The $K\Xi$ production in coupled channel chiral models up to next-to-leading order.

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arXiv:1502.07956 [nucl-th].

INTRODUCTION

Since Perturbative QCD is inappropriate to describe low energy hadron interactions, an effective theory with hadrons as degrees of freedom which respects the symmetries of QCD is needed, namely **Chiral Perturbation Theory**.

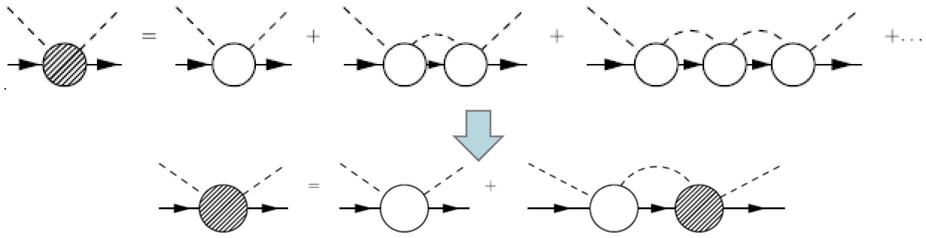
But, actually, we are in S=-1 sector, where $\bar{K}N$ interaction at low energy is dominated by the presence of the $\Lambda(1405)$ resonance. ChPT is not applicable in such a region, consequently, we have to go further.

A nonperturbative resummation is mandatory ⇨ **Unitary extension of Chiral Perturbation Theory (UChPT).**

This scheme allows the generation of bound-states and resonances dynamically. and at the same time respects the symmetries of QCD, particularly (spontaneously broken) chiral symmetry.

The pioneering work -- *Kaiser, Siegel, Weise* , NP A594 (1995) 325

Bethe-Salpeter equation:



$$\boldsymbol{T_{ij} = V_{ij} + V_{il}G_lV_{lj} + V_{il}G_lV_{lk}G_kV_{kj} + \cdots}$$

$$\boldsymbol{T_{ij} = V_{ij} + V_{il}G_lT_{lj}}$$

$$T_{ij}(E;k_i,k_j) = V_{ij}(k_i,k_j) + \sum_k \int d^3q_k V_{ik}(k_i,q_k)\tilde{G}_k(E;q_k)T_{kj}(E;q_k,k_j)$$

On shell factorization of T_{kj} *and* V_{ik}

Coupled-channel algebraic equations system

$$T_{ij}(E) = V_{ij} + \sum_k V_{ik}G_k(E)\,T_{kj}(E)\,, \quad \Rightarrow \quad \boldsymbol{T = (1 - VG)^{-1}V}$$

where $G_k(E) = \int d^3q_k \tilde{G}_k(E;q_k)$

In S=-1 sector, i,j and k indexes run over these 10 channels:

$$\boldsymbol{K^-p, \bar{K}^0n, \pi^0\Lambda, \pi^0\Sigma^0, \pi^+\Sigma^-, \pi^-\Sigma^+, \eta\Lambda, \eta\Sigma^0, K^+\Xi^-, K^0\Xi^0}$$

INTRODUCTION
UChPT as nonperturbative scheme to obtain scattering amplitude.

Loop function: $G_k = i\int \frac{d^4q}{(2\pi)^4}\frac{M_k}{E_k(\vec{q})}\frac{1}{\sqrt{s}-q^0-E_k(\vec{q})+i\epsilon}\frac{1}{q^2-m_k^2+i\epsilon}$

Adopting the dimensional regularization:

$$G_k = \frac{M_k}{16\pi^2}\left\{a_k(\mu) + ln\frac{M_k^2}{\mu^2} + \frac{m_k^2-M_k^2+s}{2s}ln\frac{m_k^2}{M_k^2} - 2i\pi\frac{q_k}{\sqrt{s}} + \frac{q_k}{\sqrt{s}}ln\left(\frac{s^2-\left((M_k^2-m_k^2)+2q_k\sqrt{s}\right)^2}{s^2-\left((M_k^2-m_k^2)-2q_k\sqrt{s}\right)^2}\right)\right\}$$

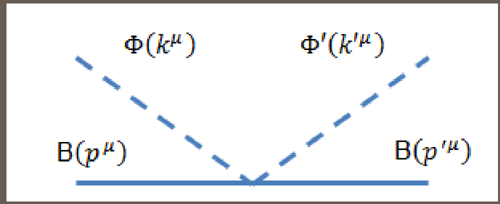
subtraction constants for the dimensional regularization scale $\mu = 1GeV$ in all the k channels.

With isospin symmetry

$$a_{K^-p} = a_{\bar{K}^0n} = a_{\bar{K}N}$$
$$a_{\pi^0\Lambda} = a_{\pi\Lambda}$$
$$a_{\pi^0\Sigma^0} = a_{\pi^+\Sigma^-} = a_{\pi^-\Sigma^+} = a_{\pi\Sigma}$$
$$a_{\eta\Lambda}$$
$$a_{\eta\Sigma^0} = a_{\eta\Sigma}$$
$$a_{K^+\Xi^-} = a_{K^0\Xi^0} = a_{K\Xi}$$

6 PARAMETERS!

FORMALISM
Effective lagrangian up to LO



WT, ***lowest order term***

$$\mathcal{L}_{MB}^{(1)}(B,U) = \langle \bar{B} i\gamma^\mu \nabla_\mu B\rangle - M_B\langle \bar{B}B\rangle + \frac{1}{2}D\langle \bar{B}\gamma^\mu\gamma_5\{u_\mu, B\}\rangle + \frac{1}{2}F\langle \bar{B}\gamma^\mu\gamma_5[u_\mu, B]\rangle$$

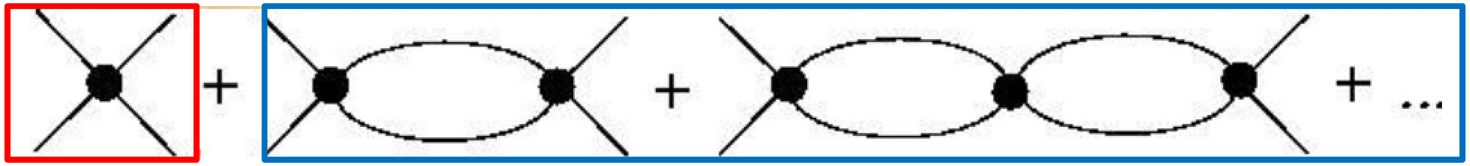
$$V_{ij}^{WT} = -C_{ij}\frac{1}{4f^2}\bar{u}(p)\gamma^\mu u(p)(k_\mu + k'_\mu)$$

At low energies + S-wave aprox.

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

For the channels of interest $C_{K^-p\to K^0\Xi^0} = C_{K^-p\to K^+\Xi^-} = 0$:

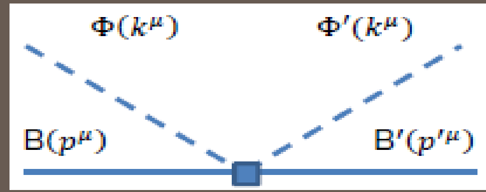
- **There is no direct contribution of these reactions at lowest order**
- **The rescattering terms due to the coupled channels are the only contribution to the scattering amplitude.**



These reactions could be very sensitive to the NLO corrections!!!

$$\mathcal{L}_{eff}(B,U) = \mathcal{L}_{MB}^{(1)}(B,U)$$

FORMALISM
Effective lagrangian up to NLO



$$\mathcal{L}_{MB}^{(2)}(B,U) = b_D\langle \bar{B}\{\chi_+, B\}\rangle + b_F\langle \bar{B}[\chi_+, B]\rangle + b_0\langle \bar{B}B\rangle\langle\chi_+\rangle + d_1\langle \bar{B}\{u_\mu,[u^\mu,B]\}\rangle + d_2\langle \bar{B}[u_\mu,[u^\mu,B]]\rangle + d_3\langle \bar{B}u_\mu\rangle\langle u^\mu B\rangle + d_4\langle \bar{B}B\rangle\langle u^\mu u_\mu\rangle$$

NLO, *next – to – leading order contact term* → At low energies + S-wave aprox. →

$$V_{ij}^{NLO} = \frac{1}{f^2}\left(D_{ij} - 2(k_\mu k'^\mu)L_{ij}\right)\sqrt{\frac{M_i+E_i}{2M_i}}\sqrt{\frac{M_j+E_j}{2M_j}}$$

$L_{K^-p\to K^0\Xi^0} \neq 0,\ L_{K^-p\to K^+\Xi^-} \neq 0$ → **direct contribution of Cascade reactions at NLO**

Finally: $V_{ij} = V_{ij}^{WT} + V_{ij}^{NLO}$ → $T = (1 - VG)^{-1}V$ → T_{ij}^{NLO}

Fitting parameters.

