Coherent Σ mixing in nonmesonic decay of light hypernuclei

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Nonmesonic weak decays of hypernuclei are interesting and challenging. In our study [1], we found that the direct quark (DQ) process is important to describe the short range physics, and the well-known n/p puzzle is roughly solved by applying the $\pi + K + DQ$ model for $\Lambda N \to NN$ transition. Recently, the importance of Σ in S-shell hypernuclei is pointed out. It is advocated that the mixing of Σ is crucial to describe the structure [2]. In this paper, we study the nonmesonic weak decays of light hypernuclei considering the coherent mixing of Σ.

Our basic approach is the same as ref.[1] where the transition potential is constructed from the direct quark mechanism for short distance and traditional meson exchange mechanism for longer distance. The initial hyperon nucleon wave functions are described in a simple shell model. We introduce the mixing of Σ to this mode:

$$|{}^{A}_{Y}Z\rangle^{J}_{I} = \sqrt{1-\beta^2}\,|{}^{A}_{\Lambda}Z\rangle^{J}_{I} + \beta\,|{}^{A}_{\Sigma}Z\rangle^{J}_{I} \tag{1}$$

where the super- and sub-script stand for the total spin and isospin for hypernuclei. Then we compute the transition amplitude and obtain the decay width. We find that virtual Σ component changes the magnitudes of the nonmesonic decay rate significantly and our estimates of the decay rates of ${}^{4}_{\Lambda}$He agree with the experimental data fairly well for a negative $\beta \simeq -0.1$. We have also pointed out that observation of final p-p state from the decay of ${}^{4}_{\Lambda}$He gives us a chance to show a clear evidence of the Σ component in Λ hypernucleus.

Table 1: Nonmesonic decay rates of ${}^{4}_{\Lambda}$He in units of Γ_Λ

${}^{4}_{\Lambda}$He	total	Γ_{pn}	Γ_{nn}	Γ_{nn}/Γ_{pn}
π+K+DQ	0.218	0.214	0.004	0.019
$\beta = -0.1$	0.168	0.165	0.003	0.017
EXP [3]	0.17±0.05	0.16±0.02	$0.01^{+0.04}_{-0.01}$	$0.06^{+0.28}_{-0.06}$

References

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