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

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Albert Feijoo Aliau

Universitat de Barcelona

Co-authors:

Volodymyr Magas & Àngels Ramos

Institut de Ciències del Cosmos

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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**.

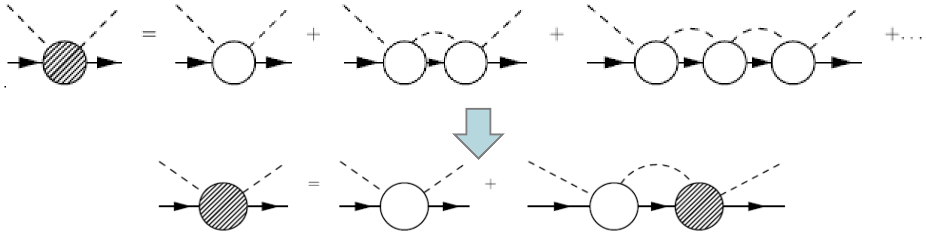
But, actually, we are in S=-1 sector, where $\bar{K}N$ interaction at low energy is dominated by the presence of the $\Lambda(1405)$ resonance. ChPT is not applicable in such a region, consequently, we have to go further.

A nonperturbative resummation is mandatory $\Rightarrow$ **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:



$$T_{ij} = V_{ij} + V_{il}G_l V_{lj} + V_{il}G_l V_{lk}G_k V_{kj} + \cdots$$

$$T_{ij} = V_{ij} + V_{il}G_l T_{lj}$$

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

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

Coupled-channel algebraic equations system

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

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

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

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

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:

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

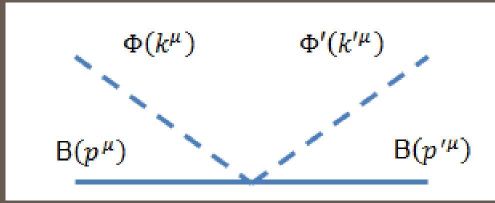
subtraction constants for the dimensional regularization scale $\mu = 1GeV$ in all the k channels.

With isospin symmetry

$$\left\{\begin{array}{c} a_{K^-p} = a_{\bar{K}^0 n} = a_{\bar{K}N} \\ a_{\pi^0\Lambda} = a_{\pi\Lambda} \\ a_{\pi^0\Sigma^0} = a_{\pi^+\Sigma^-} = a_{\pi^-\Sigma^+} = a_{\pi\Sigma} \\ a_{\eta\Lambda} \\ a_{\eta\Sigma^0} = a_{\eta\Sigma} \\ a_{K^+\Xi^-} = a_{K^0\Xi^0} = a_{K\Xi} \end{array}\right.$$

6 PARAMETERS!

FORMALISM
Effective lagrangian up to LO



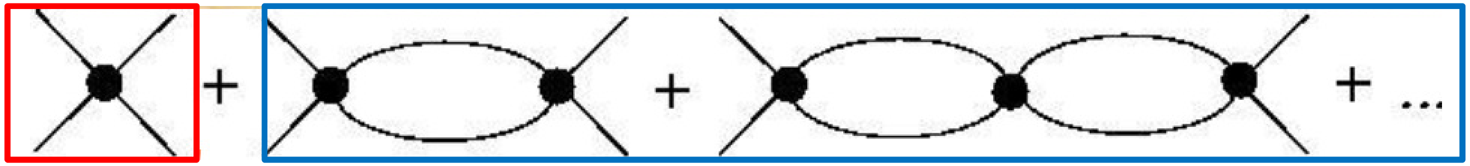
WT, *lowest order term*

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

$$V_{ij}^{WT} = -C_{ij} \frac{1}{4f^2} \bar{u}(p) \gamma^\mu u(p) (k_\mu + k'_\mu) \xrightarrow[\text{S-wave aprox.}]{\text{At low energies} \, +} V_{ij}^{WT} = -C_{ij} \frac{1}{4f^2} (k^0 + k'^0)$$

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

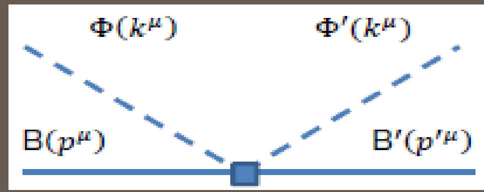
- **There is no direct contribution of these reactions at lowest order**
- **The rescattering terms due to the coupled channels are the only contribution to the scattering amplitude.**