- Decay constant f
  Its usual value, in real calculations, is between $1.15 - 1.2\ f_\pi^{exp}$ in order to simulate effects of higher order corrections . (f_π^{exp}=93.4M)
- 6 subtracting constants $a_{\bar{K}N}$, $a_{\pi\Lambda}$, $a_{\pi\Sigma}$, $a_{\eta\Lambda}$, $a_{\eta\Sigma}$, $a_{K\Xi}$
- 7 coefficients of the NLO lagrangian terms $b_0, b_D, b_F, d_1, d_2, d_3, d_4$

$$\mathcal{L}_{eff}(B,U) = \mathcal{L}_{MB}^{(1)}(B,U) + \mathcal{L}_{MB}^{(2)}(B,U)$$

Motivation for including resonances

- Inclusion of high spin and high mass resonances allows us to study the accuracy and stability of the NLO parameters ($b_0, b_D, b_F, d_1, d_2, d_3, d_4$).
- It also allows the production of angular dependent scattering amplitudes; and hence, a better reproduction of the differential cross sections experimental data.

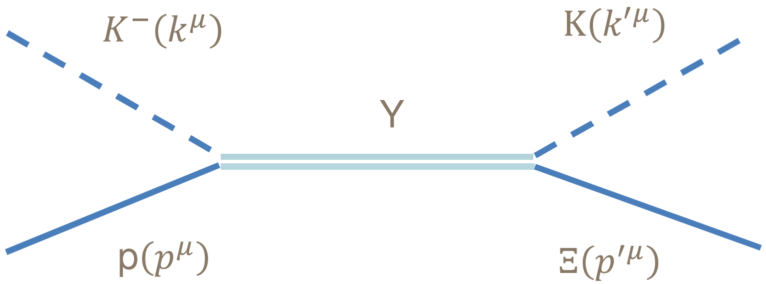
Resonance	I	(J^P)	Mass (MeV)	Γ (MeV)	$\Gamma_{K\Xi}/\Gamma$
$\Lambda(1890)$	0	$\left(\frac{3}{2}^+\right)$	1850 - 1910	60 - 200	
$\Lambda(2100)$	0	$\left(\frac{7}{2}^-\right)$	2090 - 2110	100 - 250	$< 3\%$
$\Lambda(2110)$	0	$\left(\frac{5}{2}^+\right)$	2090 - 2140	150 - 250	
$\Lambda(2350)$	0	$\left(\frac{9}{2}^+\right)$	2340 - 2370	100 - 250	
$\Sigma(1915)$	1	$\left(\frac{5}{2}^+\right)$	1900 - 1935	80 - 160	
$\Sigma(1940)$	1	$\left(\frac{3}{2}^-\right)$	1900 - 1950	150 - 300	
$\Sigma(2030)$	1	$\left(\frac{7}{2}^+\right)$	2025 - 2040	150 - 200	$< 2\%$
$\Sigma(2250)$	1	$(?^?)$	2210 - 2280	60 - 150	

In **Sharov, Korotkikh, Lanskoy, EPJA 47 (2011) 109,** a phenomenological model was suggested in which several combinations of resonances were tested concluding that $\boldsymbol{\Sigma(2030)}$ and $\boldsymbol{\Sigma(2250)}$ were the most relevant.

INCLUSION OF HYPERONIC RESONANCES

$\bar{K}N \longrightarrow Y \longrightarrow K\Xi$

Y= $\Sigma(2030)$, $\Sigma(2250)$



K. Nakayama, Y. Oh, H. Habertzettl, Phys. Rev. C74, 035205 (2006)
K. Shing Man, Y. Oh, K. Nakayama,, Phys. Rev. C83, 055201 (2011)

$$\Sigma(2030),\ J^P = \frac{7}{2}^+,\ T^{7/2^+}$$

$$\mathcal{L}_{BYK}^{7/2^\pm}(q) = -\frac{g_{BY_{7/2}K}}{m_K^3}\bar{B}\Gamma^{(\mp)}Y_{7/2}^{\mu\nu\alpha}\partial_\mu\partial_\nu\partial_\alpha K + H.c.$$

$$\Sigma(2250),\ J^P = \frac{5}{2}^-,\ T^{5/2^-}$$

$$\mathcal{L}_{BYK}^{5/2^\pm}(q) = i\frac{g_{BY_{5/2}K}}{m_K^2}\bar{B}\Gamma^{(\pm)}Y_{5/2}^{\mu\nu}\partial_\mu\partial_\nu K + H.c.$$

Finally, the scattering amplitudes related to the resonances can be obtained in the following way :

$$T^{5/2^-}(s',s) = \frac{g_{\Xi Y_{5/2}K}\,g_{NY_{5/2}\bar{K}}}{m_K^4}\bar{u}_\Xi^{s'}(p')\frac{k'_{\beta_1}k'_{\beta_2}\Delta^{\beta_1\beta_2}_{\alpha_1\alpha_2}k^{\alpha_1}k^{\alpha_2}}{\not{q} - M_{Y_{5/2}} + i\Gamma_{5/2}/2}u_N^s(p)\boxed{\exp\left(-\vec{k}^2/\Lambda_{5/2}^2\right)}\boxed{\exp\left(-\vec{k}'^2/\Lambda_{5/2}^2\right)}$$

$$T^{7/2^+}(s',s) = \frac{g_{\Xi Y_{7/2}K}\,g_{NY_{7/2}\bar{K}}}{m_K^6}\bar{u}_\Xi^{s'}(p')\frac{k'_{\beta_1}k'_{\beta_2}k'_{\beta_2}\Delta^{\beta_1\beta_2\beta_3}_{\alpha_1\alpha_2\alpha_3}k^{\alpha_1}k^{\alpha_2}k^{\alpha_3}}{\not{q} - M_{Y_{7/2}} + i\Gamma_{7/2}/2}u_N^s(p)\boxed{\exp\left(-\vec{k}^2/\Lambda_{7/2}^2\right)}\boxed{\exp\left(-\vec{k}'^2/\Lambda_{7/2}^2\right)}$$

INCLUSION OF HYPERONIC RESONANCES

$\bar{K}N \longrightarrow Y \longrightarrow K\Xi$

Y= $\Sigma(2030), \Sigma(2250)$

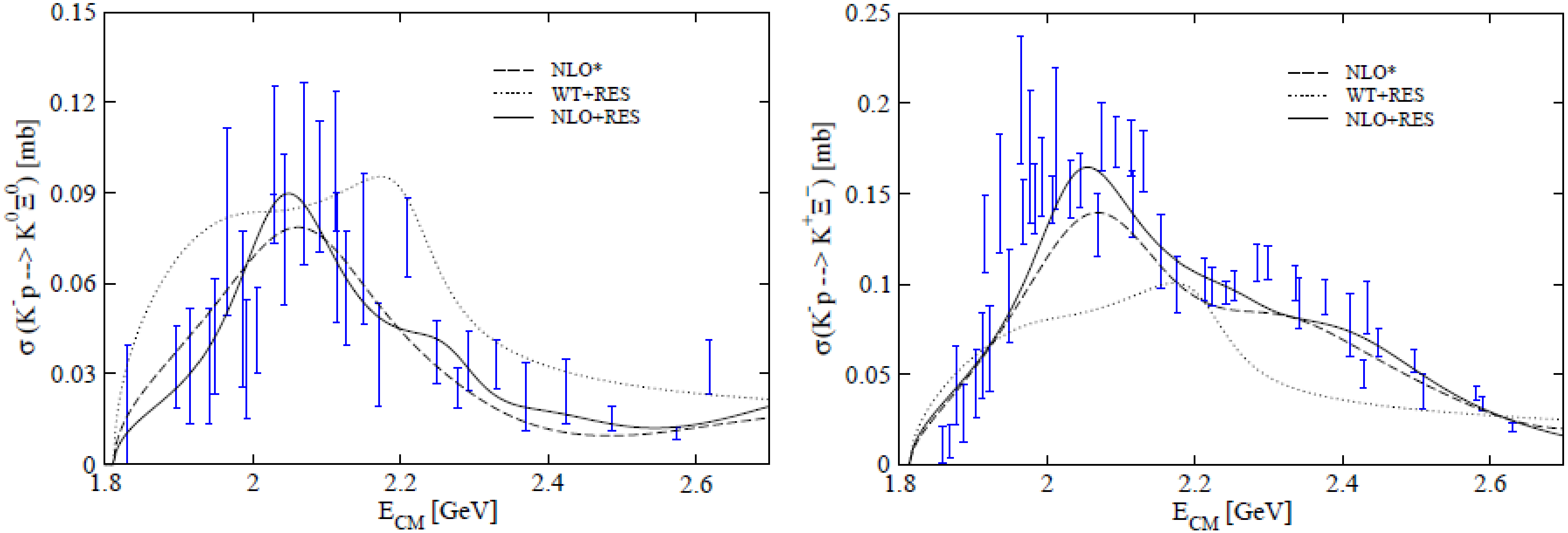
The total scattering amplitude for the $\bar{K}N \longrightarrow K\Xi$ reaction taking into account the unitarized chiral contributions up to NLO plus the phenomenological contributions from the resonances reads:

$$T^{tot}_{ij,s,s'} = T^{NLO}_{ij,s,s'} + T^{5/2^-}_{s,s'} + T^{7/2^+}_{s,s'}$$

Fitting parameters.

