Competing effects of nuclear deformation and density dependence of the ΛN interaction in B_Λ values of hypernuclei

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One of the basic quantities of Λ hypernuclei is the Λ binding energy defined as the energy gain by adding a Λ particle from the core nucleus. Recently, the dependence of B_Λ on structures of core nuclei, in particular, nuclear deformations, has been discussed in several hypernuclei theoretically [1, 2, 3]. Values of B_Λ are related to nuclear structure in two ways: one is that an increase of deformation reduces the overlap of the densities between the Λ particle and nucleons, which makes B_Λ smaller. The other is due to the density dependence of the ΛN effective interaction. In light hypernuclei and/or cluster states, the density overlap between the Λ and nucleons is significantly decreased, which can affect B_Λ through the density dependence. When the ΛN effective interaction derived from the G-matrix calculation is designed to depend on the nuclear Fermi momentum k_F, the smaller overlap makes the relevant value of k_F small, i.e., less Pauli-blocking, resulting in the increase of B_Λ. Considering this effect, it is expected that appropriate values of k_F in finite systems are reduced as overlaps become small with mass numbers, which would affect the mass dependence of B_Λ.

The aim of the present work is to reveal how the density dependence of the ΛN effective interaction affects the mass dependence of B_Λ. Since p-sd-pf shell hypernuclei have various structures, they would affect the values of B_Λ through the density dependence of the ΛN interaction. To investigate it, we apply the antisymmetrized molecular dynamics for hypernuclei (HyperAMD) to the Λ hypernuclei with $9 \leq A \leq 59$, combined with the generator coordinate method using the HyperAMD wave functions with various nuclear quadrupole deformation (β, γ) as the basis. As ΛN effective interactions, we use the ΛN G-matrix interactions derived from the Nijmegen potentials, which has the k_F dependence. In this study, we calculate k_F from the densities of the Λ particle and nucleons for each hypernucleus based on the averaged density approximation.

The B_Λ values are shown in Fig. 1 (solid line) together with observed data. One can see that the present calculation nicely reproduces the observations in wide mass region, which is achieved by taking into account core structure, especially deformation of core nuclei. To see the importance of describing the core structure, we calculate the B_Λ values using the spherical basis wave functions only (see dashed line). It shows that the B_Λ values are deviated significantly from the observed data, especially in light Λ hypernuclei in Fig. 1(b), if the core nuclei are assumed to be spherical. We also confirmed, for example in $^{12}_{\Lambda}$B, that the present calculation reproduces the intra-band $B(E2)$ of the core nuclei well, implying that core deformation is described properly. The contents of this report have been published [4].

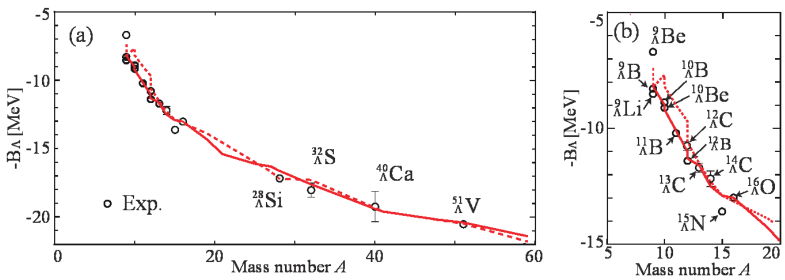

Figure 1: (a) B_Λ values calculated with the HyperAMD wave functions with (β, γ) deformation (solid) and spherical shape ($\beta = 0$) only (dashed). Open circles show observed data with mass numbers from $A = 9$ up to $A = 51$. (b) Same as (a), but magnified in the $5 \leq A \leq 20$ region.

References

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