K* vector meson coupling to the Λ(1520) resonance

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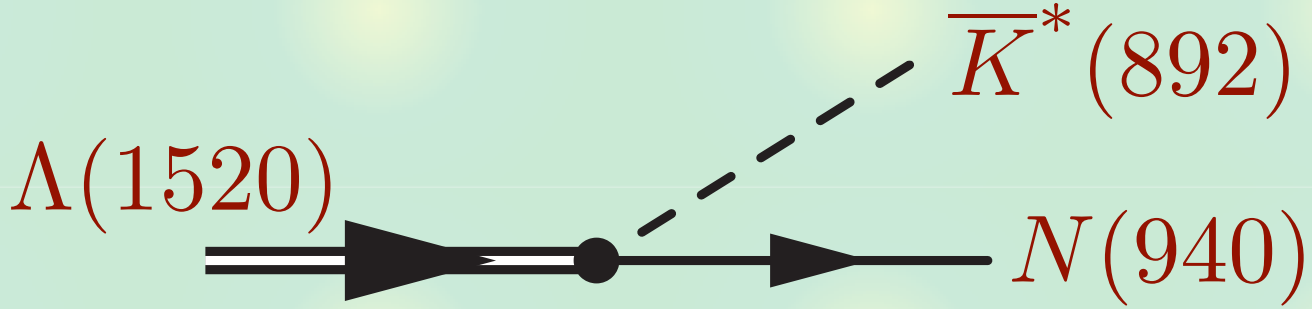
Contents



- Introduction to Λ(1520)
- Chiral unitary model
- Description of Λ(1520)
- Formulation
- Numerical results
- Summary

Introduction : Λ(1520)

$\Lambda(1520) : J^P = 3/2^-, I = 0$

Mass : 1519.5 ± 1.0 MeV
Width : 15.6 ± 1.0 MeV
Decay modes :

$\Lambda(1520) \to N\bar{K}$	**45%**
$\Lambda(1520) \to \Sigma\pi$	**42%**
$\Lambda(1520) \to \Lambda\pi\pi$	**10%**

(Naive) Quark model : SU(3) singlet

★ **large LS splitting with Λ(1405)?**

★ **decay branching ratio?**

Λ(1520) : recent interest

Photo-production experiments

Large p/n asymmetry?

LEPS @ SPring-8, CLAS @ J-lab.

S.I. Nam *et al.*, PRD 71, 114012 (2005)

Importance of the K* exchange?

D. P. Barber *et al.*, Z. Phys. C 7, 17 (1980)

A. Sibirtsev *et al.*, hep-ph/0509145

Θ^+ Λ* coherent production on deuteron

LEPS @ SPring-8

A.I. Titov *et al.*, PRC 72, 035206 (2005)

Chiral unitary model

Chiral symmetry

Low energy behavior

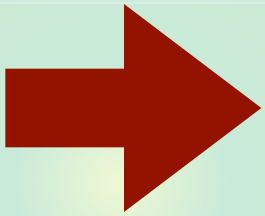
+

Unitarity of S-matrix

Non-perturbative resummation

Scattering of 8 meson(0^-) and 8 baryon($1/2^+$)

Dynamical generation



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

$\Lambda(1405), \Lambda(1670),$
$\Sigma(1620), \Xi(1620),$
$N(1535)$

Chiral unitary model

Chiral symmetry

Low energy behavior

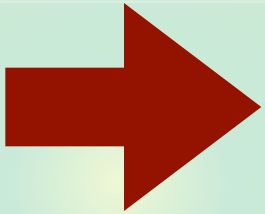
+

Unitarity of S-matrix

Non-perturbative resummation

Scattering of 8 meson(0^-) and 10 baryon($3/2^+$)