- Decay constant f
- Subtracting constants $a_{\bar{K}N}$, $a_{\pi\Lambda}$, $a_{\pi\Sigma}$, $a_{\eta\Lambda}$, $a_{\eta\Sigma}$, $a_{K\Xi}$
- Coefficients of the NLO lagrangian terms $b_0, b_D, b_F, d_1, d_2, d_3, d_4$
- Masses and width of the resonances $M_{Y_{5/2}}, M_{Y_{7/2}}, \Gamma_{5/2}, \Gamma_{7/2}$
  Not free at all, their values are constrained according to PDG summary
- Cutoff parameters from the form factor $\Lambda_{5/2}, \Lambda_{7/2}$
- Product of the coupling constants (one for each vertex) for both resonances
  $g_{\Xi Y_{5/2}K} \cdot g_{NY_{5/2}\bar{K}}$, $g_{\Xi Y_{7/2}K} \cdot g_{NY_{7/2}\bar{K}}$

Results for $\bar{K}N \longrightarrow K\Xi$ including $\Sigma(2030)$, $\Sigma(2250)$ resonances



	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
NLO*	2.37	0.189	0.664	$-0.69 + \mathrm{i}\,0.86$	300	570
WT+RES	2.37	0.193	0.667	$-0.73 + \mathrm{i}\,0.81$	307	528
NLO+RES	2.39	0.187	0.668	$-0.66 + \mathrm{i}\,0.84$	286	562
Exp.	2.36	0.189	0.664	$-0.66 + \mathrm{i}\,0.81$	283	541
	± 0.04	± 0.015	± 0.011	$(\pm 0.07) + \mathrm{i}\,(\pm 0.15)$	± 36	± 92

Table of the obtained fitting parameters

	NLO*	WT+RES	NLO+RES
$a_{\bar{K}N}$ (10^{-3})	6.799 ± 0.701	-1.965 ± 2.219	6.157 ± 0.090
$a_{\pi\Lambda}$ (10^{-3})	50.93 ± 9.18	-188.2 ± 131.7	59.10 ± 3.01
$a_{\pi\Sigma}$ (10^{-3})	-3.167 ± 1.978	0.228 ± 2.949	-1.172 ± 0.296
$a_{\eta\Lambda}$ (10^{-3})	-15.16 ± 12.32	1.608 ± 2.603	-6.987 ± 0.381
$a_{\eta\Sigma}$ (10^{-3})	-5.325 ± 0.111	208.9 ± 151.1	-5.791 ± 0.034
$a_{K\Xi}$ (10^{-3})	31.00 ± 9.441	43.04 ± 25.84	32.60 ± 11.65
f/f_π	1.197 ± 0.011	1.203 ± 0.023	1.193 ± 0.003
b_0 (GeV^{-1})	-1.158 ± 0.021	-	-0.907 ± 0.004
b_D (GeV^{-1})	0.082 ± 0.050	-	-0.151 ± 0.008
b_F (GeV^{-1})	0.294 ± 0.149	-	0.535 ± 0.047
d_1 (GeV^{-1})	-0.071 ± 0.069	-	-0.055 ± 0.055
d_2 (GeV^{-1})	0.634 ± 0.023	-	0.383 ± 0.014
d_3 (GeV^{-1})	2.819 ± 0.058	-	2.180 ± 0.011
d_4 (GeV^{-1})	-2.036 ± 0.035	-	-1.429 ± 0.006
$g_{\Xi Y_{5/2} K} \cdot g_{N Y_{5/2} \bar{K}}$	-	-5.42 ± 15.96	8.82 ± 5.72
$g_{\Xi Y_{7/2} K} \cdot g_{N Y_{7/2} \bar{K}}$	-	-0.61 ± 14.12	0.06 ± 0.20
$\Lambda_{5/2}$ (MeV)	-	576.7 ± 275.2	522.7 ± 43.8
$\Lambda_{7/2}$ (MeV)	-	623.7 ± 287.5	999.0 ± 288.0
$M_{Y_{5/2}}$ (MeV)	-	2210.0 ± 39.8	2278.8 ± 67.4
$M_{Y_{7/2}}$ (MeV)	-	2025.0 ± 9.4	2040.0 ± 9.4
$\Gamma_{5/2}$ (MeV)	-	150.0 ± 71.3	150.0 ± 54.4
$\Gamma_{7/2}$ (MeV)	-	200.0 ± 44.6	200.0 ± 32.3
$\chi^2_{\text{d.o.f.}}$	1.48	2.26	1.05

CONCLUSIONS

- Chiral Perturbation Theory with unitarization in coupled channels is a very powerful technique to describe low energy hadron dynamics.

- The $\bar{K}N \longrightarrow K\Xi$ channels are very sensitive to the NLO terms of the lagrangian, so they provide more reliable values of the NLO parameters.

- High-mass and high-spin resonances play a significant role in the $\bar{K}N \longrightarrow K\Xi$ reactions. Addition of resonant terms in the scattering amplitude gives a significantly better agreement with data (particularly in differential cross sections). And, what is no less important, the NLO coefficients gain notable accuracy.

THANK YOU

KEEP

CALM

AND

WAIT FOR

THE NEXT FITTING

FORMALISM
Effective lagrangian up to NLO

D_{ij}

	K^-p	$\bar{K}^0n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	$4(b_0+b_D)m_K^2$	$2(b_D+b_F)m_K^2$	$\frac{-(b_D+3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-b_F)\mu_1^2}{2}$	$\frac{(b_D+3b_F)\mu_2^2}{6}$	$\frac{-(b_D-b_F)\mu_2^2}{2\sqrt{3}}$	0	$(b_D-b_F)\mu_1^2$	0	0
K^0n		$4(b_0+b_D)m_K^2$	$\frac{(b_D+3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-b_F)\mu_1^2}{2}$	$\frac{(b_D+3b_F)\mu_2^2}{6}$	$\frac{(b_D-b_F)\mu_2^2}{2\sqrt{3}}$	$(b_D-b_F)\mu_1^2$	0	0	0
$\pi^0\Lambda$			$\frac{4(3b_0+b_D)m_\pi^2}{3}$	0	0	$\frac{4b_Dm_\pi^2}{3}$	0	0	$\frac{-(b_D-3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-3b_F)\mu_1^2}{2\sqrt{3}}$
$\pi^0\Sigma^0$				$4(b_0+b_D)m_\pi^2$	$\frac{4b_Dm_\pi^2}{3}$	0	0	0	$\frac{(b_D+b_F)\mu_1^2}{2}$	$\frac{(b_D+b_F)\mu_1^2}{2}$
$\eta\Lambda$					$\frac{4(3b_0\mu_3^2+b_D\mu_4^2)}{9}$	0	$\frac{4b_Dm_\pi^2}{3}$	$\frac{4b_Dm_\pi^2}{3}$	$\frac{(b_D-3b_F)\mu_2^2}{6}$	$\frac{(b_D-3b_F)\mu_2^2}{6}$
$\eta\Sigma^0$						$\frac{4(b_0\mu_3^2+b_Dm_\pi^2)}{3}$	$\frac{4b_Fm_\pi^2}{\sqrt{3}}$	$\frac{-4b_Fm_\pi^2}{\sqrt{3}}$	$\frac{-(b_D+b_F)\mu_2^2}{2\sqrt{3}}$	$\frac{(b_D+b_F)\mu_2^2}{2\sqrt{3}}$
$\pi^+\Sigma^-$							$4(b_0+b_D)m_\pi^2$	0	$(b_D+b_F)\mu_1^2$	0
$\pi^-\Sigma^+$								$4(b_0+b_D)m_\pi^2$	0	$(b_D+b_F)\mu_1^2$
$K^+\Xi^-$									$4(b_0+b_D)m_K^2$	$2(b_D-b_F)m_K^2$
$K^0\Xi^0$										$4(b_0+b_D)m_K^2$

