Interactions between Octet Baryons in the SU_6 Quark model

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In the quark model the baryon-baryon interactions for the complete octet baryons ($B_8 = N$, Λ, Σ and Ξ) are treated entirely equivalently with the well-known nucleon-nucleon (NN) interaction. Once the quark-model Hamiltonian is assumed in the framework of the resonating-group method (RGM), the explicit evaluation of the spin-flavor factors leads to the stringent flavor dependence appearing in various interaction pieces. We can thus minimize the ambiguity of the model parameters, by utilizing the rich knowledge of the NN interaction. In this study we first upgrade our previous quark model [1] for the NN and hyperon-nucleon (YN) interactions by incorporating more complete effective meson-exchange potentials such as the vector mesons and some extra interaction pieces. This model fss2 [2] reproduces the existing data of the NN and YN interactions quite well. We then proceed to explore all the B_8B_8 interactions in the strangeness $S = -2,\ -3$ and -4 sectors, without adding any extra parameters. [3] We discuss some characteristic features of the B_8B_8 interactions, focusing on the qualitative aspect. Among these features are the following: (1) There is no bound state in the B_8B_8 systems, except for the deuteron. (2) The $\Xi\Xi$ total cross sections are far smaller than the NN cross sections. (3) The ΞN interaction is strongly isospin dependent, similar to the ΣN interaction. (4) The $\Xi^-\Sigma^-$ [$\Xi\Sigma(I = 3/2)$] interaction is moderately attractive. The S-wave phase-shift behavior yielding these qualitative features of the B_8B_8 interactions is systematically understood by (1) the spin-flavor SU_6 symmetry, (2) the special role of the pion exchange, and (3) the flavor symmetry breaking. In particular, the phase-shift rise of the $\Lambda\Lambda$ interaction in fss2 is less than 20°, in contrast to the previous FSS prediction $\sim 40^\circ$. A rough estimate of $\Delta B_{\Lambda\Lambda}$ for ${}^{6}_{\Lambda\Lambda}$He in terms of the G-matrix calculation using fss2 is about 1 MeV, which is consistent with two recent double Λ-hypernuclei called "Demachi-Yanagi event" [4] (${}^{10}_{\Lambda\Lambda}$Be) and "Nagara event" [5] (${}^{6}_{\Lambda\Lambda}$He). In the isospin $I = 1$ channel, the full coupled-channel treatment for the ΞN-$\Sigma\Lambda$-$\Sigma\Sigma$ system makes the repulsive nature of the ΞN interaction in the single-channel calculation almost zero. This implies that the $\Sigma\Lambda$ channel-coupling effect is very important for the correct description of scattering observables.

References

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