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: $V_{ij} = V_{ij}^{WT} + V_{ij}^{NLO}$ → $\boxed{T = (1-VG)^{-1}V}$ → 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.**

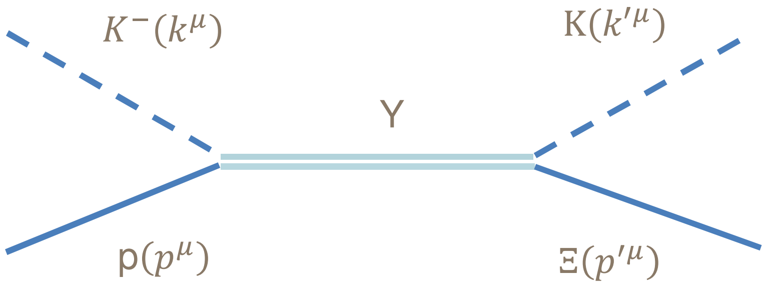
Resonance	I	(J^P)	Mass (MeV)	Γ (MeV)	$\Gamma_{K\Xi}/\Gamma$
$\Lambda(1890)$	0	$\left(\frac{3}{2}^+\right)$	1850 - 1910	60 - 200	
$\Lambda(2100)$	0	$\left(\frac{7}{2}^-\right)$	2090 - 2110	100 - 250	$< 3\%$
$\Lambda(2110)$	0	$\left(\frac{5}{2}^+\right)$	2090 - 2140	150 - 250	
$\Lambda(2350)$	0	$\left(\frac{9}{2}^+\right)$	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 :

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

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

INCLUSION OF HYPERONIC RESONANCES

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

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

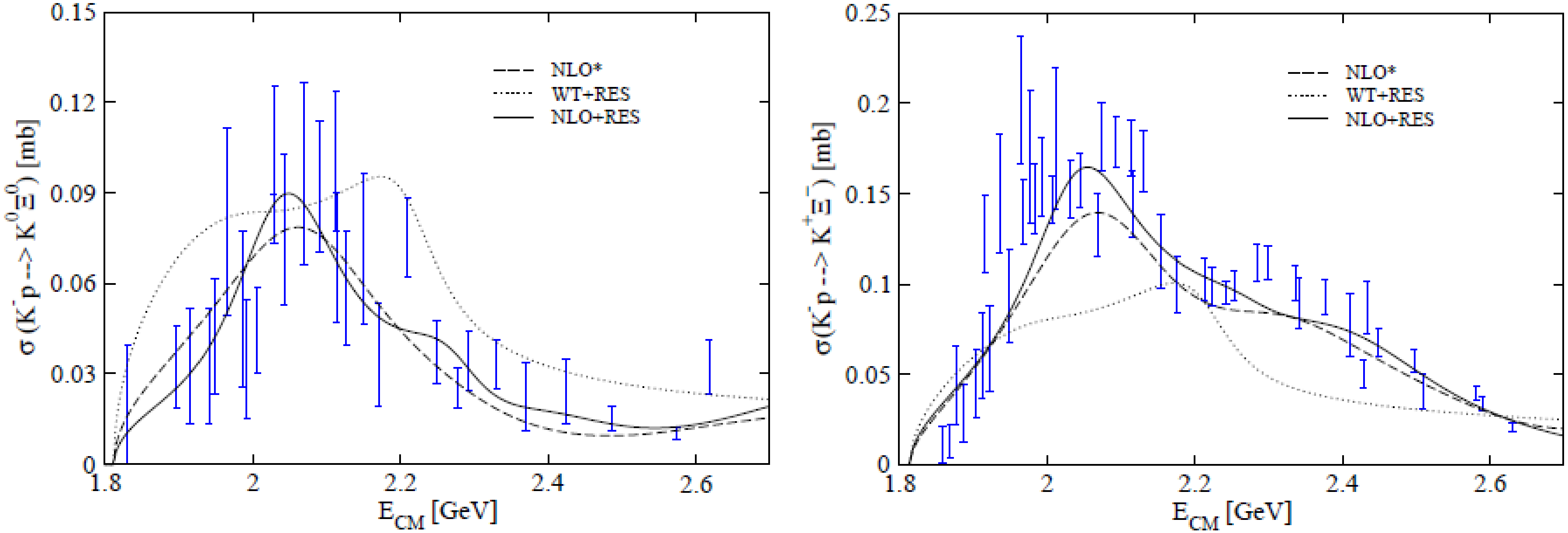
The total scattering amplitude for the $\bar{K}N \longrightarrow K\Xi$ reaction taking into account the unitarized chiral contributions up to NLO plus the phenomenological contributions from the resonances reads:

