Comments

Comments are short papers which comment on papers of other authors previously published in **Physical Review C**. *Each Comment should state clearly to which paper it refers and must be accompanied by a brief abstract.*

Comment on "Radiative capture reaction $^7Be(p,\gamma)^8B$ at low energies"

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A calculation of the $^7Be(p,\gamma)^8B$ cross section at low energies by Kim *et al.* does not significantly improve on previous calculations. In particular, their treatment of the resonant contribution is open to criticism.

In a recent paper, Kim *et al.*[1] (hereafter referred to as KPK) calculate the $^7Be(p,\gamma)^8B$ cross section at low energies on the basis of a direct-capture single-particle model. KPK use the same model for both the nonresonant contribution, due to $E1$ transitions from *s*- and *d*-wave initial states to a *p*-wave final state, and the resonant contribution, due to $M1$ and $E2$ transitions from *p*- and *f*-wave initial states. For the nonresonant contribution, they appear to obtain good agreement with an earlier calculation by Barker[2] (hereafter referred to as *B*), which had predicted a cross section much less than the then-accepted experimental one.

KPK say that the resonant part of the cross section was ignored in *B*, so that the $M1$ resonance which appears as a sharp peak at $E_{\mathrm{c.m.}}=633$ keV (corresponding to the 1^+ first excited state of ^8B) was not reproduced. This is not true. Although the resonant contribution was not calculated in *B* by a direct-capture model, the parameter values required to fit the observed peak were compared with those obtained from shell model calculations. There was reasonable agreement for the spectroscopic factor (*B*, Table I), which determines the width of the peak, but the $M1$ radiation width (*B*, Table III), which determines the area of the peak, suggested a cross section appreciably less than the measured one, as also occurred for the nonresonant cross section (see also Barker and Spear[3]).

Calculation of the resonant contribution by a direct-capture model, as is done by KPK following the earlier work of Robertson,[4] had already been criticized in *B*, essentially because both shell model and experimental values of the spectroscopic factor for the 1^+ state suggest that it does not look like $^7Be(g.s.)+p$ (see *B*, Table I). Consequently, the width of the sharp resonance calculated by KPK is too large—about 70 keV as compared with the experimental value of 40 ± 10 keV.[5] There are other deficiencies in KPK's single-particle model for the 1^+ state, in that their descriptions of the analog 1^+ states in the ^8Li and ^8B mirror nuclei are inconsistent, and neither description is justified by shell model calculations. KPK use an optical potential with both central and spin-orbit parts. The spin-orbit interaction is of the form $\mathbf{l}_a\cdot\mathbf{S}_a$ or $\mathbf{l}_b\cdot\mathbf{S}_a$ (in the notation of KPK), which removes the degeneracy between $p_{3/2}$ and $p_{1/2}$ nucleons, but otherwise does not depend on the spin of the ^8Li or ^8B state. The 2^+ ground states are taken as pure $p_{3/2}$ configurations, which is well justified by shell model calculations (e.g., Cohen and Kurath[6] give spectroscopic factors $\mathcal{S}_{3/2}=0.977$, $\mathcal{S}_{1/2}=0.056$). The 633 keV resonance in $^7Be(p,\gamma)^8B$, corresponding to the 1^+ state of ^8B, is also attributed to $p_{3/2}$ protons, which is made possible by the use of different central depths for the bound and scattering states. KPK obtained the strength of the spin-orbit interaction by fitting the energy difference of the bound 2^+ and 1^+ states of ^8Li, assuming a $^7Li(g.s.)+n$ structure for each, with a $p_{3/2}$ neutron for the 2^+ state and a $p_{1/2}$ neutron for the 1^+ state (the central depth being taken the same for each state). Thus, they inconsistently describe the 1^+ first excited state of ^8B as $^7Be(g.s.)+p(p_{3/2})$ and that of ^8Li as $^7Li(g.s.)+n(p_{1/2})$. Shell model calculations do not support either description (Cohen and Kurath[6] give $\mathcal{S}_{3/2}=0.322$, $\mathcal{S}_{1/2}=0.124$). Since the potential used by KPK is independent of the total J value of the initial capturing state, so differing from the earlier work by Robertson,[4] the 633 keV resonance in KPK erroneously contains 2^+ and 3^+ contributions as well as 1^+. Likewise, the $p_{1/2}$ resonance found by KPK at about 1.4 MeV contains 1^+ and 2^+ contributions, but no 1^+ or 2^+ state of ^8B at this energy is either observed experimentally or expected from shell model calculations.

As far as the nonresonant $^7Be(p,\gamma)^8B$ cross section is concerned, KPK chose a single set of potential parameter values and consequently obtained a single prediction of the low-energy astrophysical S factor. KPK do not give any justification for their particular choice, nor do they indicate the sensitivity of the S factor to their choice. The calculations in *B* indicate that reasonable changes in the values of some of these parameters could appreciably change the resultant value of the low-energy S factor. Consequently, the particular value $S(20\ \mathrm{keV})=0.024$ keV b obtained by KPK is not very significant.

In summary, the main points of this Comment are that KPK's calculation of the resonant contribution to the $^{7}Be(p,\gamma)^{8}B$ cross section is inferior to an earlier calculation,[2] and that KPK's value for $S(20\ keV)$ has an appearance of reliability that is misleading because it is based on a single set of potential parameter values that is not justified.

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[6]S. Cohen and D. Kurath, Nucl. Phys. **A101**, 1 (1967).