Reply to "Comment on 'Properties of ^{26}Mg and ^{26}Si in the *sd* shell model and the determination of the ^{25}Al(p,γ)^{26}Si reaction rate' "

W. A. Richter,[1,2] B. Alex Brown,[3] A. Signoracci,[3] and M. Wiescher[4]
[1]*iThemba LABS, P.O. Box 722, Somerset West 7129, South Africa*
[2]*Department of Physics, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa*
[3]*Department of Physics and Astronomy and National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824-1321, USA*
[4]*Department of Physics and Joint Institute for Nuclear Astrophysics, University of Notre Dame, Notre Dame, Indiana 46556, USA*
(Received 27 September 2011; published 7 November 2011)

We discuss the implications for the ^{25}Al(p, γ)^{26}Si resonance-capture rate that result from the updates on the experimental data given in the Comment.

DOI: 10.1103/PhysRevC.84.059802 PACS number(s): 26.30.−k, 21.10.Sf, 21.60.Cs, 25.40.Lw

The Comment by Chipps *et al.* [1] starts with a reminder of the astrophysical importance of this reaction. They present arguments for revised experimental values for the Q value and resonance energy of a final state. Our original paper [2] was not meant to update the experimental situation beyond that given in the paper by Matic *et al.* [3]. We appreciate the updated averages and have used them to recalculate the rate. We change the Q values from 5.5123 to 5.5137 MeV and the energy of the 3^+ state from 5.9152(18) to their average of 5.923(2). The resonance energy for the 3^+ state changes from 403 to 409 keV. The ratio of the new rate (B) to our old rate (A) is shown in Fig. 1(a). Figure 1(b) shows the ratio of the new rate (B) to that given in the 2010 evaluation [4]. The energy changes improve the agreement with the 2010 evaluation in the region of $\log_{10}(T9) = -0.7$.

The observation [5] of a 5.888-MeV resonance in the ^{24}Mg(^{3}He,n)^{26}Si reaction that γ decays to three low-lying 2^+ states in ^{26}Si is an indication that the experimental situation is not yet final. The γ decay looks like that expected for the 0_4^+ state. The γ branchings for the mirror state in ^{26}Mg obtained with the USDB Hamiltonian are 94% (2_1^+), 2% (2_2^+), and 2% (2_3^+), similar to what is observed in ^{26}Mg. The calculated branchings in ^{26}Si of 59% (2_1^+), 35% (2_2^+), and 4% (2_3^+) have a large mirror asymmetry and appear to be in qualitative agreement with those observed in Ref. [5].

A puzzle is why the 5.888-MeV state does not appear in the older (^{3}He,n) experiment [6] where two states were observed in this energy region at 5.912 and 5.946 MeV. In the mirror reaction ^{24}Mg(t, p)^{26}Mg [7] one observes a relatively strong 0_4^+ state (state number 14 in Fig. 2 of Ref. [7]) and a very weak 3_3^+ state (state number 13 in that figure). Based on this mirror reaction one might expect the relatively strong state observed in Ref. [6] at 5.912 MeV to be the 0_4^+ state and the weaker one at 5.946 MeV to be the 3_3^+ state.

The 3_3^+ state is well established from the ^{26}P β-delayed proton decay [8,9] to have a resonance energy of 0.412 MeV, consistent with the average energy of 5.923(2) MeV given in Table I of the Comment [1]. A large absolute proton branch of $b = 0.91(10)$ for this 3_3^+ state has recently been measured [10]. This is in agreement with our (USDB) value [2] of $b = 0.967$. (Use of the experimental γ-decay lifetime in ^{26}Mg in place of our USDB value would give $b = 0.991^{+0.002}_{-0.007}$.) We also note from Table 3 of Ref. [11] that the experimental spectroscopic factors of the positive-parity levels obtained from the ^{25}Mg(d, p)^{26}Mg reaction are in good agreement with the USD theoretical values and with those we used in Ref. [2] including that for the 3_3^+ state. The 3_3^+ state is most important for the astrophysical rate because it is an $\ell = 0$ resonance. The position of the 0_4^+ state and its relationship to states populated in reaction experiments is not clear, but because it is an $\ell = 2$ resonance it is not very important for the astrophysical rate.

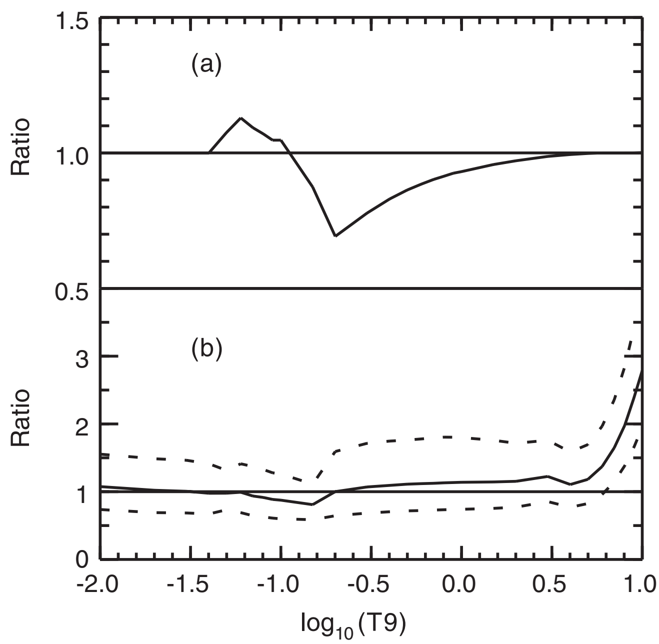

FIG. 1. (a) The new rate (B) divided by the old rate (A) of Ref. [2]. (b) The new rate (B) divided by the rate given in the 2010 evaluation (Table B.37 of Ref. [4]); the solid line is for the median rate and the dashed lines are for the low and high rates.

This work is partly supported by NSF Grant No. PHY-1068217, NSF Grant No. PHY08-22648 (Joint Institute for Nuclear Astrophysics), and the National Research Foundation of South Africa.

[1] K. A. Chipps *et al*., Phys. Rev. C **84**, 059801 (2011).
[2] W. A. Richter, B. A. Brown, A. Signoracci, and M. Wiescher, Phys. Rev. C **83**, 065803 (2011).
[3] A. Matic *et al*., Phys. Rev. C **82**, 025807 (2010).
[4] C. Iliadis, R. Longland, A. E. Champagne, A. Coc, and R. Fitzgerald, Nucl. Phys. A **841**, 31 (2010).
[5] N. de Sereville *et al*., **PoS(NIC XI)**, 212 (2011).
[6] Y. Parpottas, S. M. Grimes, S. Al-Quraishi, C. R. Brune, T. N. Massey, J. E. Oldendick, A. Salas, and R. T. Wheeler, Phys. Rev. C **70**, 065805 (2004).
[7] W. P. Alford, J. A. Cameron, E. Habib, and B. H. Wildenthal, Nucl. Phys. A **454**, 189 (1986).
[8] J. C. Thomas *et al*., Eur. Phys. J. A **21**, 419 (2004).
[9] C. Wrede, Phys. Rev. C **79**, 035803 (2009).
[10] K. A. Chipps *et al*., Phys. Rev. C **82**, 045803 (2010).
[11] H. F. R. Arciszewski, E. A. Bakkum, C. P. M. Van Engelen, P. M. Endt, and R. Kamermans, Nucl. Phys. A **430**, 234 (1984).