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THE CASCADE-DEUTERON SYSTEM

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Recently there has been considerable speculation about the possible existence of the 'H' dibaryon (first proposed by Jaffe¹), as a deeply bound six quark state. This in turn has generated considerable interest in doubly strange $\Lambda\Lambda$ hypernuclei such as ${}_{\Lambda\Lambda}^6\text{He}$. Confirmation of a claim for the observation of ${}_{\Lambda\Lambda}^6\text{He}$ would argue strongly against the existence of a deeply bound 'H'.

To examine this problem we have considered the interaction of a Ξ hyperon with a deuteron in a full three-body analysis. We have included coupling between the $\Xi - N$ and the $\Lambda - \Lambda$ channels within the framework of separable two-body interactions². Ultimately, we will perform the full break-up calculation, *i.e.* $\Xi - d \rightarrow \Lambda\Lambda N$, with the hope of shedding some light on the interpretation of the neutron spectrum observed in Ξ^- capture on the deuteron. Here we present an outline of how we derived the AGS equations for the ΞNN system. In the three-body system consisting of (Ξ , Λ and N) we have the following possible final states when a Ξ reacts with a deuteron:

$$\begin{aligned}
 \Xi + (NN) &\rightarrow \Xi + (NN) & X_{\Xi\Xi} \\
 &\rightarrow N_i + (\Xi N) & X_{N_i\Xi} \\
 &\rightarrow N_i + (\Lambda\Lambda) & Y_{N_i\Xi} \\
 &\rightarrow \Lambda_i + (\Lambda N_j) & Y_{N_i\Xi}^{N_j} .
 \end{aligned} \tag{1}$$

If we were to turn off the coupling between the $\Xi - N$ and $\Lambda - \Lambda$ channels, then the system would decouple into two separate three-body problems; the ΞNN system and the $\Lambda\Lambda N$ system.

Initially it is productive to write down the AGS equations giving each particle a distinctive label, then to take the appropriate linear combinations of these equations to get the final equation for physical amplitudes with the correct anti-symmetry included. We chose to concentrate on the particle labeling only in deriving these equations, realizing that they are operator equations in the space of three-body states. These operator equations take the form

$$X_{\Xi\Xi} = \sum_{i=1}^2 Z_{\Xi N_i} \tau_{N_i}^{\Xi\Xi} X_{N_i\Xi} + \sum_{i=1}^2 Z_{\Xi N_i} \tau_{N_i}^{\Xi\Lambda} Y_{N_i\Xi} \tag{2}$$

$$X_{N_i\Xi} = Z_{N_i\Xi} + Z_{N_i N_j} \tau_{N_j}^{\Xi\Xi} X_{N_j\Xi} + Z_{N_i N_j} \tau_{N_j}^{\Xi\Lambda} Y_{N_j\Xi} + Z_{N_i\Xi} \tau_{\Xi}^{N_i N_j} X_{\Xi\Xi} \tag{3}$$

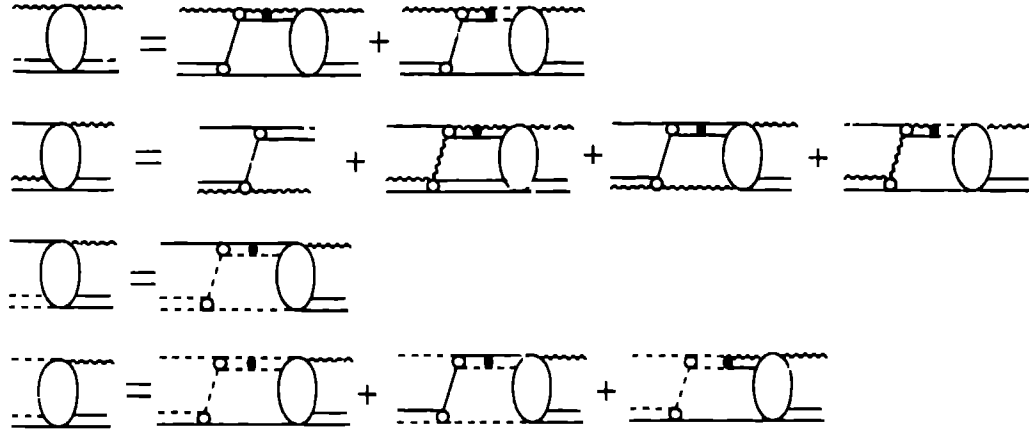
$$Y_{N_1\Xi} = \sum_{j=1}^2 Z_{N_1\Lambda_j} \tau_{\Lambda_j}^{\Lambda(3-j)N_1} Y_{\Lambda_j\Xi}^{N_1} \quad (4)$$

$$Y_{\Lambda_i\Xi}^{N_j} = Z_{\Lambda_i N_j} \tau_{N_j}^{\Lambda\Lambda} Y_{N_j\Xi} + Z_{\Lambda_i N_j} \tau_{N_j}^{\Lambda\Xi} X_{N_j\Xi} + Z_{\Lambda_i\Lambda_k} \tau_{\Lambda_k}^{\Lambda_i N_k} Y_{\Lambda_k\Xi}^{N_j}, \quad (5)$$

Where the amplitudes X and Y are defined in Eq. (1). Here, $\tau_{\alpha_i}^{\beta\gamma}$ represents the propagation of a pair in a quasi-particle state with initial channel γ , final channel β and particle α_i as spectator. The Born term $Z_{\alpha\beta}$ is the one particle exchange amplitude. With the following definitions of the physical amplitudes

$$\begin{aligned} X_{\Xi\Xi}^{AS} &\equiv X_{\Xi\Xi} & X_{N\Xi}^{AS} &\equiv \frac{1}{\sqrt{2}} [X_{N_1\Xi} - X_{N_2\Xi}] \\ Y_{N\Xi}^{AS} &\equiv \frac{1}{\sqrt{2}} [Y_{N_1\Xi} - Y_{N_2\Xi}] & Y_{\Lambda\Xi}^{AS} &\equiv \frac{1}{2} [Y_{\Lambda_1\Xi}^{N_1} - Y_{\Lambda_2\Xi}^{N_1} - Y_{\Lambda_1\Xi}^{N_2} + Y_{\Lambda_2\Xi}^{N_2}], \end{aligned} \quad (6)$$

we can combine the Eqs. (2) to (5) to arrive at the following system of equations for the physical amplitudes illustrated in diagrammatic form where the solid line represents a N , the dashed line a Λ and the zig-zag line the Ξ .



In deriving these equations we have made use of the symmetries of the one particle exchange amplitudes.²

We will present results for $\Xi - d$ elastic scattering using the above equations for separable approximations to the $\Xi N - \Lambda\Lambda$ potentials resulting from the $SU(3)$ rotated OBE potentials with different short range cut-offs. These results will be compared with similar results based on separable potentials that fit the phase shifts resulting from quark model calculations for the $\Xi N - \Lambda\Lambda$ system. In this way we hope to ultimately gain some insight into the effect of a bound state or resonance in the $\Xi N - \Lambda\Lambda$ system on the neutron spectrum in Ξ capture on the deuteron.

REFERENCES

1. R. L. Jaffe, Phys. Rev. Lett. **38**, 195 (1977).
2. I. R. Afnan, B. F. Gibson, Phys. Rev. C **41**, 2787 (1990).