DWIA production cross sections of ${}^{12}_{\Lambda}$B and ${}^{10}_{\Lambda}$Be calculated with extended wave functions

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Recently the $(e, e'K^+)$ reaction experiments done at the Jefferson Lab have provided us with remarkably high resolution data in the production spectroscopy of hypernuclei such as ${}^{12}_{\Lambda}$C, ${}^{16}_{\Lambda}$N, and ${}^{10}_{\Lambda}$Be [1-3]. These experiments have confirmed the major peaks and subpeaks predicted in DWIA by employing the Λ particle in s- and p-orbit coupled with the nuclear core states confined within the p-shell configuration, $\underline{[\alpha](0p_{3/2}0p_{1/2})^n}$.[4] However, it is interesting to observe extra strengths at $E_x \simeq 9$ MeV excitation in ${}^{12}\mathrm{C}(e, e'K^+){}^{12}_{\Lambda}\mathrm{B}$ and also at $E_x \simeq 8.4$ MeV excitation in ${}^{10}\mathrm{B}(e, e'K^+){}^{10}_{\Lambda}\mathrm{Be}$, because these extra subpeaks are hard to be explained within the multi-p-shell configurations. We note that the similar extra peaks have been observed also in the (π^+, K^+) reaction on the same targets, respectively. Therefore the extension of the model space is necessary and interesting challenge in view of the present hypernuclear spectroscopy.

In order to explain these extra states, one naturally includes the $1\hbar\omega$-excited positive parity nucler core states which in fact appear at $Ex \simeq 6.8-9.5$ MeV in ^{11}B. To be consistent with this extension of the nuclear model space, here we take account of the $2\hbar\omega$-excited configurations to describe the nomal (positive) parity nuclear core states of ^{11}B and the target ground state of ^{12}C. Thus the nuclear configurations concerned here are represented as follows:

$$\begin{aligned} {}^{12}\mathrm{C}(0^+_g) &= \underline{[\alpha](p)^8} + [\alpha](p)^6(sd)^2 + [0s^{-2}_{1/2}](p)^{10} && (1) \\ {}^{11}\mathrm{B}(J^-) &= \underline{[\alpha](p)^7} + [\alpha](p)^5(sd)^2 + [0s^{-2}_{1/2}](p)^9 && (2) \\ {}^{11}\mathrm{B}(J^+) &= [\alpha](p)^6(sd)^1 + [0s^{-1}_{1/2}](p)^8 && (3) \end{aligned}$$

where $(p)^8$ stands for $(0p_{3/2}0p_{1/2})^8$, etc. and the configurations employed traditionally so far for the (γ, K^+) calculation are underlined. The spurious center-of-mass motion effects involved in the model space extension are removed. Thus, in the extended model space, the Λ-hypernuclear states are described with parity-mixed nuclear core states as

$${}^{12}_{\Lambda}\mathrm{B}(J^{\mp}_H) = [{}^{11}\mathrm{B}(J^{\mp}) \times \Lambda(0s_{1/2})] + [{}^{11}\mathrm{B}(J^{\pm}) \times \Lambda(0p_{3/2}0p_{1/2})] \quad (4)$$

The nuclear core states and hypernuclear states are solved in these configuration spaces, respectively. The obtained wave functions are used to estimate the spectroscopic amplitudes and the DWIA cross sections of the ${}^{12}\mathrm{C}(\gamma, K^+){}^{12}_{\Lambda}\mathrm{B}$ reaction typically at $E_\gamma = 1.3$ GeV and $\theta_K^{(Lab)} = 3$ deg. As for the elementary process of $\gamma p \to \Lambda K^+$, the Saclay-Lyon amplitudes and other available ones are employed. The paralell calculations are performed also for the ${}^{10}\mathrm{B}(\gamma, K^+){}^{10}_{\Lambda}\mathrm{Be}$ reaction. We will discuss the calculated results in comparison with the experiments.

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