Shell model spectra of light hypernuclei with ΛN and ΛNN forces: the final results concerned hyperon-nucleon interaction parameters

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Abstract

Low lying spectra of light hypernuclei are analyzed using data on hypernuclear γ-lines [1] in the framework of the shell model motivated in ref. [2] where in addition to the ΛN effective interaction with two-body parameters Δ, S_Λ, S_n and T [3] the phenomenological zero-range three-body force

$$V = \delta(\mathbf{r}_\Lambda - \mathbf{r}_1)\delta\mathbf{r}_\Lambda - \mathbf{r}_2)(t + t_s\boldsymbol{\sigma}_\Lambda(\boldsymbol{\sigma}_1 + \boldsymbol{\sigma}_2))$$

has been introduced. Matrix elements $(s_\Lambda sp|V|s_\Lambda sp)$, $(s_\Lambda p^2|V|s_\Lambda p^2)$ were calculated with the oscillator wave functions for nucleons and with the Woods-Saxon potential wave functions for a Λ particle. The calculations show an extremely week t-dependence of energy splittings and for definiteness sake we take t=176 MeVfm^6 [2]. Using the $(3/2^+,5/2^+)$ doublet splitting (DS) in ${}^{9}_{\Lambda}$Be and three levels $(1^-_1,1^-_2,2^-)$ in ${}^{16}_{\Lambda}$O the values of Δ, S_n, T and t_s have been found as functions of S_Λ in the interval -0.015$\leq S_\Lambda \leq$-0.006 (MeV). Spectra of ${}^{9}_{\Lambda}$Be, ${}^{10}_{\Lambda}$B, ${}^{11}_{\Lambda}$B, ${}^{12}_{\Lambda}$C, ${}^{13}_{\Lambda}$C, ${}^{15}_{\Lambda}$N, ${}^{16}_{\Lambda}$O were calculated with the common values of S_n, T and t_s using the total set of the $0\hbar\omega$ nuclear states. Small variations of Δ_A were taken into account by the scaling factor α_A ($\Delta_A = \alpha_A\Delta_{16}$) estimated for the Gaussian shape of the ΛN potential. The S_Λ-dependence of the ground state DS in ${}^{12}_{\Lambda}$C and ${}^{11}_{\Lambda}$B derived with the NN forces CKB(I,II,III) (the Cohen-Kurath interaction corrected by Barker) [4] excludes the interactions CKB(I,III) whereas the variant CKB(II) reproduces the observed DS (161 keV and 264 keV)in the vicinity of $S_\Lambda \simeq$-0.007. As this takes place, the unobserved DS in ${}^{10}_{\Lambda}$B does not exceed 70keV. The acceptable parameters are Δ_{16}=0.082, S_Λ =-0.007, S_n=-0.33, T=0.023 (MeV) and t_s=216.5 MeVfm^6. In this model the calculated values Δ and $|S_\Lambda|$ are considerable less than ones given in ref. [5]. The description of DS in ${}^{7}_{\Lambda}$Li demands the higher value of Δ that reflects an influence of the cluster structure of ${}^{7}_{\Lambda}$Li [6].

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