Binding Energy Difference of Light Mirror Hypernuclei and Nuclei

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Introduction

Strangeness degree of freedom can be experimentally injected in a bound nuclear system through the (K^-,π^-), $(K^-,\pi^-\gamma)$, (π^0,K^+), $(e,e^{'}K^+)$, (π^-,K^+), and (K^-,K^+) reactions, for example. As a consequence of such strangeness exchanging process, a more generalised form of matter made up of nucleons (n and p) and hyperons $(\Lambda,\Sigma,\text{or}\,\Xi)$ is formed. There are hypernuclei with finite number of baryons, which are ordinarily stable as binding effects lengthen the life time of strong interaction process $\Lambda N\rightarrow\Lambda N$ to the order of 10^{-10} seconds. We have a wide spectrum of stable hypernuclear systems bound with one or two hyperons. Strangeness induces subtle distortions in the nuclear system and introduces new symmetries replacing older ones [1]. It modifies various physicsl observables like size, shape, density profiles, halo/skin structure, energy breckdown and nuclear core polarization etc. This is because hyperons in the surrounding of nucleons are not Pauli blocked, and therefore feel nuclear force different from nucleon-nucleon (NN) force. Hypernuclei are unique laboratories to test these interesting aspects owing to the presence of the strangeness degree of freedom. Physics of hypernuclei is interested due to the impurity of hyperon(s) in nuclei. This hyperons play glue like role which attracts the neighbouring nucleons. In our present work we will focus on mirror hypernuclei and corresponding mirror nuclei (which is core of mirror hypernuclei).

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The Generalised Mass Formula for Hypernuclei and Nuclei

We used the generalised mass formula to calculate Binding Energy Difference (BED). The generalized mass formula for hypernuclei and nuclei is given by[2]

$$B(A,Z)=15.777A-18.34A^{2/3}-0.71\frac{Z(Z-1)}{A^{1/3}}\\-\frac{23.21(N-Z_c)^2}{(1+\exp(-A/17))A}+(1-\exp(-A/30))\delta\\+n_Y[0.0335(m_Y)-26.7-48.7|S|A^{-2/3}]\quad(1)$$

The inclusion of mass of hyperon in the above formula is due to SU(3) symmetry breacking. Where, $\delta=12A^{-1/2}$ for even N, Z_c; = -$12A^{-1/2}$ for odd N, Z_c and =0 otherwise. δ would be zero for mirror hypernuclei. n_Y is no. of hyperons and M_Y mass of hyperons in MeV. $A=N+Z_c+n_Y$ is mass no. N and Z_c is no. of neutrons and protons respectively. Using this formula we calculated the BED for mirror hypernuclei and nuclei. The BED for mirror nuclei is given by

$$\Delta E_c=B(N+1,Z)-B(N,Z+1)$$

where, $B(N+1,Z)$ is the binding energy of the nucleus wth N neutrons and Z protons. For the hypernuclei this is given by

$$\Delta E_c=B(N+1,Z)_{hyp}-B(N,Z+1)_{hyp}$$

Binding energy difference (BED) and binding energy difference per baryon no. (BED/A) for mirror hypernuclei is given in Table I. Dotted line in Fig. 1 is for corresponding mirror nuclei.

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TABLE I: Binding Energy Difference (BED) and Binding Energy Difference per baryon number(BED/A) of mirror hypernuclei

Mirror Hypernuclei	BED	BED/A
${}^{4}_{\Lambda}H -{}^{4}_{\Lambda} He$	0.894	.223
${}^{6}_{\Lambda}He -{}^{6}_{\Lambda} Li$	1.563	.260
${}^{8}_{\Lambda}Li -{}^{8}_{\Lambda} Be$	2.130	.266
${}^{10}_{\Lambda}Be -{}^{10}_{\Lambda} B$	2.636	.263
${}^{12}_{\Lambda}B -{}^{12}_{\Lambda} C$	3.102	.285
${}^{14}_{\Lambda}C -{}^{14}_{\Lambda} N$	3.535	.252
${}^{16}_{\Lambda}N -{}^{16}_{\Lambda} O$	3.945	.246

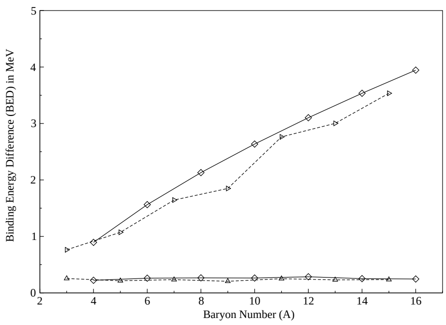

FIG. 1: BED and BED/A vs baryon number (A) for mirror hypernuclei and nuclei. Solid line corresponds to mirror hypernuclei and dotted line correspond to mirror nuclei respectively.

References

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