Dynamical generation



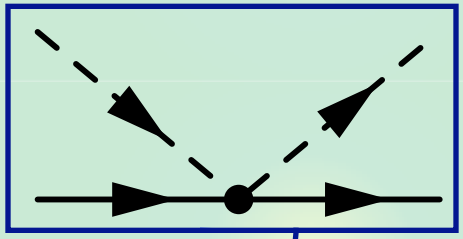
$J^P = 3/2^-$ resonances

$\Lambda(1520), \Sigma(1670),$
$\Xi(1820), \ldots$

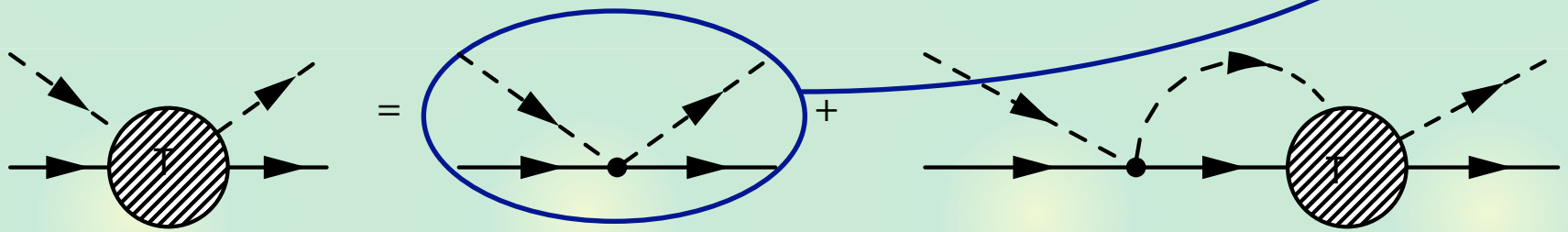
Framework of the chiral unitary model

Chiral perturbation theory

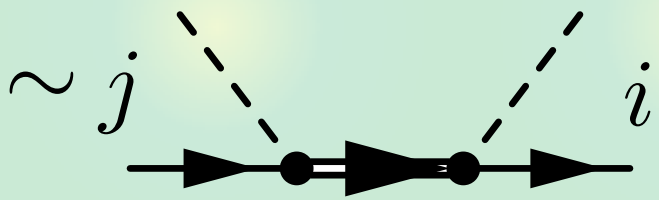
$$\mathcal{L}_{WT} = \frac{1}{4f^2}\mathrm{Tr}(\bar{B}i\gamma^\mu[(\Phi\partial_\mu\Phi - \partial_\mu\Phi\Phi), B])$$