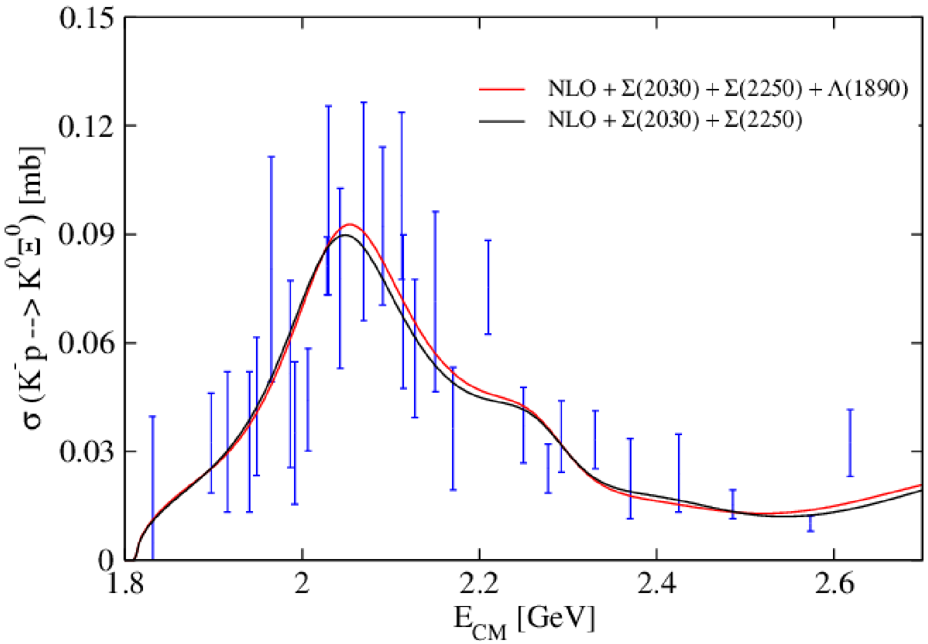
L_{ij}

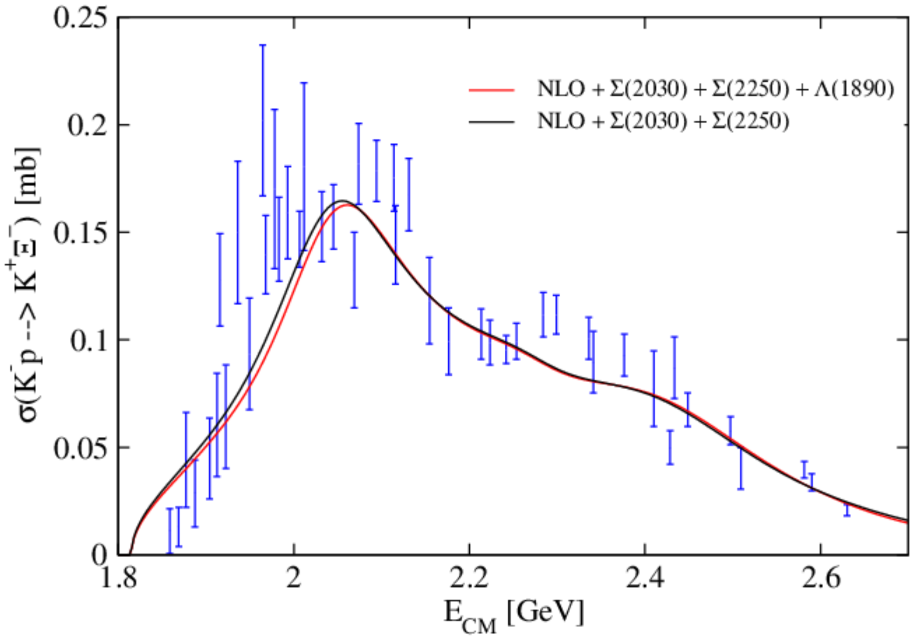
	K^-p	$\bar{K}^0n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	$2d_2+d_3+2d_4$	$d_1+d_2+d_3$	$\frac{-\sqrt{3}(d_1+d_2)}{2}$	$\frac{-d_1-d_2+2d_3}{2}$	$\frac{d_1-3d_2+2d_3}{2}$	$\frac{d_1-3d_2}{2\sqrt{3}}$	$-2d_2+d_3$	$-d_1+d_2+d_3$	$-4d_2+2d_3$	$-2d_2+d_3$
$\bar{K}^0n$		$2d_2+d_3+2d_4$	$\frac{\sqrt{3}(d_1+d_2)}{2}$	$\frac{-d_1-d_2+2d_3}{2}$	$\frac{d_1-3d_2+2d_3}{2}$	$\frac{-(d_1-3d_2)}{2\sqrt{3}}$	$-d_1+d_2+d_3$	$-2d_2+d_3$	$-2d_2+d_3$	$-4d_2+2d_3$
$\pi^0\Lambda$			$2d_4$	0	0	d_3	0	0	$\frac{\sqrt{3}(d_1-d_2)}{2}$	$\frac{-\sqrt{3}(d_1-d_2)}{2}$
$\pi^0\Sigma^0$				$2(d_3+d_4)$	d_3	0	$-2d_2+d_3$	$-2d_2+d_3$	$\frac{d_1-d_2+2d_3}{2}$	$\frac{d_1-d_2+2d_3}{2}$
$\eta\Lambda$					$2(d_3+d_4)$	0	d_3	d_3	$\frac{-d_1-3d_2+2d_3}{2}$	$\frac{-d_1-3d_2+2d_3}{2}$
$\eta\Sigma^0$						$2d_4$	$\frac{2d_1}{\sqrt{3}}$	$\frac{-2d_1}{\sqrt{3}}$	$\frac{-(d_1+3d_2)}{2\sqrt{3}}$	$\frac{d_1+3d_2}{2\sqrt{3}}$
$\pi^+\Sigma^-$							$2d_2+d_3+2d_4$	$-4d_2+2d_3$	$d_1+d_2+d_3$	$-2d_2+d_3$
$\pi^-\Sigma^+$								$2d_2+d_3+2d_4$	$-2d_2+d_3$	$d_1+d_2+d_3$
$K^+\Xi^-$									$2d_2+d_3+2d_4$	$-d_1+d_2+d_3$
$K^0\Xi^0$										$2d_2+d_3+2d_4$

RESULTS II

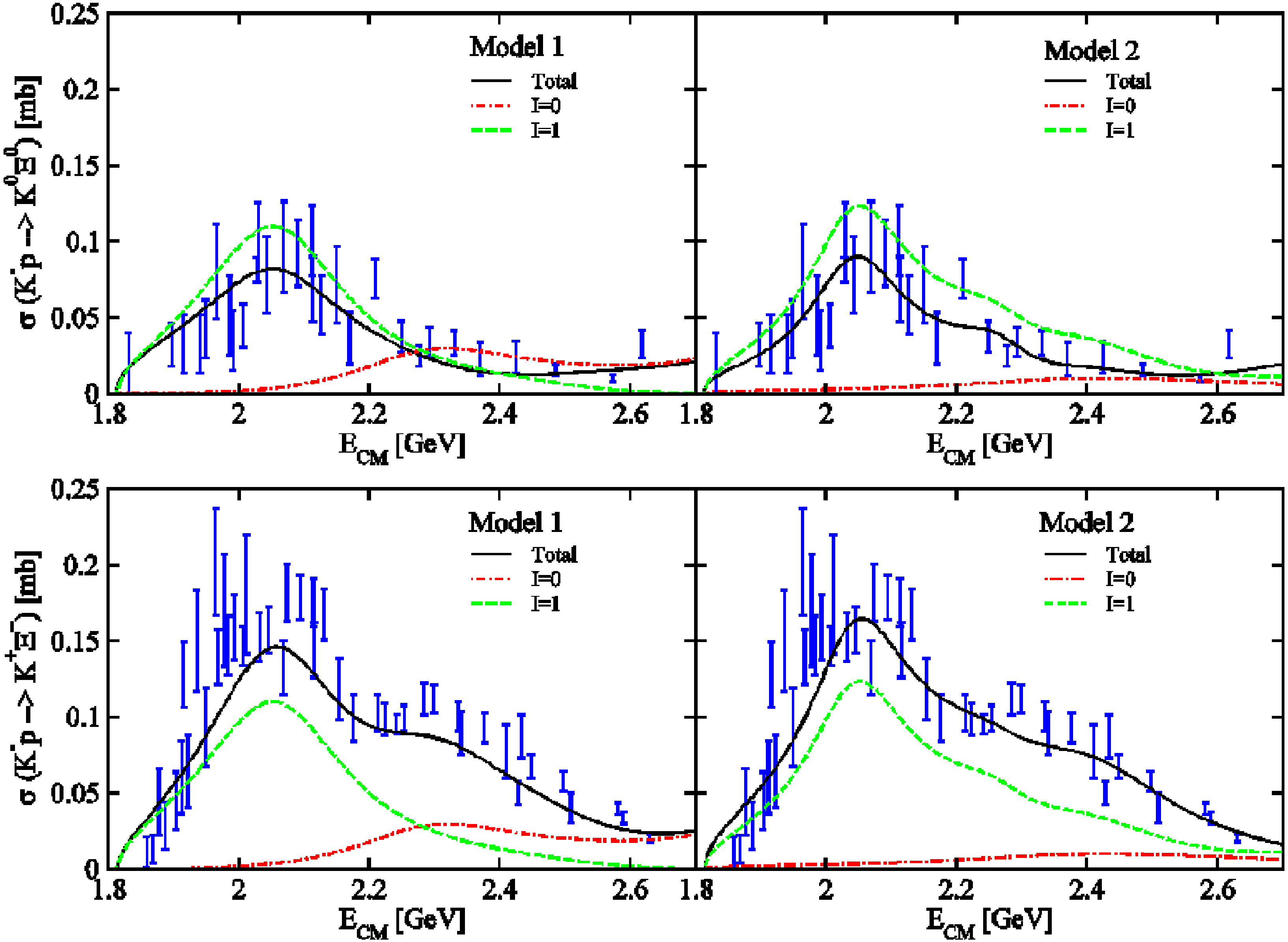
What happens if a third resonance is added?