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

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
$\chi^2_{\mathrm{d.o.f.}}$	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	$(b_D+b_F)\mu_1^2$
$K^+\Xi^-$									$4(b_0+b_D)m_K^2$	$2(b_D-b_F)m_K^2$
$K^0\Xi^0$										$4(b_0+b_D)m_K^2$

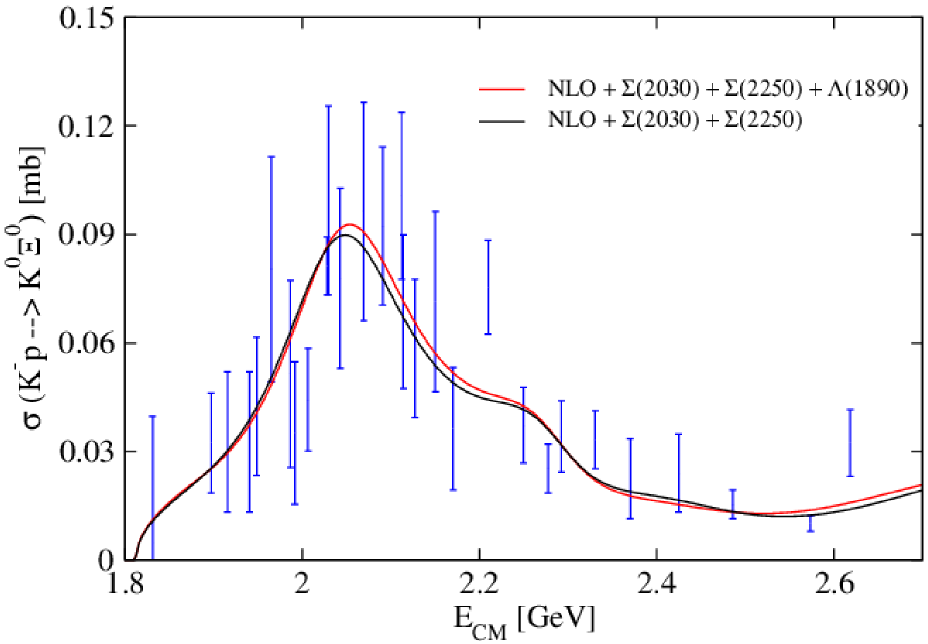
L_{ij}

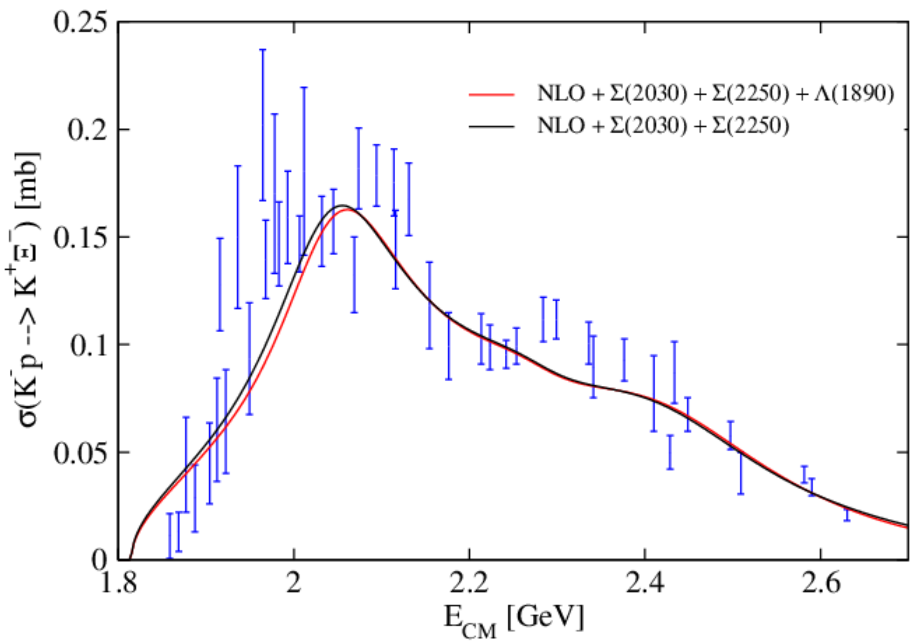
	K^-p	$\bar{K}^0n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	$2d_2+d_3+2d_4$	$d_1+d_2+d_3$	$\frac{-\sqrt{3}(d_1+d_2)}{2}$	$\frac{-d_1-d_2+2d_3}{2}$	$\frac{d_1-3d_2+2d_3}{2}$	$\frac{d_1-3d_2}{2\sqrt{3}}$	$-2d_2+d_3$	$-d_1+d_2+d_3$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