Unitarization



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



Decuplet-Octet scattering

Interaction of 8 meson and 10 baryon is derived from chiral perturbation theory

E. Kolomeitsev *et al.*, PLB 585, 243 (2004)
S. Sarkar *et al.*, NPA 750, 294 (2005)

non-relativistic reduction + s-wave

$$V_{ij} = -\frac{1}{4f^2} C_{ij} (k^0 + k'^0)$$

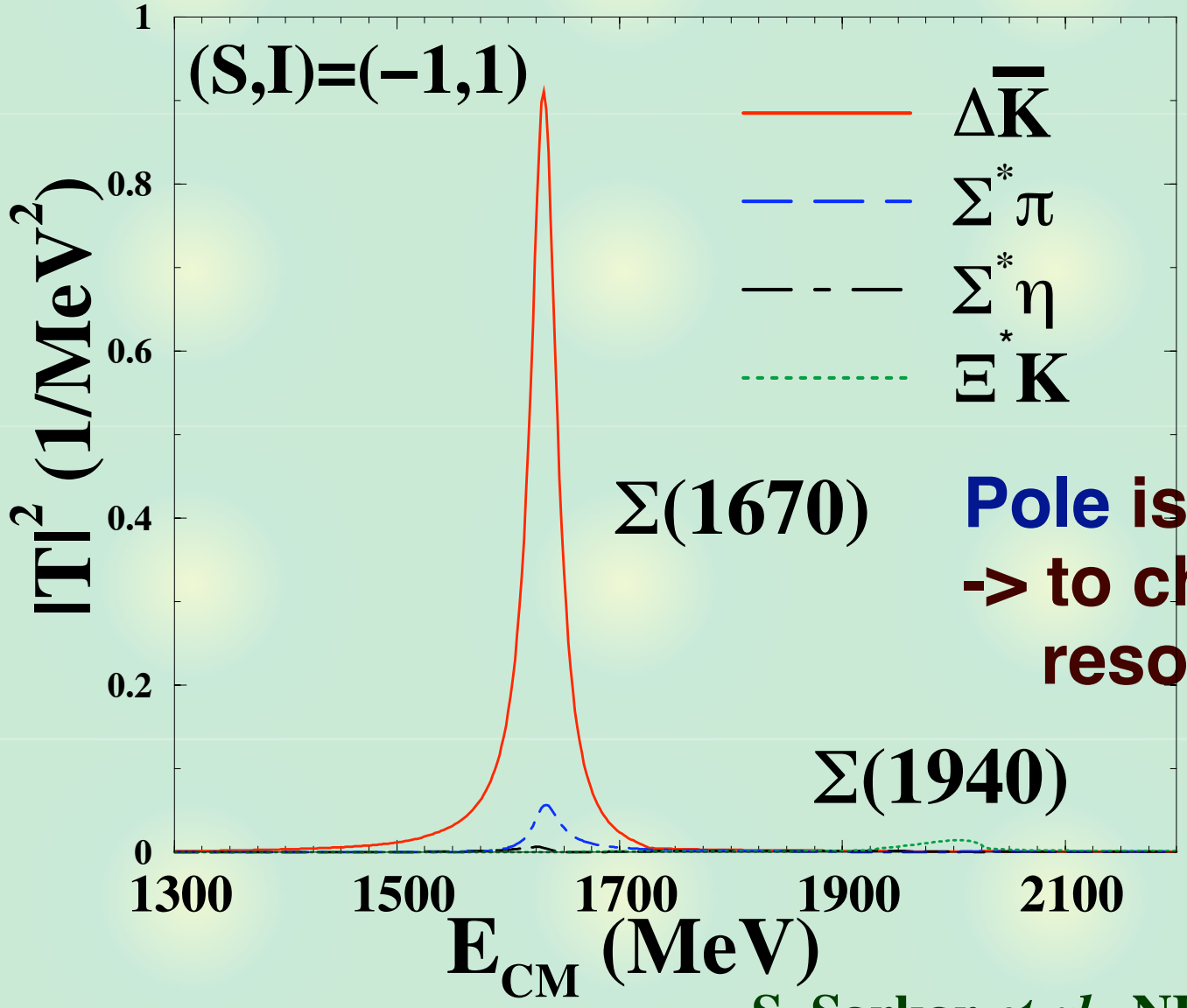
-> same structure as 8–8 scattering

SU(3) decomposition

$$8 \times 10 = 8 + 10 + 27 + 35$$ repulsive

attractive weakly attractive

Results for the Decuplet-Octet scattering

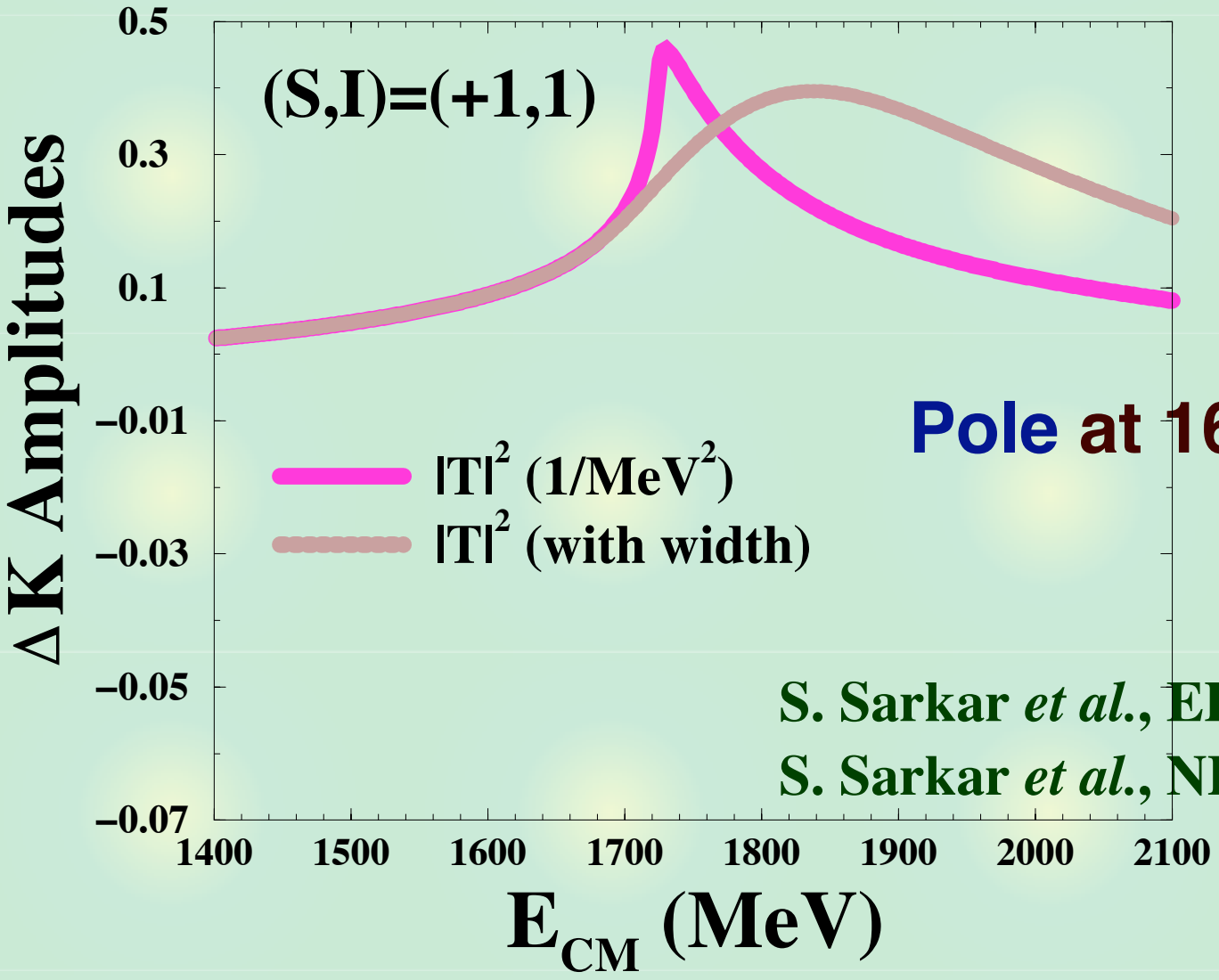


Pole is searched for -> to check whether resonance or not

S. Sarkar *et al.*, NPA 750, 294 (2005)

Results for the exotic state?