For instance **Λ(1890),** as it was done in B. C. Jackson, Y. Oh, H. Haberzettl and K. Nakayama, arXiv: 1503.00845 [nucl-th].



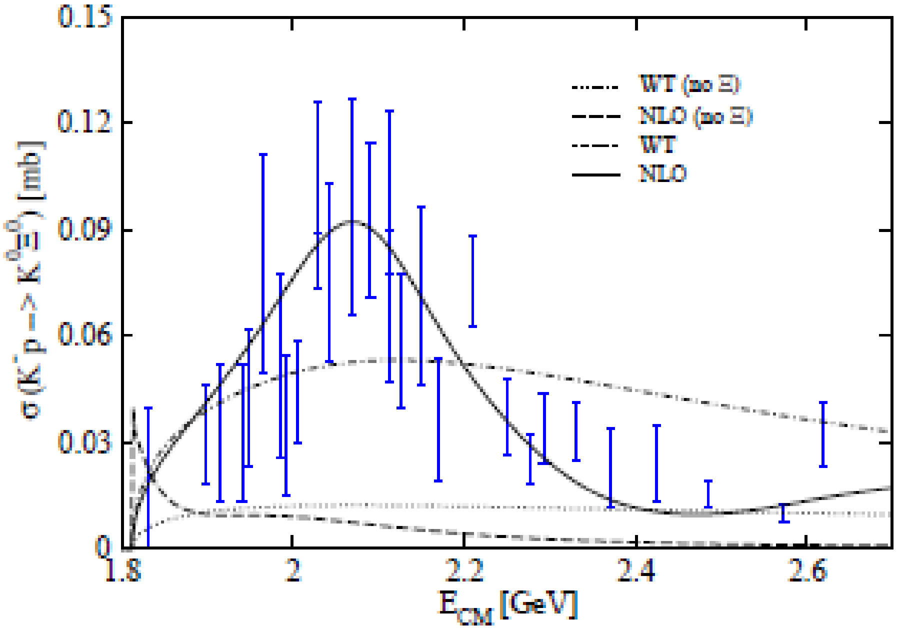


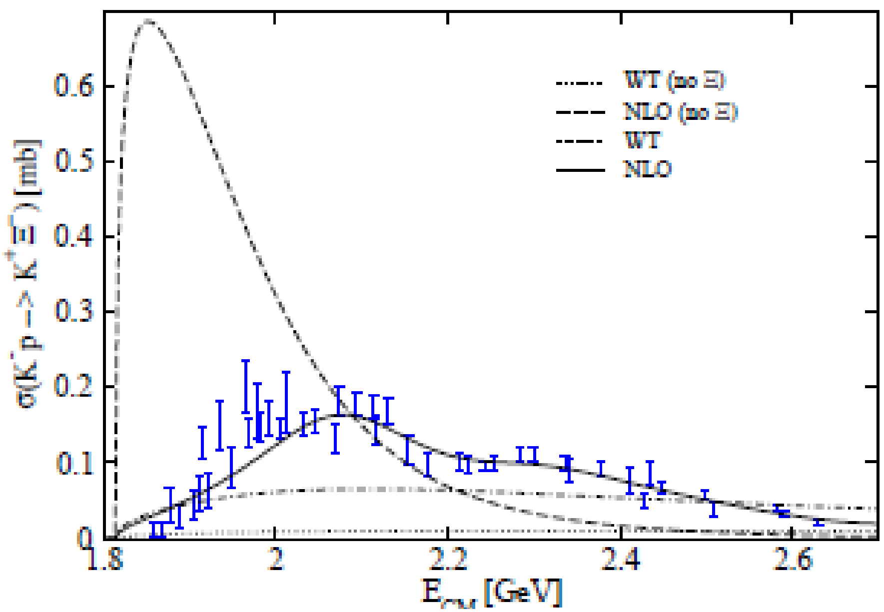
RESULTS II



Model 1
Total
I=0
I=1
Model 2
Total
I=0
I=1
σ (K⁻p -> K⁰Ξ⁰) [mb]
σ (K⁻p -> K⁺Ξ⁻) [mb]
E_CM [GeV]
0.25
0.2
0.15
0.1
0.05
0
1.8
2
2.2
2.4
2.6