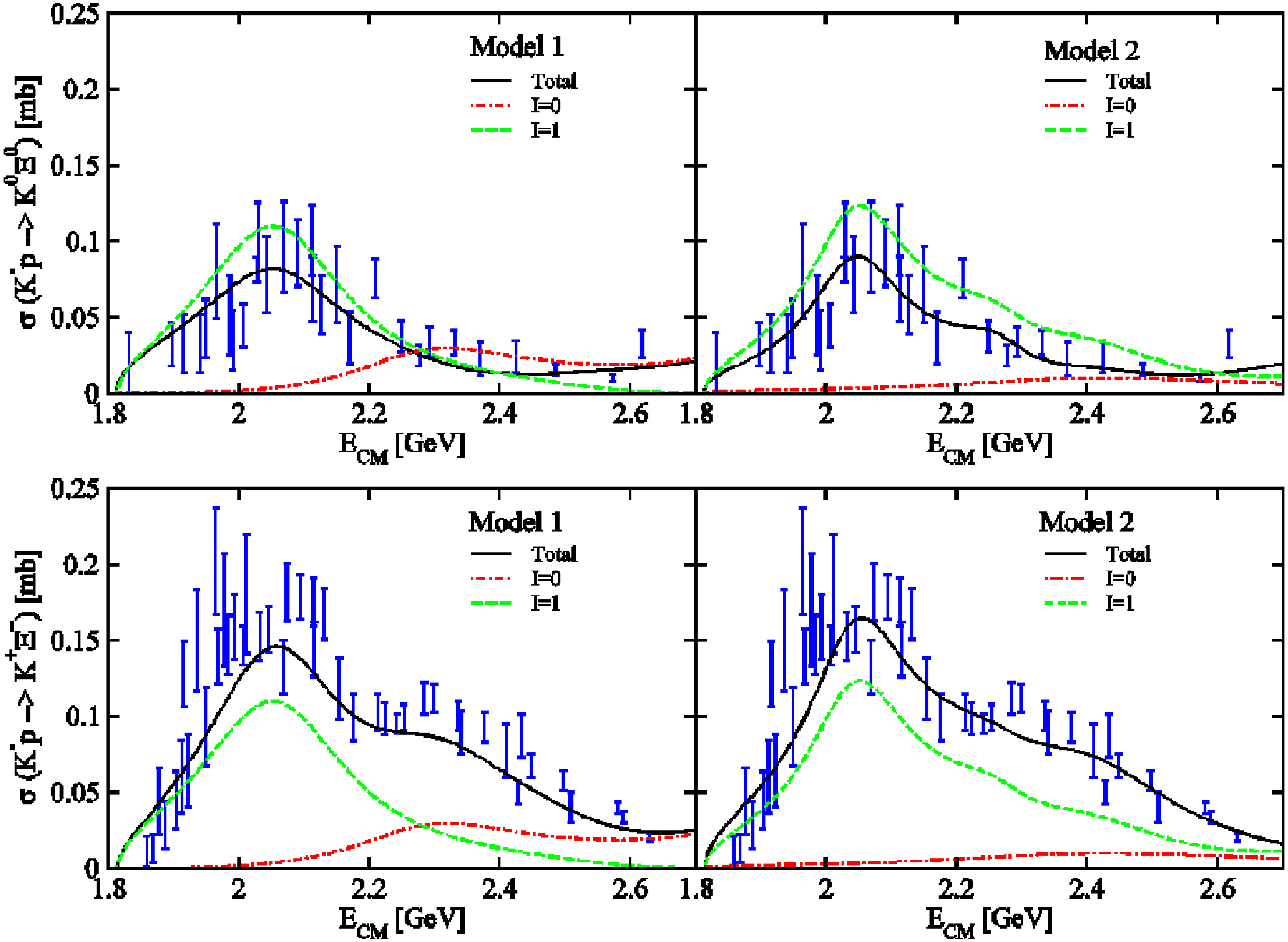
What happens if a third resonance is added?

