$\Lambda(1405)$ production in the $\pi^- p \to K^0\pi\Sigma$ reaction

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We study the $\pi^- p \to K^0\pi\Sigma$ reaction where the $\Lambda(1405)$ resonance is generated dynamically using the chiral unitary model [1]. Recently, in this approach, it has been reported that there are two resonances around the energy region 1400 MeV with the quantum numbers of $\Lambda(1405)$, $I(J^P) = 0(1/2^-)$ [2, 3]. The pole at lower energy has a larger width than the one appearing at higher energy, and the lower energy resonance couples strongly to $\pi\Sigma$ and the higher resonance to $\bar{K}N$. If this is the case, the shape of the $\pi\Sigma$ mass distribution obtained for a certain reaction should depend on the dynamics of the reaction [4]. Here we investigate the $\pi^- p \to K^0\pi\Sigma$ reaction from this viewpoint. Detailed argument of this study can be found in Ref. [5].

The diagram for $\pi^- p \to K^0\pi\Sigma$ is described in Fig. 1. The shaded blob involves tree level $\pi^- p \to K^0 MB$ amplitudes, while an open blob involves the final state interaction $MB \to \pi\Sigma$, which is calculated by chiral unitary model and $\Lambda(1405)$ is generated dynamically. The initial process is calculated by the chiral Lagrangians (t_χ), which is the sum of the meson pole and contact terms (Fig. 2). In addition to the chiral mechanism, we take into account the possibility of having a resonance excitation (t_R) in the πN collision as shown in Fig. 2. We take $N^*(1710)$ into account, adopting a coupling of Weinberg-Tomozawa type for resonance to the MMB channel [5]. Combining the two contributions ($t = t_\chi + t_R$), the invariant mass distribution is calculated. For completeness, we include a recoil factor and the strong form factor for which we take a standard monopole form factor with $\Lambda = 800$ MeV.

In Fig. 3, we show the results for the resonant mechanism (dashed line) together with the results obtained from the chiral mechanisms (dotted line) with the energy $\sqrt{s} = 2020$ MeV ($p_\pi = 1690$ MeV in the laboratory frame). This is the energy at which the experiment was done [6]. The resonance parameters are chosen well within the experimental boundaries. The total cross sections of various channels are also in good agreement with data.

We have shown how the two different mechanisms (chiral and $N^*(1710)$ terms) filtered each one of the resonance contributions, and then how the coherent sum of the amplitudes

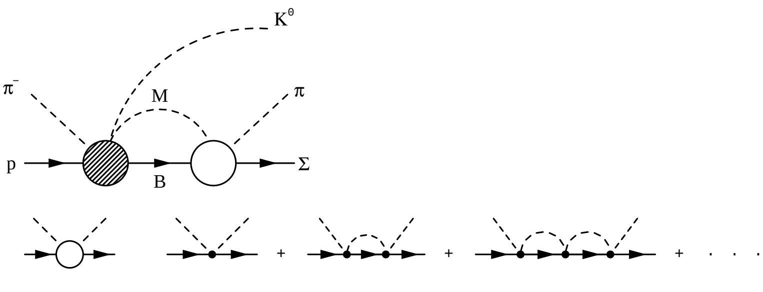

Figure 1: Diagrams entering the production of the $\Lambda(1405)$ in the $\pi^- p \to K^0\pi\Sigma$.

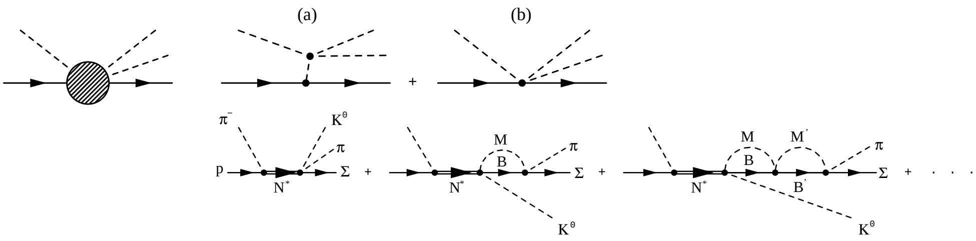

Figure 2: Initial process by chiral model. (a) : Meson pole term, (b) contact term, bottom : Resonant term.

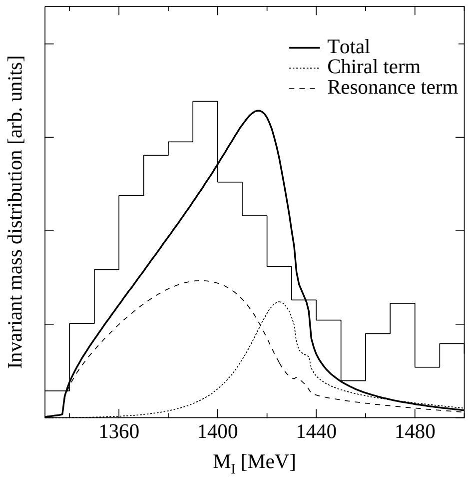

Figure 3: Invariant mass distribution of $\pi\Sigma$ obtained by averaging $\pi^+\Sigma^-$ and $\pi^-\Sigma^+$. The histogram shows the experimental data taken from Ref. [6]

from the two mechanisms could describe the data. The present study is also telling us that there might be other processes where the reaction mechanism of $\Lambda(1405)$ production filters one or another resonance, hence leading to very different shapes for the $\pi\Sigma$ mass distribution. The $\gamma p \to K^*\Lambda(1405)$ is considered to be a candidate to pick up the narrow higher energy resonance [7]. The findings of this article should stimulate further theoretical and experimental works that help us pin down the existence and properties of these two resonances.

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