Results for $\bar{K}N \longrightarrow K\Xi$

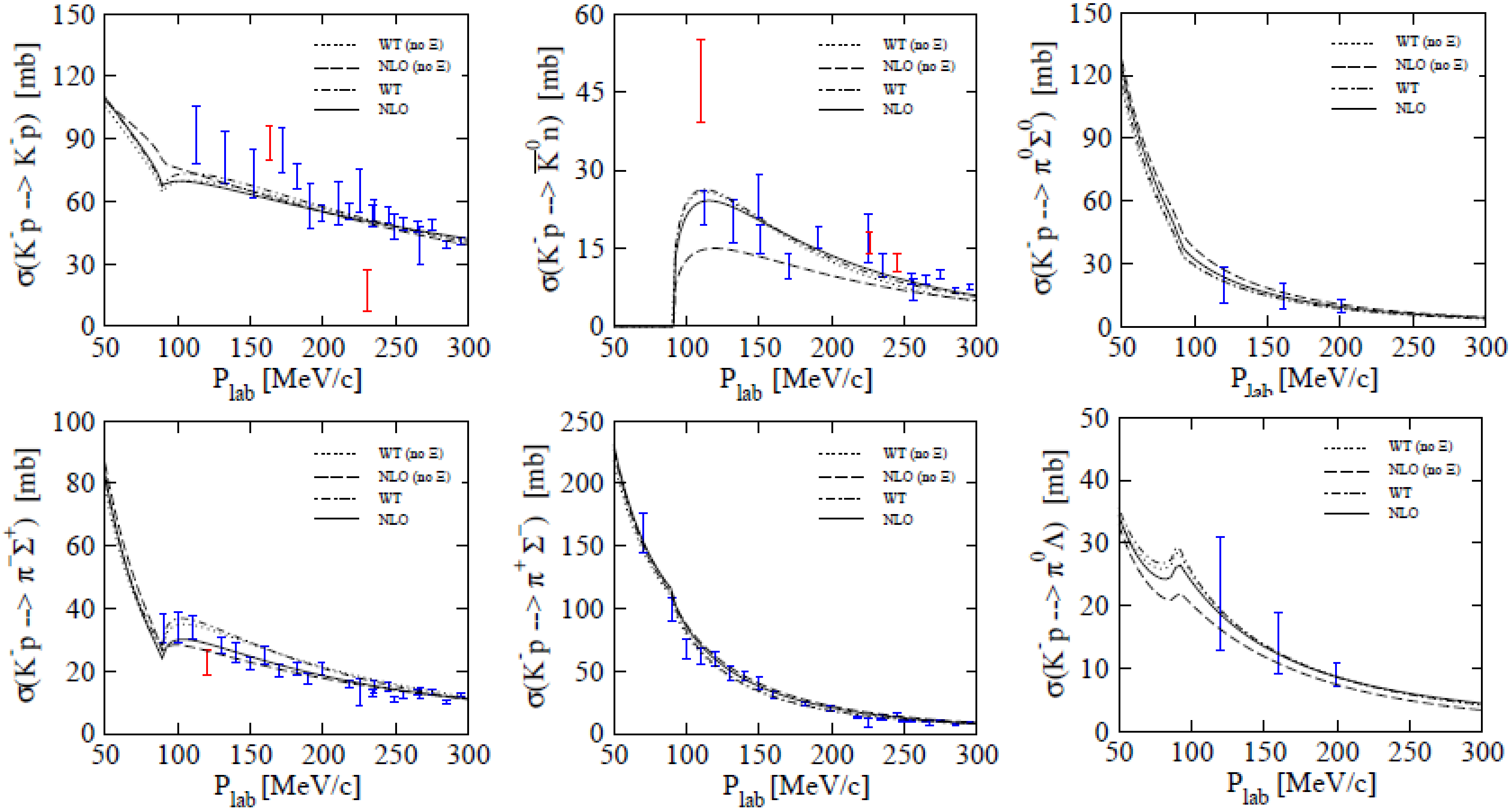




	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
WT (no $K\Xi$)	2.37	0.191	0.665	$-0.76 + i\,0.79$	316	511
NLO (no $K\Xi$)	2.36	0.188	0.662	$-0.67 + i\,0.84$	290	559
WT	2.36	0.192	0.667	$-0.76 + i\,0.84$	318	543
NLO	2.36	0.189	0.664	$-0.73 + i\,0.85$	310	557
Exp.	2.36 ± 0.04	0.189 ± 0.015	0.664 ± 0.011	$-0.66 + i\,0.81$ $(\pm 0.07) + i\,(\pm 0.15)$	283 ± 36	541 ± 92

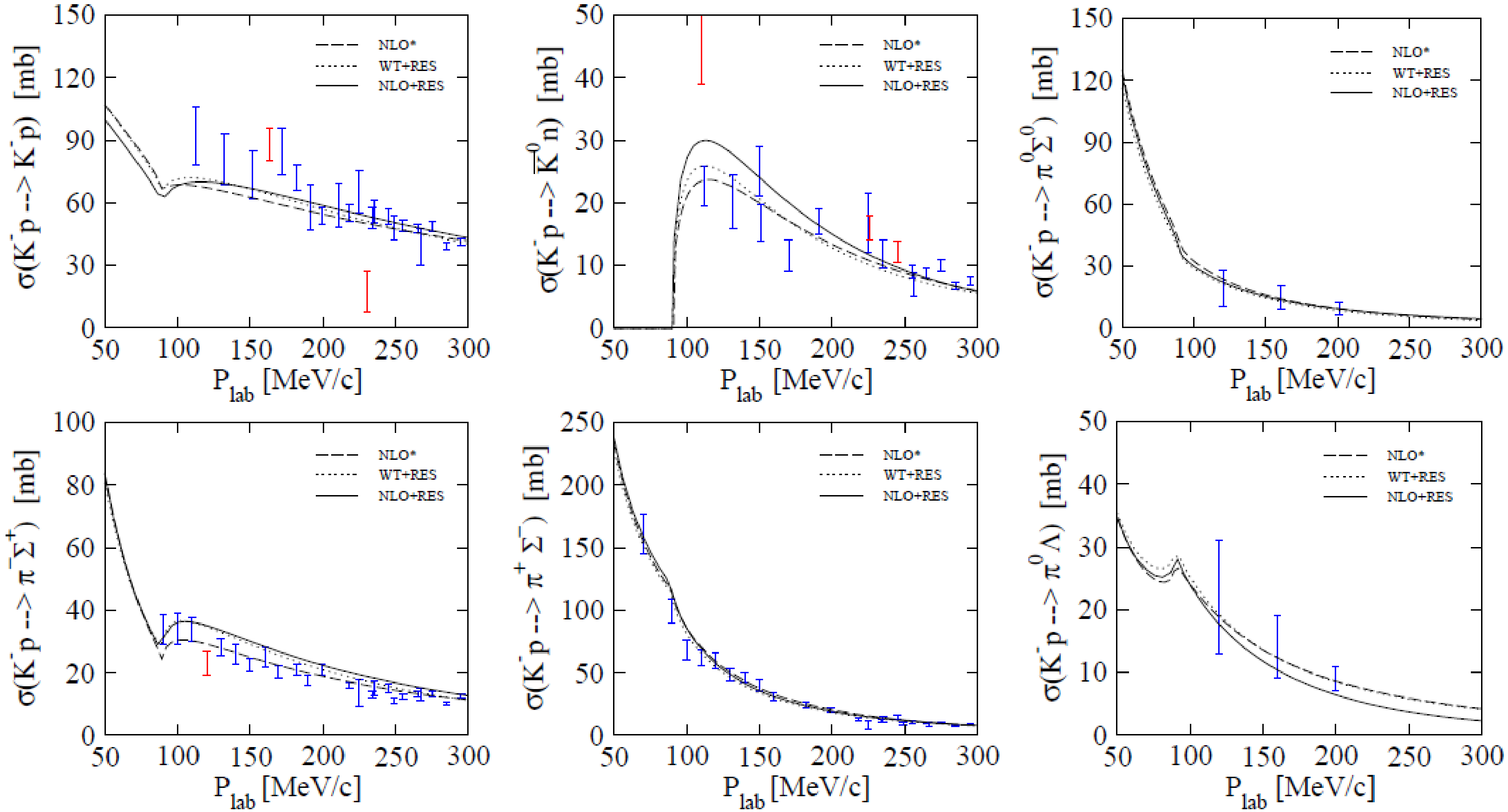
	WT (no $K\Xi$)	NLO (no $K\Xi$)	WT	NLO
$a_{\bar{K}N}$ (10^{-3})	-1.681 ± 0.738	5.151 ± 0.736	-1.986 ± 2.153	6.550 ± 0.625
$a_{\pi\Lambda}$ (10^{-3})	33.63 ± 11.11	21.61 ± 10.00	-248.6 ± 122.0	54.84 ± 7.51
$a_{\pi\Sigma}$ (10^{-3})	0.048 ± 1.925	3.078 ± 2.101	0.382 ± 2.711	-2.291 ± 1.894
$a_{\eta\Lambda}$ (10^{-3})	1.589 ± 1.160	-10.460 ± 0.432	1.696 ± 2.451	-14.16 ± 12.69
$a_{\eta\Sigma}$ (10^{-3})	-45.87 ± 14.06	-8.577 ± 0.353	277.8 ± 139.1	-5.166 ± 0.068
$a_{K\Xi}$ (10^{-3})	-78.49 ± 47.92	4.10 ± 12.67	30.85 ± 10.58	27.03 ± 7.83
f/f_π	1.202 ± 0.053	1.186 ± 0.012	1.202 ± 0.119	1.197 ± 0.008
b_0 (GeV^{-1})	-	-0.861 ± 0.014	-	-1.214 ± 0.014
b_D (GeV^{-1})	-	0.202 ± 0.011	-	0.052 ± 0.040
b_F (GeV^{-1})	-	0.020 ± 0.057	-	0.264 ± 0.146
d_1 (GeV^{-1})	-	0.089 ± 0.096	-	-0.105 ± 0.056
d_2 (GeV^{-1})	-	0.598 ± 0.062	-	0.647 ± 0.019
d_3 (GeV^{-1})	-	0.473 ± 0.026	-	2.847 ± 0.042
d_4 (GeV^{-1})	-	-0.913 ± 0.031	-	-2.096 ± 0.024
$\chi^2_{\mathrm{d.o.f.}}$	0.62	0.39	2.57	0.65

