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Meson-theoretic potentials and the hypertriton: A reply*

B. F. Gibson
Theoretical Division, Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87544

D. R. Lehman
Department of Physics, The George Washington University, Washington, D. C. 20006
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We argue on the basis of model calculations that the introduction of short-range repulsion and Λ-Σ coupling into the separable potential approximation to meson-theoretic potentials will not alter the conclusions previously obtained. In addition, it is shown that the introduction of the tensor force into the *N-N* triplet interaction, which produces a larger effect than either of the other two modifications, will not alter the conclusions.

[NUCLEAR STRUCTURE $^{3}_{\Lambda}$H, *Y-N* potentials, separable potential three-body calculation, B_Λ.]

As was noted by the authors[1] and reemphasized by Schick,[2] it was assumed in our original calculations of the hypertriton binding energy that (1) the Λ-Σ coupling could be reasonably accounted for by the use of effective Λ-*N* interactions and (2) the binding in the hypertriton is sufficiently weak that short-range repulsion in the Λ-*N* interaction would not significantly affect the conclusions reached. Schick[2] states that his previous investigation[3] of Λ-Σ coupling and his present calculations with repulsive potentials show that these effects are instead large enough to invalidate the conclusions[1] of the authors. We argue below that such is not the case.

Consider first the effects of Λ-Σ coupling. Dabrowski and Fedorynska[4] studied the problem of independently varying the coupling in each of the singlet and triplet *Y-N* interactions and showed that when the coupling is determined by the available experimental data, the binding is *increased* by some 0.1 – 0.2 MeV depending upon the relative sign of the singlet and triplet coupling parameters. Specifically, they showed that for coupling only in the triplet *Y-N* potential the binding energy was increased from 0.49 to a value of 0.63 MeV; the assumption of zero coupling in the singlet potential was shown to be consistent with the experimental data on all of the various *Y-N* reactions by Wycech.[5] It was also shown that for the very weak singlet coupling not excluded by the data that (1) if the signs of the coupling parameters were the same, the binding was reduced from the value of 0.63 MeV obtained with no singlet coupling to 0.58 MeV and (2) if the signs of the coupling parameters were different, the binding was increased to 0.70 MeV. Thus, one can understand the reduction in the binding of the hypertriton obtained by Schick and Toepfer,[3] but if the coupling is restricted by the experimental scattering data, then it appears that Λ-Σ coupling must increase the binding energy slightly over any value obtained for model A in the approximation used by the authors in their original calculations.

Consider next the effects of including short-range repulsion in the Λ-*N* interactions. We have estimated the $^{3}_{\Lambda}$H binding energy in a model in which we use an average Λ-*N* interaction to represent both the triplet and singlet potentials; our short-range repulsion was assumed to be given by the same parametrization as that used in the *N-N* singlet potential G_1 given in Refs. 6 or 7 where the form factor is $p^2/(\beta^2+p^2)^2$. Assuming for the Λ-*N* potential a scattering length and an effective range of

$$a = -2.21 \text{ fm}, \quad r = 2.24 \text{ fm}$$

the calculated phase shifts reached a maximum of approximately 34° and passed through zero at a center of mass energy of approximately 150 MeV. Including this repulsion in the potential decreased the binding by approximately 0.18 MeV from its value of 0.83 MeV when there was no short-range repulsion but the same scattering length and effective range were assumed. Borysowicz and Dabrowski[8] have also studied the problem; they showed that for a repulsive shell interaction with a hard shell radius $r_c = 0.4$ fm the binding energy of $^{3}_{\Lambda}$H would be reduced from 0.93 MeV to a value of 0.3 MeV or from 0.5 MeV to 0.1 MeV depending upon the scattering lengths and effective ranges assumed for the Λ-*N* interactions. However, comparison of the ^{3}H calculations of Dabrowski and Dworzecka,[9] in which the same repulsive shell was used, with the work of Gibson and Stephenson,[6] in which repulsive form factors of the type $p^2/(\beta^2+p^2)^2$ were used, indicates that a value of $r_c = 0.15$ fm would give a similar short-range repulsion and ^{3}H binding and might be more reasonable. In that case the reduction in binding energy of the hypertriton would be more like 0.15 – 0.2 MeV. Thus, it appears that the inclusion of short-range repulsion might reduce the binding energy that we obtained for model A by 0.2 MeV, but such a reduction would not alter our conclusions.

We do not understand the much larger reduction in binding energy obtained by Schick (approximately a factor of 2) when repulsion was introduced into his potentials. Possibly the Mongan type of potential that Schick used is the source of this difference; Arnold and MacKellar have discussed some of the difficulties that can arise with such potentials, where the same form factor is used in both the attractive and repulsive terms.[10]

A more important deficiency in our original calculation than either of the two discussed above was the use of a central potential to represent the triplet N-N interaction. Inclusion of the tensor force in triton calculations reduces the binding energy much more than the inclusion of short-range repulsion in the singlet potential. Thus it would seem that introducing the N-N tensor force into the hypertriton calculation would reduce the binding by more than the 0.18 MeV discussed above. Indeed, this is the case. We find that introducing the N-N tensor force would reduce the hypertriton binding for model A by some 0.25 – 0.3 MeV.

However, taking into account our estimates of the reduction in binding due to inclusion of the triplet N-N force and the short-range repulsion in the Λ-N potential as well as the increase in binding due to the Λ-Σ coupling, it would appear that the Λ-separation energy calculated for model A would still be too large while that for model B would be in reasonable agreement with experiment. Thus our conclusions[1] remain unaltered.

We wish to correct a misprint[1]: the value of $a^t_{p\Lambda}$ in model A should read −1.32 fm, which is the value actually used in our calculations.

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