Pole of the S-matrix of the ${}^{4}_{\Sigma}$He hypernucleus on Riemann sheets

T. Harada[1]**, Y. Hirabayashi**[2]

[1]Osaka Electro-Communication University, Neyagawa, Osaka, 572-8530, Japan.

[2]Information Initiative Center, Hokkaido University, Sapporo, 060-0811, Japan.

In this note, we focus on a pole position of the S matrix for a ${}^{4}_{\Sigma}$He hypernucleus on the Riemann sheets in the complex E plane. The existence of the ${}^{4}_{\Sigma}$He hypernucleus is experimentally confirmed in a ^{4}He(K^-, π^-) reaction at $p_{K^-} = 0.6$ GeV/c [1]. This state may be identified as an s-wave Σ quasibound (or unstable bound) state with $J^\pi = 0^+$, $T \simeq 1/2$ [2]. Recently, we demonstrated the inclusive and Σ-Λ conversion spectra in the ^{4}He(K^-, π^-) reaction at 1.5 GeV/c [3] in order to obtain evidence for p-wave Σ resonant states at J-PARC experiments. This investigation may lead to the quantitative understanding of ΣN interaction.

Now let us evaluate a pole position of the 3-channel coupled system in a (^{3}He-Λ)+(^{3}H-Σ^+)+(^{3}He-Σ^0) model [2], solving the multichannel Lippmann-Schwinger equation with a phenomenological $3N$–Y potential determined by theoretical analyzes [1]. For s-waves, we confirm the Σ quasibound state with $J^\pi = 0^+$, $T \simeq 1/2$ in ${}^{4}_{\Sigma}$He, as shown in Fig. 1. The pole is located at $\mathcal{E}_{\Sigma^+} = -1.1 - i6.3$ MeV near the Σ threshold on the *second* Riemann sheet $[-++]$. For p-waves, we consider a potential obtained by introducing strength factors of N_R and N_I into the s-wave potential we used, because the potential is still unknown; N_R and N_I denote the factors for the real and imaginary parts, respectively. If we choose $N_R = 1.0$ and $N_I = 1.0$ as the same s-wave potential, we find a Σ resonant state with $J^\pi = 1^-$, $T \simeq 1/2$ at $\mathcal{E}_{\Sigma^+} = +1.4 - i3.1$ MeV on the *fourth* Riemann sheet $[---]$, as shown in Fig. 2. We obtain the pole position of ${}^{4}_{\Sigma}$He when changing (N_R, N_I), and study the shape and magnitudes of the corresponding inclusive and conversion spectra in the ^{4}He(K^-, π^-) reaction [3]. Consequently, we predict the possible existence of the p-wave Σ resonant state in ${}^{4}_{\Sigma}$He near the Σ threshold on the Riemann sheets.

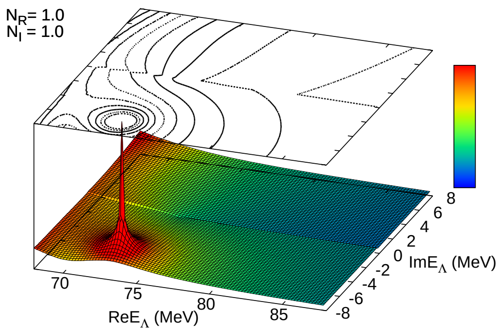

Figure 1: Pole of the S-matrix of the s-wave state with $J^\pi = 0^+$ at $\mathcal{E}_{\Sigma^+} = -1.1 - i6.3$ MeV on the $[+--]$ sheet in the ${}^{4}_{\Sigma}$He hypernucleus.

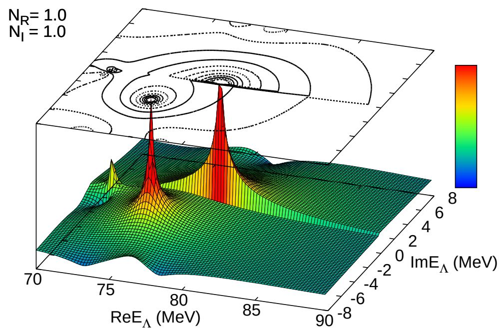

Figure 2: Pole of the S-matrix of the p-wave state with $J^\pi = 1^-$ at $\mathcal{E}_{\Sigma^+} = +1.4 - i3.1$ MeV on the $[---]$ sheet in the ${}^{4}_{\Sigma}$He hypernucleus.

[1] T. Nagae, et al., Phys. Rev. Lett. 80 (1998) 1605.

[2] T. Harada, Phys. Rev. Lett. 81 (1998) 5287; Nucl. Phys. A 672 (2000) 181.

[3] T. Harada, Y. Hirabayashi, Phys. Lett. B740 (2015) 312.