Results for $\bar{K}N \longrightarrow K\Xi$



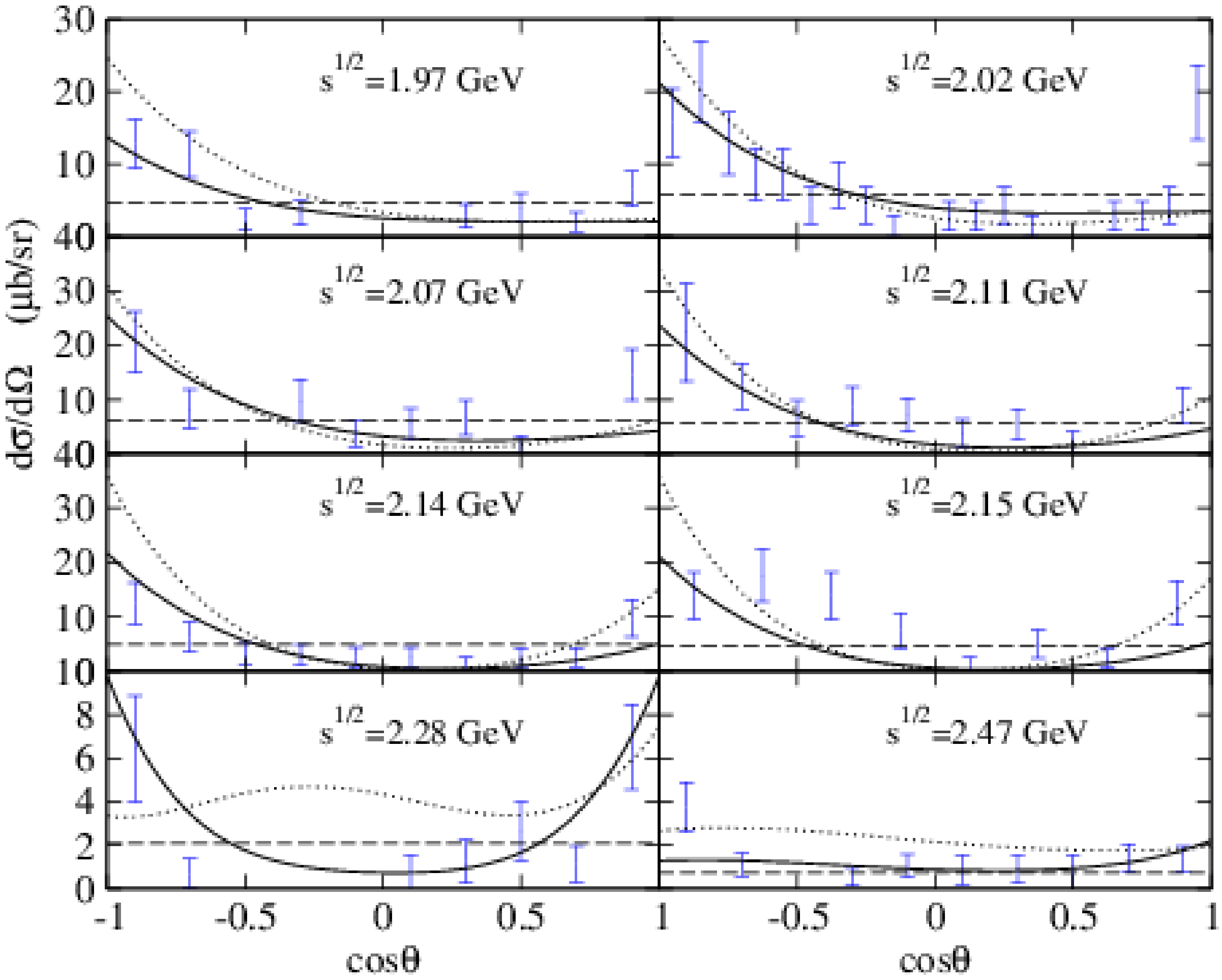
	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
WT (no $K\Xi$)	2.37	0.191	0.665	$-0.76 + \mathrm{i}\,0.79$	316	511
NLO (no $K\Xi$)	2.36	0.188	0.662	$-0.67 + \mathrm{i}\,0.84$	290	559
WT	2.36	0.192	0.667	$-0.76 + \mathrm{i}\,0.84$	318	543
NLO	2.36	0.189	0.664	$-0.73 + \mathrm{i}\,0.85$	310	557
Exp.	2.36 ± 0.04	0.189 ± 0.015	0.664 ± 0.011	$-0.66 + \mathrm{i}\,0.81$ $(\pm 0.07) + \mathrm{i}\,(\pm 0.15)$	283 ± 36	541 ± 92

Results for $\bar{K}N \longrightarrow K\Xi$ including $\Sigma(2030)$, $\Sigma(2250)$ resonances

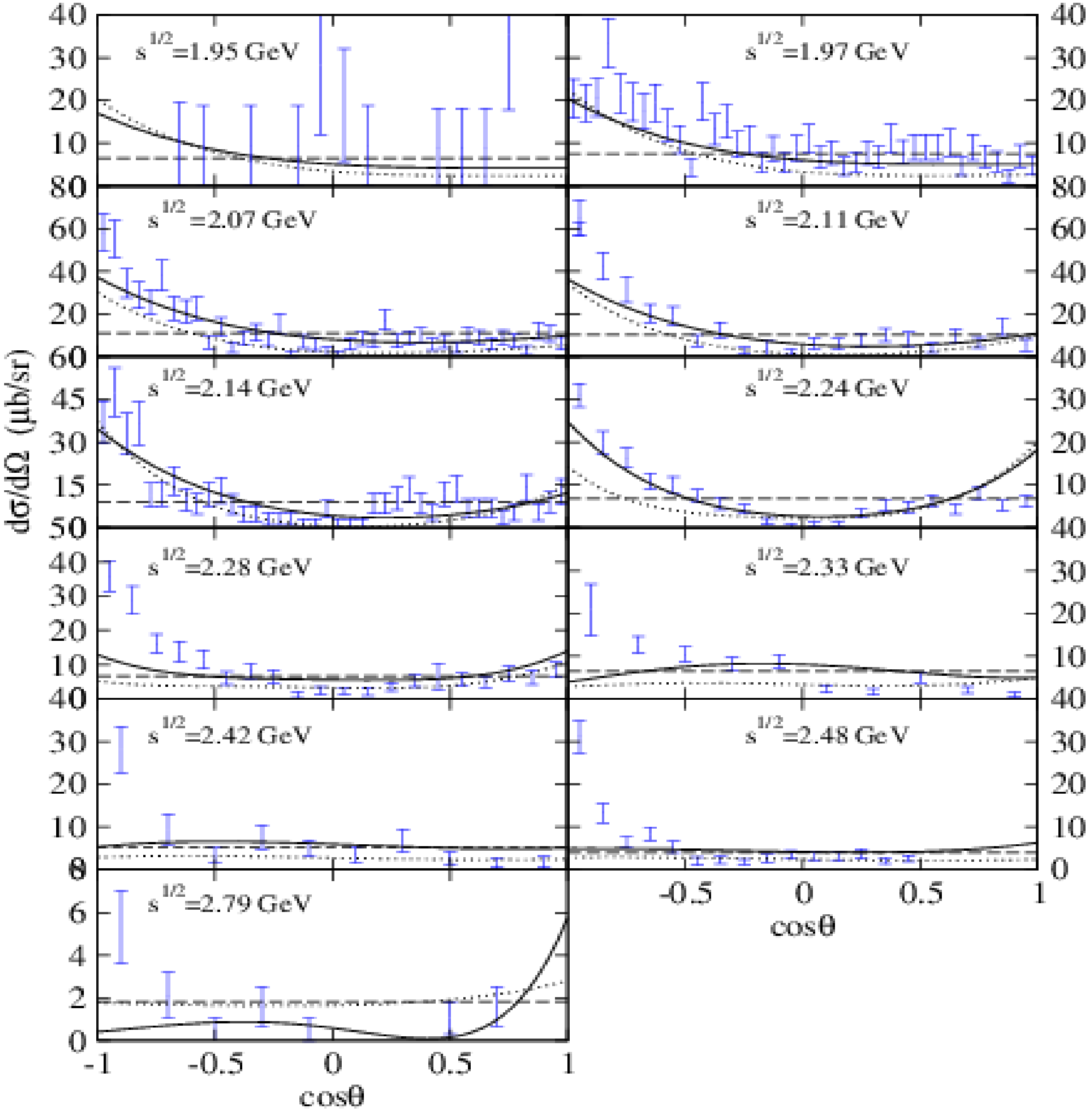


	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
NLO*	2.37	0.189	0.664	$-0.69 + i\,0.86$	300	570
WT+RES	2.37	0.193	0.667	$-0.73 + i\,0.81$	307	528
NLO+RES	2.39	0.187	0.668	$-0.66 + i\,0.84$	286	562
Exp.	2.36	0.189	0.664	$-0.66 + i\,0.81$	283	541
	± 0.04	± 0.015	± 0.011	$(\pm 0.07) + i\,(\pm 0.15)$	± 36	± 92

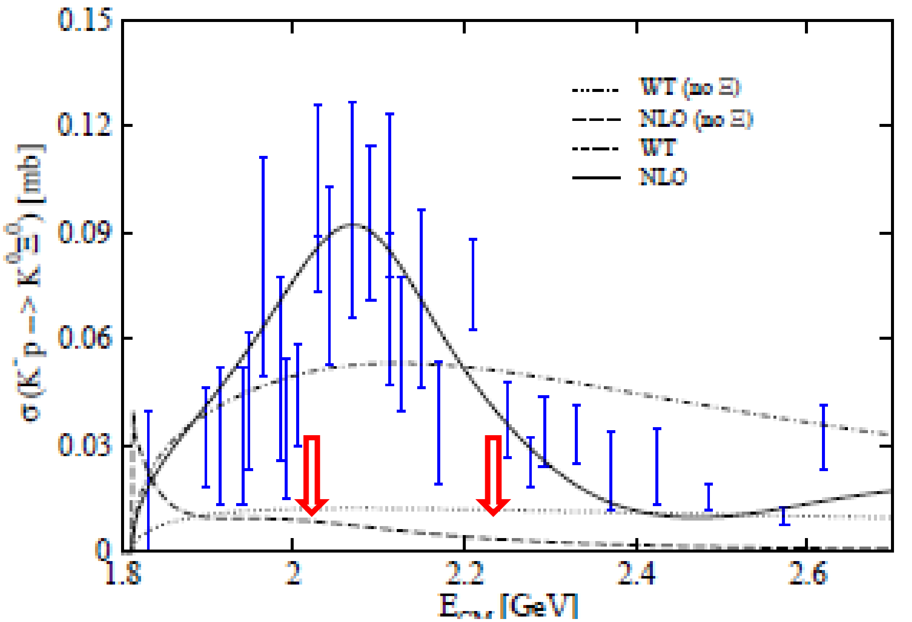
Differential cross section of the $\bar{K}N \longrightarrow K^0\Xi^0$



