YN and YY Interactions in an OBE Model and Hypernuclei

K. Tominaga† and T. Ueda

Faculty of Science, Ehime University, Matsuyama 790-8577, Japan

Recently, we constructed a One-Boson-Exchange Potential(OBEP) for ΛN, $\Lambda\Lambda$, ΞN systems in the framework of the nonet mesons and the SU(3) invariance[1, 2]. This is based on the NN OBEP due to Ueda, Riewe and Green[3]. In the single-channel calculation, the effect of $\Lambda N - \Sigma N$ and $\Lambda\Lambda - \Sigma\Sigma$ channel couplings are effectively included in the contribution of the σ exchange. The ΛN potential is consistent with the binding energy of hypertriton (${}^{3}_{\Lambda}$H) as well as Λp total cross sections. Furthermore, $0^+ - 1^+$ splitting energies for ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He, which give the best experimental information on the ΛN spin-spin interaction, are considerably reproduced, applying our ΛN potential[4]. The relative strength of the ΛN ${}^1S_0$ and ${}^3S_1$ contributions are well determined by the analysis of both the hypertriton binding enegy and the Λp total cross sections. The $\Lambda\Lambda$ potential gives sufficient attraction to reproduce the difference $\Delta B_{\Lambda\Lambda}$ of the double-Λ hypernuclei (${}^{6}_{\Lambda\Lambda}$He, ${}^{10}_{\Lambda\Lambda}$Be, ${}^{13}_{\Lambda\Lambda}$B). The attraction in the $\Lambda\Lambda$ ${}^1S_0$ state is approximately similar to that in the ΛN ${}^1S_0$ state at medium range. By assuming to be $g_{\Xi\Xi\sigma} = g_{NN\sigma}$, we get relatively weak attraction in the $\Xi N(I = 0, 1)$ ${}^1S_0$ and $\Xi N(I = 0, 1)$ ${}^3S_1$ states in comparison with those in the ΛN S-waves and $\Lambda\Lambda$ ${}^1S_0$ states.

In the same framework, we develop this model by treating the $\Lambda N - \Sigma N$ channel coupling explicitly. We take (π, η, K, η'), (ρ, ω, K^*, ϕ) and (δ, S^*, $K_0^*(1430)$, $f_0(1581)$) as the pseudoscalar, vector and scalar nonet, respectively. Additionally, the isosinglet scalar meson σ is introduced, which represents the $I = 0$, $J^P = 0^+$ part of the correlated and uncorrelated 2π exchanges. We treat the vector and scalar mesons as involving the correlated and uncorrelated two octet exchanges.

The adjustable parameters, $g_{\Lambda\Lambda\sigma}$, $g_{\Sigma\Sigma\sigma}$, θ_V and θ_S, are determined by fitting to the data of the total cross sections for $\Lambda p \to \Lambda p$,$\Sigma^+ p \to \Sigma^+ p$, $\Sigma^- p \to \Sigma^- p$, $\Sigma^- p \to \Sigma^0 n$, $\Sigma^- p \to \Lambda n$ and the binding energy of hypertriton.

In the case that the adjustable parameters are determined by fitting to the data of the YN total cross sections and ΛN ${}^1S_0$ and ${}^3S_1$ scattering lengths obtained in the single-channel calculation, we found the structure at $p_{lab} \approx 450$MeV/c in $\Lambda p \to \Lambda p$ total cross sections due to the resonance in the ΛN ${}^1S_0$ state as shown in Figs. 1 and 2. This resonance disappears by adjusting the form factor parameter for the $\Sigma\Sigma\pi$ vertex. The cusp at the ΣN threshold in $\Lambda p \to \Lambda p$ total cross sections is due to the enhancement in the ΛN ${}^3S_1$ state. The low-energy parameters in the ΛN ${}^1S_0$ and ${}^3S_1$ states are shown in Table 1. In the $\Sigma N(I = 3/2)$ ${}^3S_1$ state, there is a bound state due to strong attraction from the central force as shown in Fig. 2. To remove these unwanted features: the resonance in the ΛN ${}^1S_0$ state and the bound state in the ΣN ${}^3S_1$ state, the calculation is now in progress, introducing the contribution from the Π[5].

