TITLE: The Cascade-Deuteron System

AUTHOR(S):   S.B. Carr. Flinders University
I. R. Afnan, Flinders University
B.F. Gibson, T-5

SUBMITTED TO: Contributed Paper to the International Conference on
Hypernuclear and Strange Particle Physics, Vancouver, B.C.,
Canada, July 4-8, 1994

MASTER

Los Alamos   Los Alamos National Laboratory
Los Alamos, New Mexico 87545

THE CASCADE-DEUTERON SYSTEM

S. B. Carr and I. R. Afnan
School of physical sciences, Flinders University of South Australia
Bedford Park, SA, Australia, 5042

B. F. Gibson
Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM, USA 87545

Recently there has been considerable speculation about the possible existence of the 'H' dibaryon (first proposed by Jaffe[1]), as a deeply bound six quark state. This in turn has generated considerable interest in doubly strange $\Lambda\Lambda$ hypernuclei such as $_{\Lambda\Lambda}^{6}$He. Confirmation of a claim for the observation of $_{\Lambda\Lambda}^{6}$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 frame work of separable two-body interactions[2]. 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 ouline 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

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

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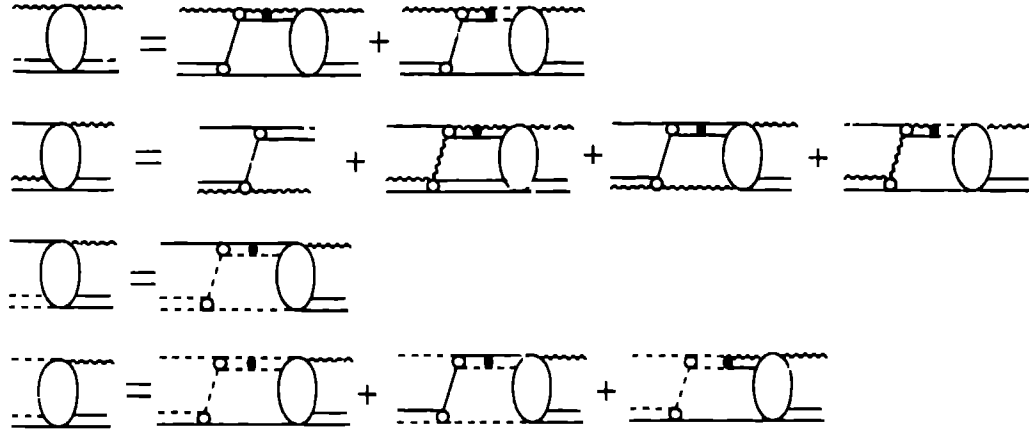\tag{3}
$$

$$Y_{N_i\Xi} = \sum_{j=1}^{2} Z_{N_i\Lambda_j} \tau_{\Lambda_j}^{\Lambda_{(3-j)}N_i} Y_{\Lambda_j\Xi}^{N_i} \qquad (4)$$

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

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 chunnel 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

$$X_{\Xi\Xi}^{AS} \equiv X_{\Xi\Xi} \qquad X_{N\Xi}^{AS} \equiv \frac{1}{\sqrt{2}}\left[X_{N_1\Xi} - X_{N_2\Xi}\right]$$

$$Y_{N\Xi}^{AS} \equiv \frac{1}{\sqrt{2}}\left[Y_{N_1\Xi} - Y_{N_2\Xi}\right] \qquad Y_{\Lambda\Xi}^{AS} \equiv \frac{1}{2}\left[Y_{\Lambda_1\Xi}^{N_1} - Y_{\Lambda_2\Xi}^{N_1} - Y_{\Lambda_1\Xi}^{N_2} + Y_{\Lambda_2\Xi}^{N_2}\right] , \qquad (6)$$

we can combine the Eqs. (2) to (5) to arrive at the following system of equations for the p'rsical amplitudes illustrated in diagramatic 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 ultimatly 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).