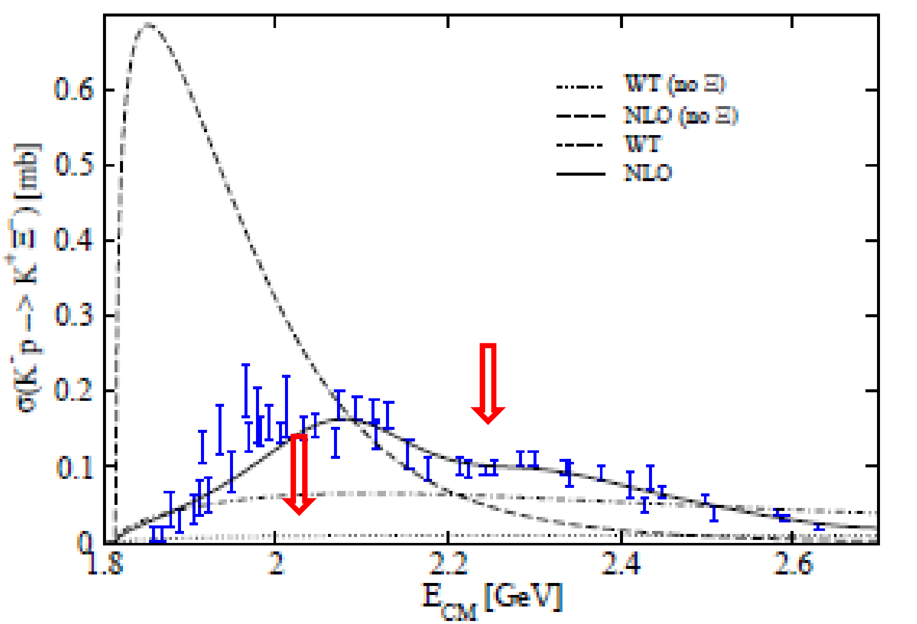
Differential cross section of the $\bar{K}N \longrightarrow K^+\Xi^-$



RESULTS I



Resonance	I (J^P)	Mass (MeV)	Γ (MeV)	$\Gamma_{K\Xi}/\Gamma$
$\Lambda(1890)$	$0\left(\frac{3}{2}^+\right)$	1850 - 1910	60 - 200	
$\Lambda(2100)$	$0\left(\frac{7}{2}^-\right)$	2090 - 2110	100 - 250	$< 3\%$
$\Lambda(2110)$	$0\left(\frac{5}{2}^+\right)$	2090 - 2140	150 - 250	
$\Lambda(2350)$	$0\left(\frac{9}{2}^+\right)$	2340 - 2370	100 - 250	
$\Sigma(1915)$	$1\left(\frac{5}{2}^+\right)$	1900 - 1935	80 - 160	
$\Sigma(1940)$	$1\left(\frac{3}{2}^-\right)$	1900 - 1950	150 - 300	
$\Sigma(2030)$	$1\left(\frac{7}{2}^+\right)$	2025 - 2040	150 - 200	$< 2\%$
$\Sigma(2250)$	$1\,(?^?)$	2210 - 2280	60 - 150	



Experimental data VS. the NLO model.

contribution of $\bar{K}N \longrightarrow Y \longrightarrow K\Xi$ reactions to the scattering amplitude.

In **Sharov, Korotkikh, Lanskoy, EPJA 47 (2011) 109,** a phenomenological model was suggested in which several combinations of resonances were tested

INCLUSION OF HYPERONIC RESONANCIES IN $\bar{K}N \longrightarrow K\Xi$

$$\Delta_{\alpha_1\alpha_2}^{\beta_1\beta_2}\left(\frac{5}{2}\right) = \frac{1}{2}\left(\theta_{\alpha_1}^{\beta_1}\theta_{\alpha_2}^{\beta_2} + \theta_{\alpha_1}^{\beta_2}\theta_{\alpha_2}^{\beta_1}\right) - \frac{1}{2}\theta_{\alpha_1\alpha_2}\theta^{\beta_1\beta_2} - \frac{1}{10}\left(\bar{\gamma}_{\alpha_1}\bar{\gamma}^{\beta_1}\theta_{\alpha_2}^{\beta_2} + \bar{\gamma}_{\alpha_1}\bar{\gamma}^{\beta_2}\theta_{\alpha_2}^{\beta_1} + \bar{\gamma}_{\alpha_2}\bar{\gamma}^{\beta_1}\theta_{\alpha_1}^{\beta_2} + \bar{\gamma}_{\alpha_2}\bar{\gamma}^{\beta_2}\theta_{\alpha_1}^{\beta_1}\right)$$

$$\theta_{\mu}^{\nu} = g_{\mu}^{\nu} - \frac{q_{\mu} q^{\nu}}{M_{Y}^{2}} \qquad \bar{\gamma}_{\mu} = \gamma_{\mu} - \frac{q_{\mu}\not{q}}{M_{Y}^{2}}$$

$$\Delta_{\alpha_1\alpha_2\alpha_3}^{\beta_1\beta_2\beta_3}\left(\frac{7}{2}\right) = \frac{1}{36}\sum_{P(\alpha)P(\beta)}\left(\theta_{\alpha_1}^{\beta_1}\theta_{\alpha_2}^{\beta_2}\theta_{\alpha_3}^{\beta_3} - \frac{3}{7}\theta_{\alpha_1}^{\beta_1}\theta_{\alpha_2\alpha_3}\theta^{\beta_2\beta_3} - \frac{3}{7}\bar{\gamma}_{\alpha_1}\bar{\gamma}^{\beta_1}\theta_{\alpha_2}^{\beta_2}\theta_{\alpha_3}^{\beta_3} + \frac{3}{35}\bar{\gamma}_{\alpha_1}\bar{\gamma}^{\beta_1}\theta_{\alpha_2\alpha_3}\theta^{\beta_2\beta_3}\right)$$

INCLUSION OF HYPERONIC RESONANCES IN $\bar{K}N \longrightarrow K\Xi$

Taking into account the scattering amplitude given by LS equations for a NLO Chiral Lagrangian and the phenomenological contributions from the resonances, the total scattering amplitude for the $\bar{K}N \longrightarrow K\Xi$ reaction should be written as:

$$T^{tot}_{ij,s,s'} = T^{LS}_{ij,s,s'} + T^{5/2^-}_{s,s'} + T^{7/2^+}_{s,s'}$$

Being aware of isospin symmetry, the coupling constants for each channel have to integrate this fact in its value.

$\Sigma(2030)$, $\Sigma(2250)$ both have I=1 ⟹

$$|K^+\Xi^-\rangle = -\frac{1}{\sqrt{2}}\left(|K\Xi\rangle_{I=1} + |K\Xi\rangle_{I=0}\right)$$

$$|K^0\Xi^0\rangle = \frac{1}{\sqrt{2}}\left(|K\Xi\rangle_{I=1} - |K\Xi\rangle_{I=0}\right)$$

Or in a equivalent manner:

- $K^-p \longrightarrow K^+\Xi^-$ ⟹ $T^{tot}_{s,s'} = T^{LS}_{s,s'} - T^{5/2^-}_{s,s'} - T^{7/2^+}_{s,s'}$
- $K^-p \longrightarrow K^0\Xi^0$ ⟹ $T^{tot}_{s,s'} = T^{LS}_{s,s'} + T^{5/2^-}_{s,s'} + T^{7/2^+}_{s,s'}$

On going work …

In order to improve results, the model could be developed taking into account:

- **Born (direct and cross) diagrams** (fine tunning)

$$\mathcal{L}_{MB}^{(YUKAWA)}(B,U) = \frac{1}{2} D\langle \bar{B}\gamma^{\mu}\gamma_5\{u_{\mu}, B\}\rangle + \frac{1}{2} F\langle \bar{B}\gamma^{\mu}\gamma_5[u_{\mu}, B]\rangle$$