Table 1: The low-energy parameters in the ΛN ${}^1S_0$ and ${}^3S_1$ states.

$a({}^1S_0)$ (fm)	$r({}^1S_0)$ (fm)	$a({}^3S_1)$ (fm)	$r({}^3S_1)$ (fm)
-2.70	2.02	-1.73	3.32

†Present address: Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan

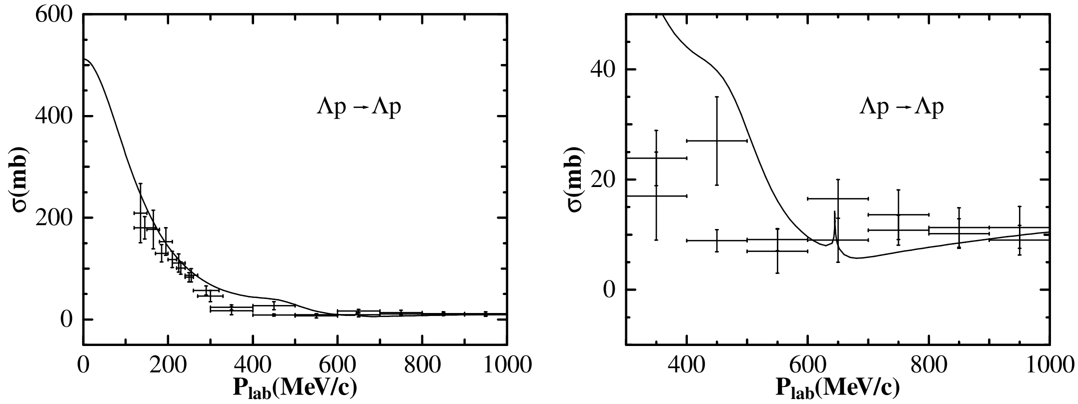

Figure 1: The Λp elastic total cross sections. The solid line shows the theoretical results from the $\Lambda N - \Sigma N$ coupled channel calculation.

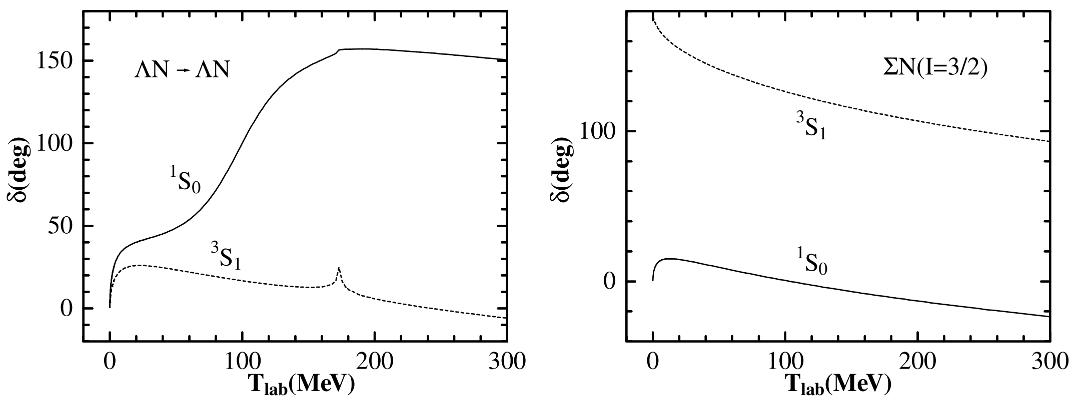

Figure 2: The ΛN $^1S_0$ and $^3S_1$ phase shifts in the $\Lambda N - \Sigma N$ coupled channel calculation (left) and the $\Sigma N(I = 3/2)$ $^1S_0$ and $^3S_1$ phase shifts (right).

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