$8 \times 10 = 8 + 10 + 27 + 35$ weakly attractive



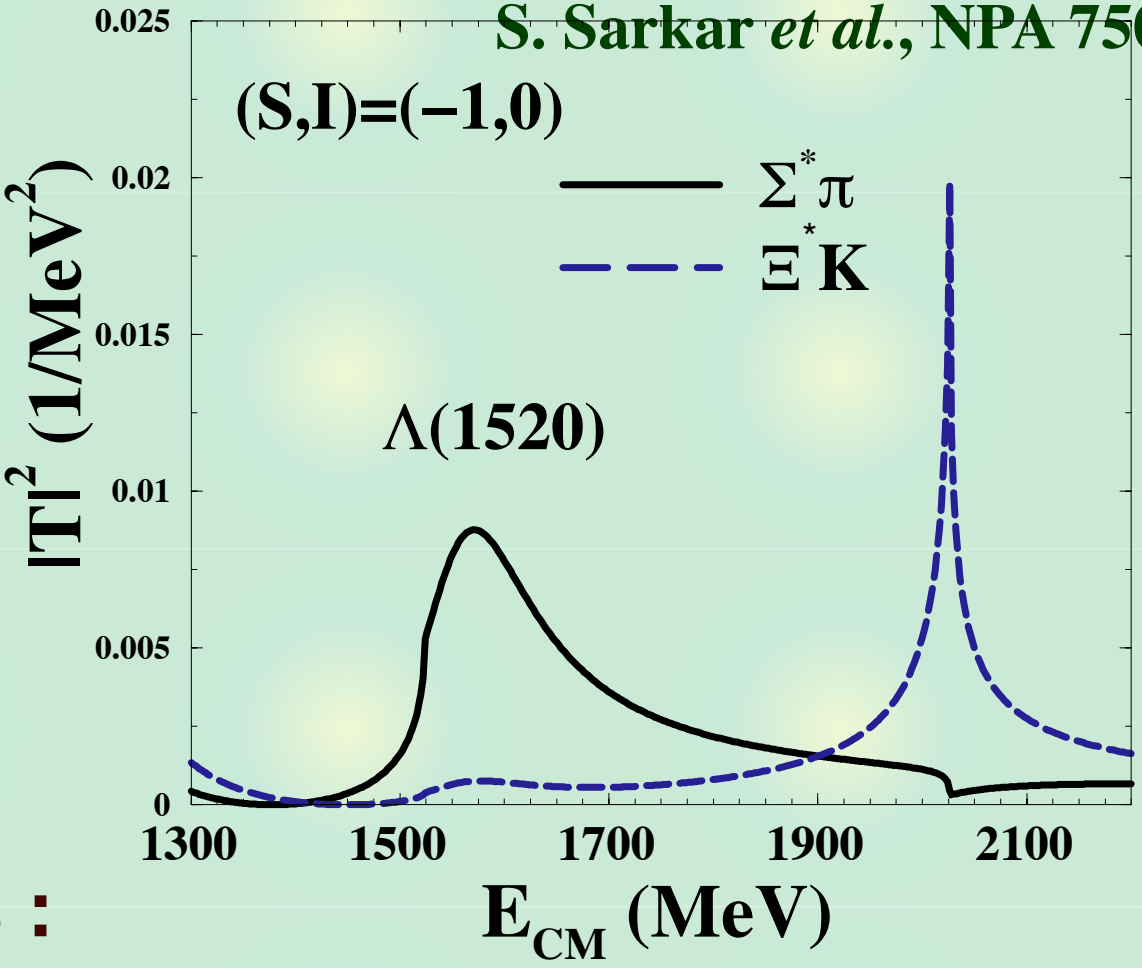
Pole at 1635 MeV

S. Sarkar *et al.*, EPJ A24, 287 (2005)

S. Sarkar *et al.*, NPA 750, 294 (2005)

Result for Λ(1520)

S. Sarkar *et al.*, NPA 750, 294 (2005)



Caveats :

★ Decuplet baryons do not decay

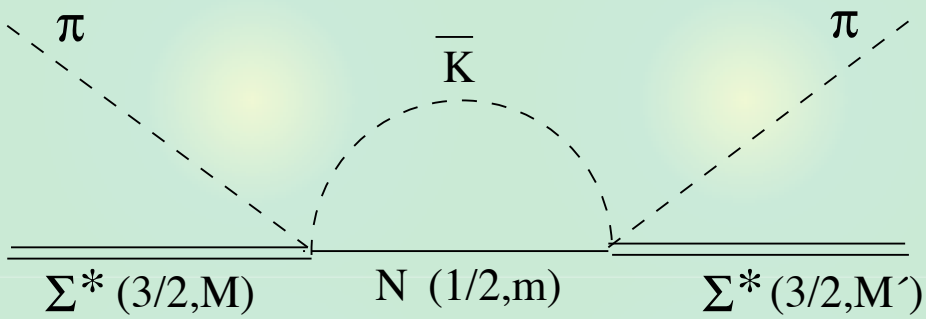
★ No coupling to other MB channels

-> Results should be regarded as qualitative

Quantitative description of Λ(1520)

More quantitative description

-> include d-wave channels : $\bar{K}$N, πΣ



Additional coupling constants

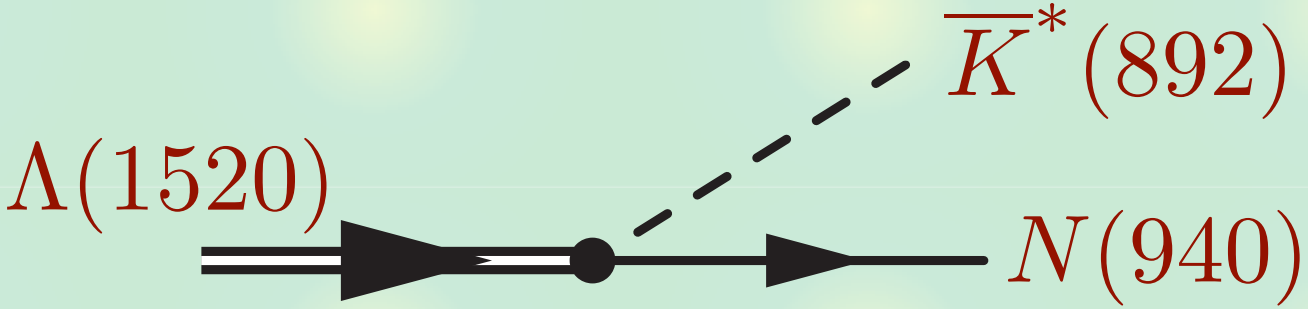
-> Decay width, branching ratio are reproduced

S. Sarkar *et al.*, PRC 72, 015206 (2005) -> K induced reaction

L. Roca *et al.*, in preparation -> photon, π induced production

M. Döring *et al.*, in preparation -> radiative decay

Formulation



Effective interaction Lagrangian

$$\mathcal{L}_{\Lambda^*\bar{K}^*N} = \frac{g_{\Lambda^*\bar{K}^*N}}{M_{K^*}}\bar{\Lambda}^*_\mu\gamma_\nu(\partial^\mu K^{*\nu} - \partial^\nu K^{*\mu})N + h.c.$$