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



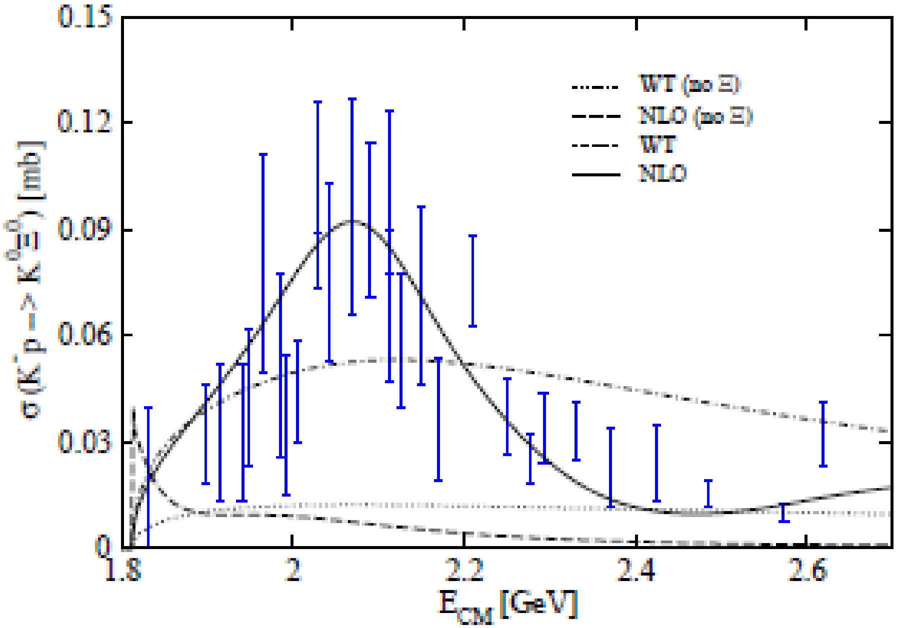


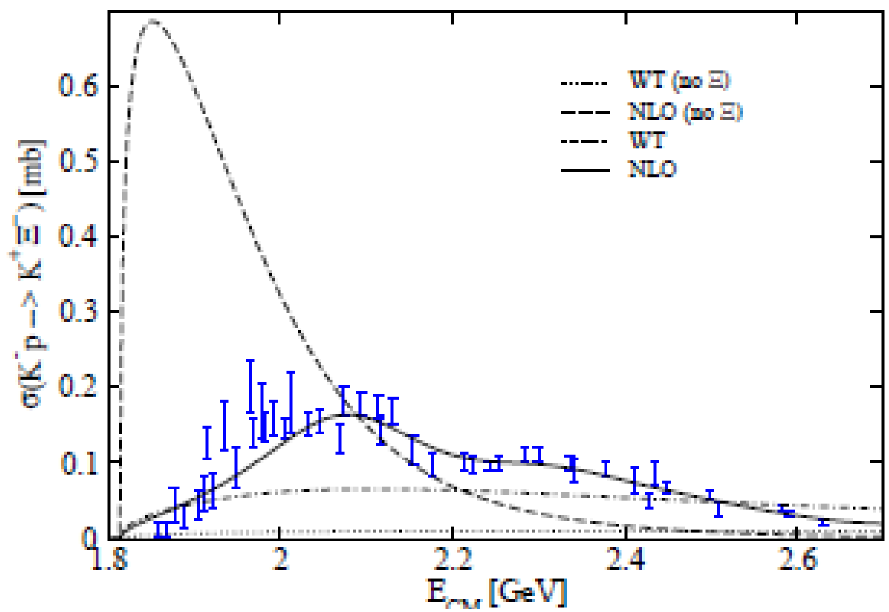
RESULTS II



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

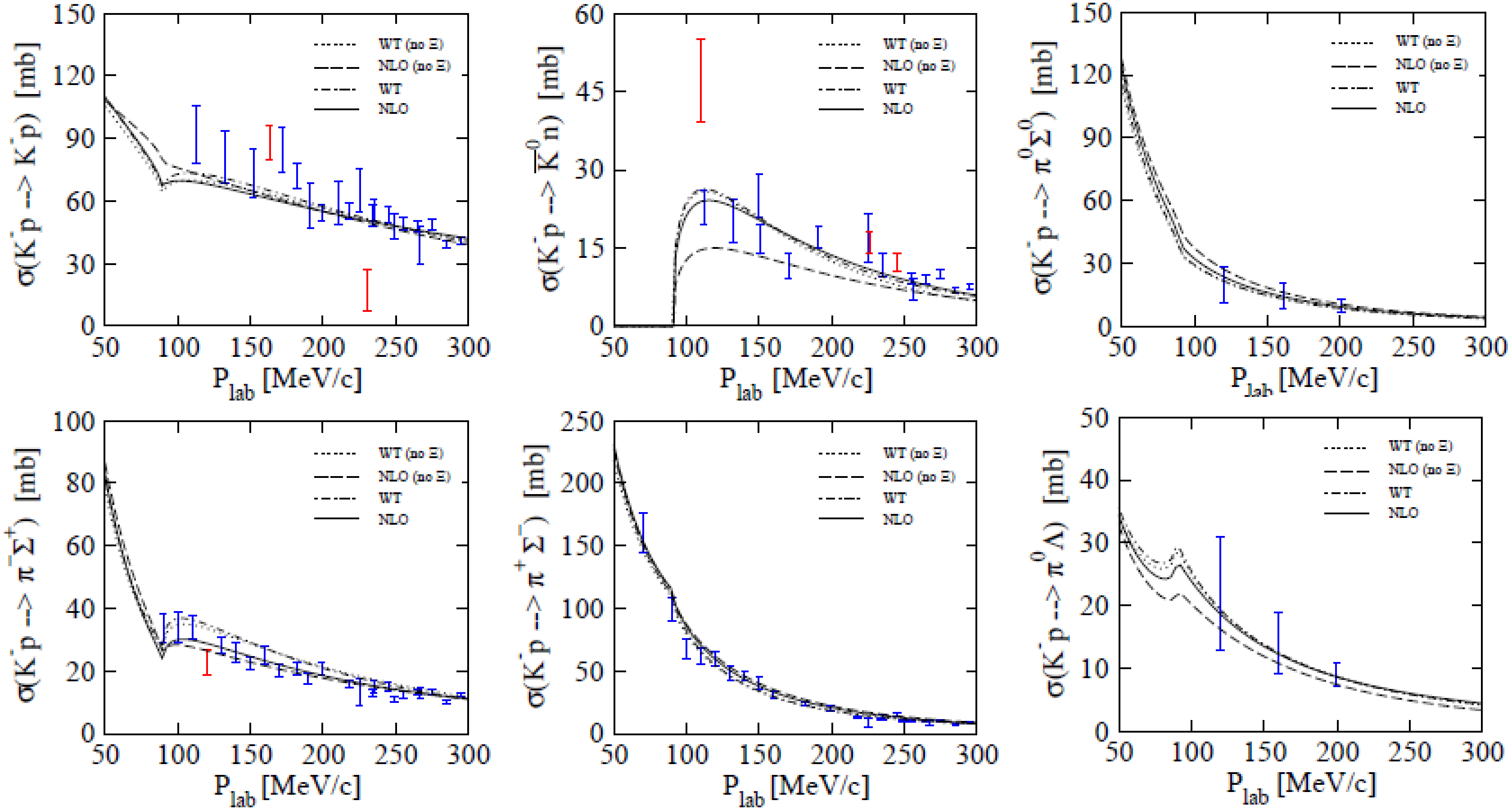




	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
WT (no $K\Xi$)	2.37	0.191	0.665	$-0.76 + i\,0.79$	316	511
NLO (no $K\Xi$)	2.36	0.188	0.662	$-0.67 + i\,0.84$	290	559
WT	2.36	0.192	0.667	$-0.76 + i\,0.84$	318	543
NLO	2.36	0.189	0.664	$-0.73 + i\,0.85$	310	557
Exp.	2.36 ±0.04	0.189 ±0.015	0.664 ±0.011	$-0.66 + i\,0.81$ $(\pm0.07) + i\,(\pm0.15)$	283 ±36	541 ±92

