The onset of binding for ΛΛ and ΛΞ hypernuclei

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New Faddeev-Yakubovsky calculations are reported for ${}_{\Lambda\Lambda}^{4}$H considered both as a three-body $\Lambda\Lambda d$ system and as a four-body $\Lambda\Lambda pn$ system [1], and for several other ΛΛ hypernuclei [2,3]: for ${}_{\Lambda\Lambda}^{5}$H - ${}_{\Lambda\Lambda}^{5}$He as three-body $\Lambda\Lambda^3$H - $\Lambda\Lambda^3$He systems, for ${}_{\Lambda\Lambda}^{6}$He as a three-body $\Lambda\Lambda\alpha$ system and for ${}_{\Lambda\Lambda}^{10}$Be as a four-body $\Lambda\Lambda\alpha\alpha$ system, using s-wave ΛΛ potentials motivated by Nijmegen model interactions. Our Faddeev calculations suggest that the binding energy of the uniquely determined ${}_{\Lambda\Lambda}^{6}$He event seen recently in the KEK-PS E373 emulsion experiment [4], $\Delta B_{\Lambda\Lambda} = 1.0 \pm 0.3$ MeV, is compatible with fairly weak ΛΛ interaction potentials similar to those provided by the Nijmegen soft-core one-boson-exchange model NSC97 [5] and that the ${}_{\Lambda\Lambda}^{5}$H - ${}_{\Lambda\Lambda}^{5}$He hypernuclei are particle-stable even in the limit $V_{\Lambda\Lambda} \to 0$ of a vanishingly attractive ΛΛ interaction [3]. Furthermore, whereas the Faddeev calculations for ${}_{\Lambda\Lambda}^{4}$H considered as a three-body $\Lambda\Lambda d$ system yield binding over a wide range of ΛΛ interaction strengths, with $B_{\Lambda\Lambda} \lesssim 0.5$ MeV not in disagreement with the events suggested recently by the BNL-AGS E906 collaboration [6] as due to ${}_{\Lambda\Lambda}^{4}$H, the four-body Faddeev-Yakubovsky calcualtions for ${}_{\Lambda\Lambda}^{4}$H do *not* produce a bound state even for ΛΛ interactions considerably stronger than that implied by the ${}_{\Lambda\Lambda}^{6}$He event and even if the $(3/2)^+$ excited state of ${}_{\Lambda}^{3}$H is made slightly bound [1]. We interpret the non-binding of ${}_{\Lambda\Lambda}^{4}$H in our four-body calculation as manifestation of screening in the Faddeev-Yakubovsky calculation [1]. In contrast, due to the special $\alpha\alpha$ structure of the ^{8}Be core, a four-body Faddeev-Yakubovsky calculation for ${}_{\Lambda\Lambda}^{10}$Be gives rise to a larger binding energy than that produced by a suitably defined three-body Faddeev calculation. Normalizing our four-body ${}_{\Lambda\Lambda}^{10}$Be calculation to the recently measured binding energy of ${}_{\Lambda\Lambda}^{6}$He [4], we predict $\Delta B_{\Lambda\Lambda}({}_{\Lambda\Lambda}^{10}\mathrm{Be}) = 2.5 \pm 0.3$ MeV, in strong disagreement with earlier reports as discussed in Ref.[3].

For stranger systems, Faddeev calculations of light ΛΞ hypernuclei, using ΛΞ interactions which simulate model NSC97, suggest that ${}_{\Lambda\Xi}^{6}$He marks the onset of nuclear stability for Ξ hyperons [2], but that ${}_{\Lambda\Lambda\Xi}^{7}$He may not be particle-stable due to screening effects. The implications of our calculations to multistrange hypernuclei and to the stability of strange hadronic matter are discussed [7].

References

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