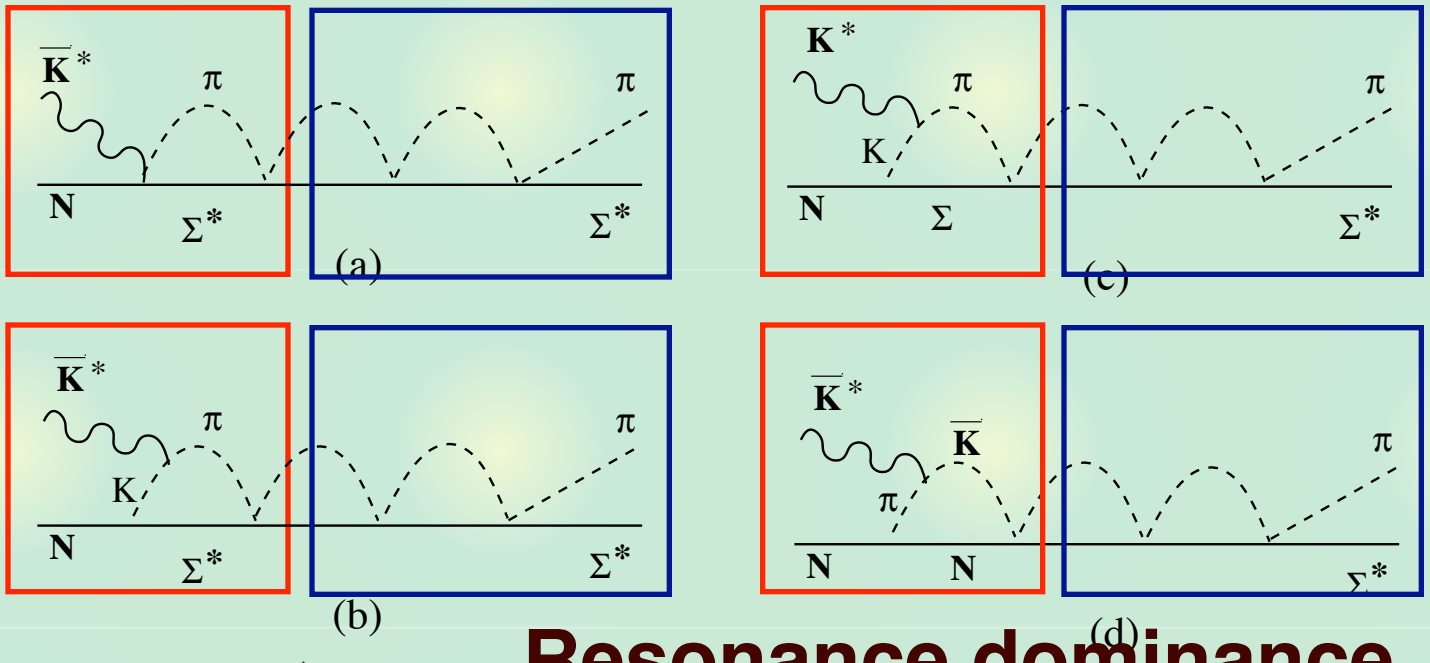
Non-relativistic reduction (s-wave)

$$-it_{\Lambda^*\bar{K}^*N} = g_{\Lambda^*\bar{K}^*N}\boldsymbol{S}\cdot\boldsymbol{\epsilon}$$

Formulation

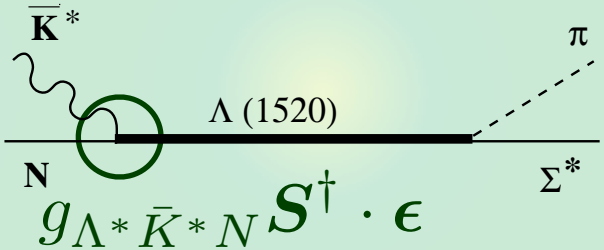
Amplitude for $\bar{K}^* N \to \pi \Sigma^*$

