4]) in this Comment].” (my italics) Of course, the results of Ref. [3] have nothing to say about what may or may not have been populated in the ^{9}Be(^{16}O,^{14}O) reaction. And, that part of their statement is contradicted by the fact that the 3.888-MeV state *is* populated in a $2n$ stripping reaction, viz. ^{9}Be(t,p) [2].

They also claim that it is unlikely that the $5/2^-$ state is populated in their reaction. It could have a small direct one-step connection to ^{12}Be(gs) through a nonzero $1f_{5/2}$ spectroscopic factor. The fact that the $5/2^-$ state has an observable decay [5] to the 0^+ gs is evidence of some $f_{5/2}$ strength. Also, it is strongly connected to the 2^+ state of ^{10}Be—as demonstrated by its BR [5], and it could be strongly populated in a two-step (or coupled channels) process involving $E2$ excitations in ^{12}Be and ^{11}Be accompanied by p-shell neutron removal. But, the important point is not the theory, but what do the data say. Their peak (inset of their Fig. 2) could easily contain the $5/2^-$ state at the 15%–20 % level (see below) without noticeable distortion to the peak. They state that, if the $5/2^-$ state is made, it decays predominantly to the gs. That statement is contradicted by the fact that its decay to the 2^+ is known [5].

The authors quote an excitation energy for the $3/2^-$ state that is smaller than any previously published value. They quote an energy of 3.956(15) MeV from the compilation [9] and 3.969^{+20}_{-9} from β decay [5], but they do not mention the value of 3.955(1) from (t,p). [2] The fact that their n decay energy is 80(2) keV is, by itself, proof that the $5/2^-$ state makes some contribution because the excitation energy of 3.955(1) for the $3/2^-$ state in Ref. [2] corresponds to $E_{\mathrm{n}} = 86(1)$ keV. If the $5/2^-$ state is populated at all, their 80-keV energy would be a weighted average of 19 (or 18) keV and an energy higher than 80 keV. A sizable $5/2^-$ contribution could easily be present, given the width of their peak. I find, by explicit calculation, that the sum of two peaks, at 18 and 86 keV, in the ratio 0.15/0.85, is well fitted as a single peak with a centroid of 79 keV. If the $5/2^-$ state has any cross section, their energy is wrong as is their BR. (It is known [5] to decay to the 2^+.) In fact, unless they know how much $5/2^-$ is present, they cannot analyze their data to extract an energy or a spectroscopic factor. Their uncertainty of 2 keV seems overly optimistic for the $3/2^-$ state when the peak is 150-keV wide. Even if the uncertainty in their peak position is somehow correct, the energy of the $3/2^-$ state could still be wrong by as much as 6–8 keV if the $5/2^-$ state is populated.

[1] H. T. Fortune, G.-B. Liu, and D. E. Alburger, Phys. Rev. C **50**, 1355 (1994).
[2] G.-B. Liu and H. T. Fortune, Phys. Rev. C **42**, 167 (1990).
[3] W. A. Peters *et al.*, Phys. Rev. C **83**, 057304 (2011).
[4] P. J. Haigh *et al.*, Phys. Rev. C **79**, 014302 (2009).
[5] Y. Hirayama *et al.*, Phys. Lett. B **611**, 239 (2005).
[6] S. Cohen and D. Kurath, Nucl. Phys. A **141**, 145 (1970).
[7] H. G. Bohlen *et al.*, Nucl. Phys. A **734**, 345 (2004).
[8] H. T. Fortune and R. Sherr, Phys. Rev. C **83**, 054314 (2011).
[9] F. Ajzenberg-Selove, Nucl. Phys. A **506**, 1 (1990).