Photoproduction of K^* for the study of $\Lambda(1405)$

The photo-induced K* vector meson production is investigated for the study of $\Lambda(1405)$. This reaction is particularly suited to the isolation of the second pole in the $\Lambda(1405)$ region which couples dominantly to the $\bar{K}N$ channel. We obtained the mass distribution of the $\Lambda(1405)$ which peaks at 1420 MeV, and differs from the nominal one.

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Motivation : Two poles?

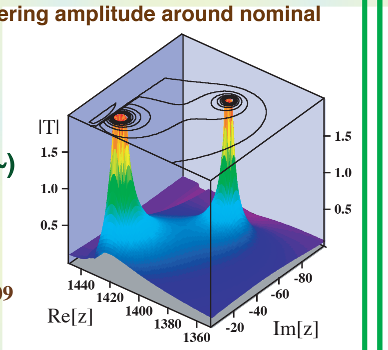
There are two poles of the scattering amplitude around nominal $\Lambda(1405)$ energy region.

Cloudy bag model (1990)

J. Fink, *et al.* PRC41, 2720

Chiral unitary model (2000~)

J. A, Oller, *et al.* PLB500, 263
E. Oset, *et al.* PLB527, 99
D. Jido, *et al.* PRC66, 025203
T. Hyodo, *et al.* PRC68, 018201
C. Garcia-Recio, *et al.* PRD67, 076009
D. Jido, *et al.* NPA725, 181
T. Hyodo, *et al.* PRC68, 065203



Poles in complex energy plane

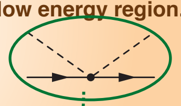
Chiral unitary model

We calculate s-wave coupled channel meson-baryon scatterings, where $1/2^-$ baryon resonances are generated.

Chiral symmetry

We use the interaction based on the chiral perturbation theory, which well describes hadron dynamics at low energy region.

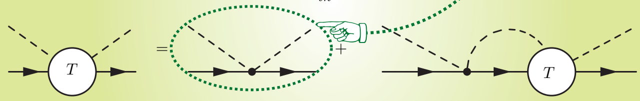
$$\mathcal{L}_{WT} = \frac{1}{4f^2}\mathrm{Tr}(\bar{B}i\gamma^\mu[(\Phi\partial_\mu\Phi - \partial_\mu\Phi\Phi), B])$$



Unitarity of S-matrix

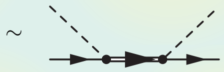
In order to maintain the unitarity condition, N/D method is used.

$$T^{-1}(\sqrt{s}) = -a(s_0) - \frac{s-s_0}{\pi}\int_{s_{th}}^{\infty} ds' \frac{\rho(s')}{(s'-s)(s'-s_0)} + V^{-1}(\sqrt{s})$$



We obtain the T-matrix amplitude in analytic way. Around the resonance energy region, the amplitude can be regarded as sum of the Breit-Wigner and background terms.

$$T_{ij}(\sqrt{s}) = \frac{g_i g_j}{\sqrt{s} - M_R + i\Gamma_R/2} + T_{ij}^{BG}$$

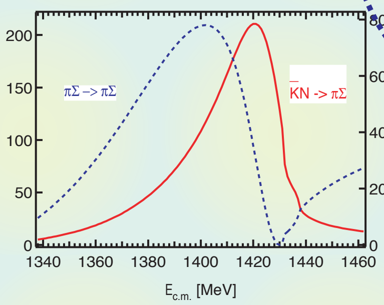


$J^P = 1/2^-$ **resonances**

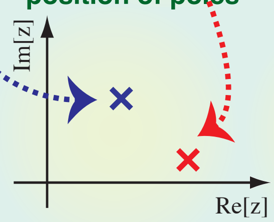
$\Lambda(1405)$ in the chiral unitary model

Two poles : 1390 + 66i ($\pi\Sigma$), 1426 + 16i ($\bar{K}N$)

$\pi\Sigma$ mass distribution



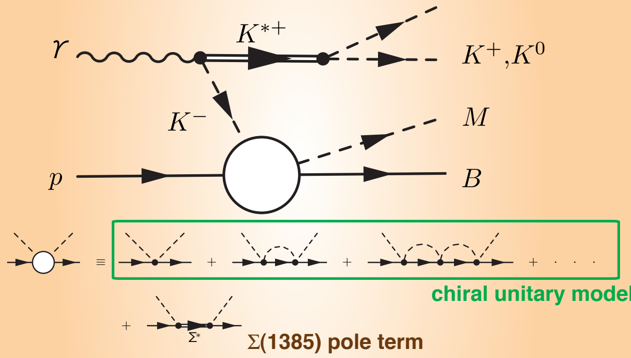
position of poles



D. Jido, *et al.*, Nucl. Phys. A725, 181 (2003)

Model for the reaction

Diagram of the reaction



Isospin decomposition of $\pi\Sigma$ states

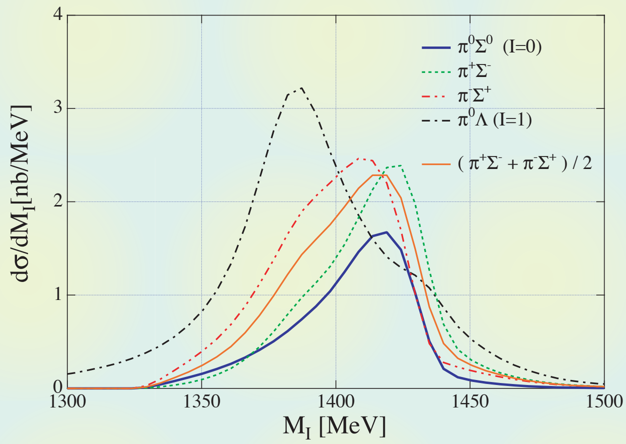
$$\frac{d\sigma(\pi^\pm\Sigma^\mp)}{dM_I} \propto \frac{1}{3}|T^{(0)}|^2 + \frac{1}{2}|T^{(1)}|^2 \pm \frac{2}{\sqrt{6}}\mathrm{Re}(T^{(0)}T^{(1)*})$$

Interference term

$$\frac{d\sigma(\pi^0\Sigma^0)}{dM_I} \propto \frac{1}{3}|T^{(0)}|^2$$

pure I=0 amplitude

Numerical results



Invariant mass distributions for several channels

Conclusions

We study the structure of $\Lambda(1405)$ using the chiral unitary model.

There are **two poles** in the scattering amplitude around nominal $\Lambda(1405)$.

1390 + 66i : strongly couples to $\pi\Sigma$
1426 + 16i : strongly couples to $\bar{K}N$

By observing the **charged $\pi\Sigma$** states in γp -> $K^*\Lambda(1405)$, it is possible to isolate the **higher energy pole**.

If we observe the **neutral $\pi\Sigma$ state, clear I=0 distribution** is obtained.

T. H., A. Hosaka, M. J. Vicente Vacas, E. Oset, nucl-th/0401051