Microscopic couplings **Chiral unitary model**



Resonance dominance

$$P_0 \sim M_{\Lambda^*}$$



Formulation

Calculated by evaluating diagrams

$$g_{\Lambda^*\bar{K}^*N}(P_0,k) = g_{\Lambda^*\pi\Sigma^*}\left[G_{\pi\Sigma^*}(P_0)+\frac{2}{3}\tilde{G}_{\pi\Sigma^*K}(P_0,k)\right]g_{\pi\Sigma^*\bar{K}^*N}$$

$$+g_{\Lambda^*\pi\Sigma}\tilde{G}_{\pi\Sigma K}(P_0,k)g_{\pi\Sigma\bar{K}^*N}+g_{\Lambda^*\bar{K}N}\tilde{G}_{\bar{K}N\pi}(P_0,k)g_{\bar{K}N\bar{K}^*N}$$

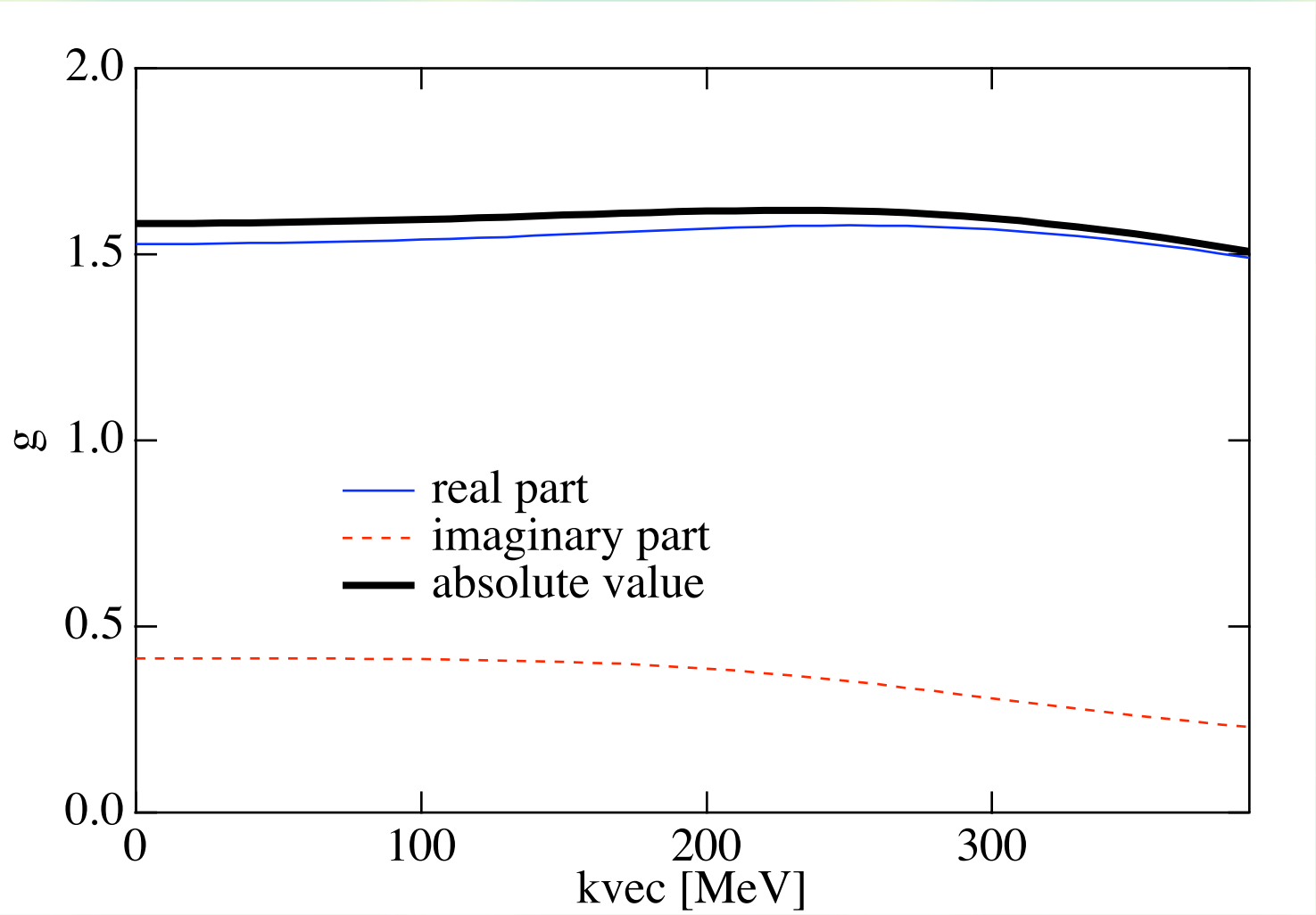
Residue of the pole in chiral unitary mdoel

Evaluate this at

$P_0 = 1520$ MeV **(resonance dominance)**

$k \sim 0$ MeV **(s-wave dominance)**

Numerical result



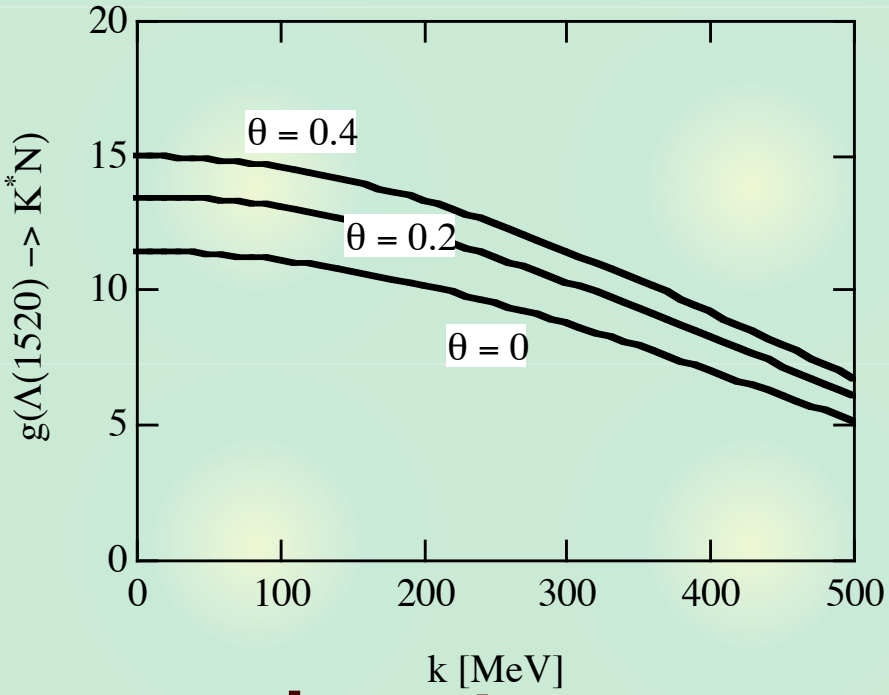
Small number : |g| ~ O(1)

Comparison with other estimations

Chrial unitary model : |g| ~ O(1)

Quark model : g ~ O(10)

θ : mixing angle



Fitting by Regge model to experiment

g = +7.1 or -12.6

Chrial unitary model gives a small number.

Summary : mixing scheme

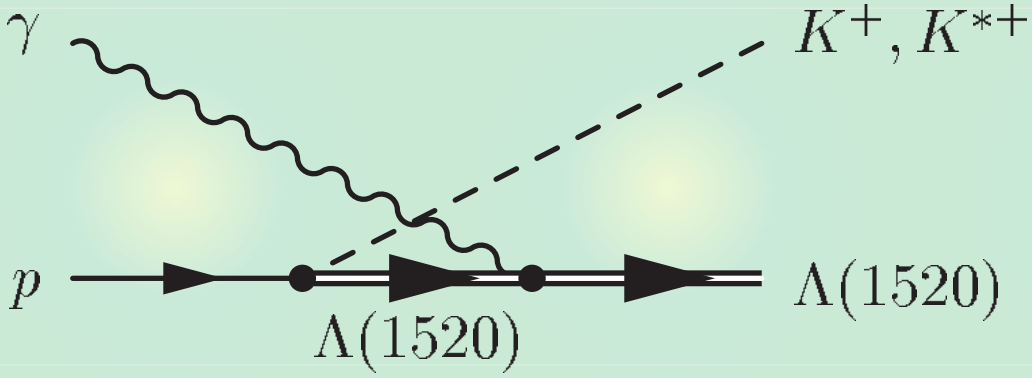
We calculate the $\bar{K}^*N$ coupling to the $\Lambda(1520)$ in the chiral unitary model

- The $\Lambda(1520)$ is generated dynamically in the **8meson-10baryon** scattering with phenomenological couplings to the **d-wave 8meson-8baryon channels**.
- The obtained coupling constant is **small** compared with the quark model result.
  - ★ difference of quark structure?
  - ★ difference of SU(3) structure?

Further investigation is needed.

Experiments?

u-channel photoproduction : Λ(1520) at forward



Measure the ratio of K and K* couplings

background : ground state Λ exchange