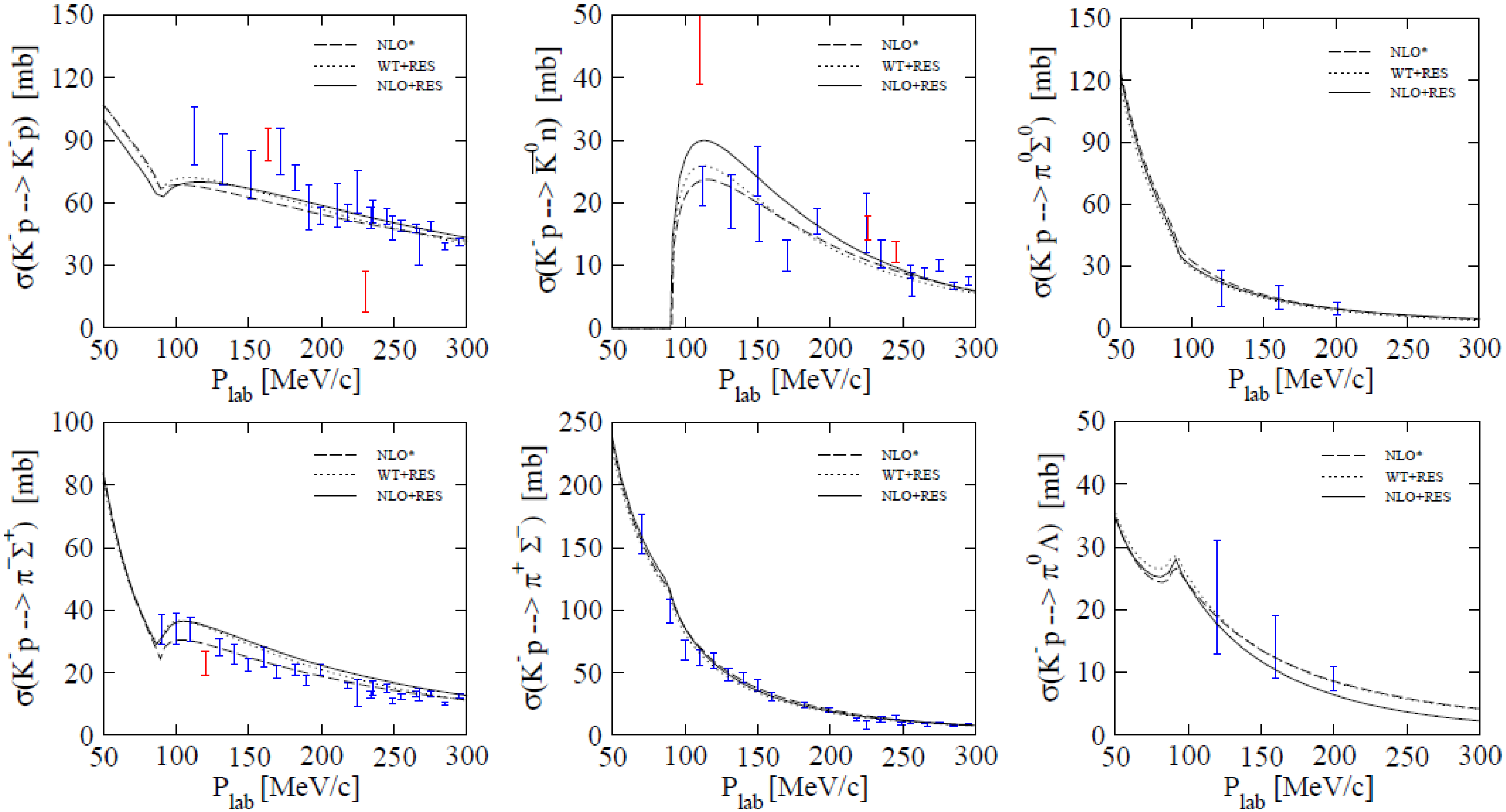
	WT (no $K\Xi$)	NLO (no $K\Xi$)	WT	NLO
$a_{\bar{K}N}$ (10^{-3})	-1.681 ± 0.738	5.151 ± 0.736	-1.986 ± 2.153	6.550 ± 0.625
$a_{\pi\Lambda}$ (10^{-3})	33.63 ± 11.11	21.61 ± 10.00	-248.6 ± 122.0	54.84 ± 7.51
$a_{\pi\Sigma}$ (10^{-3})	0.048 ± 1.925	3.078 ± 2.101	0.382 ± 2.711	-2.291 ± 1.894
$a_{\eta\Lambda}$ (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
$\chi^2_{\rm d.o.f.}$	0.62	0.39	2.57	0.65

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



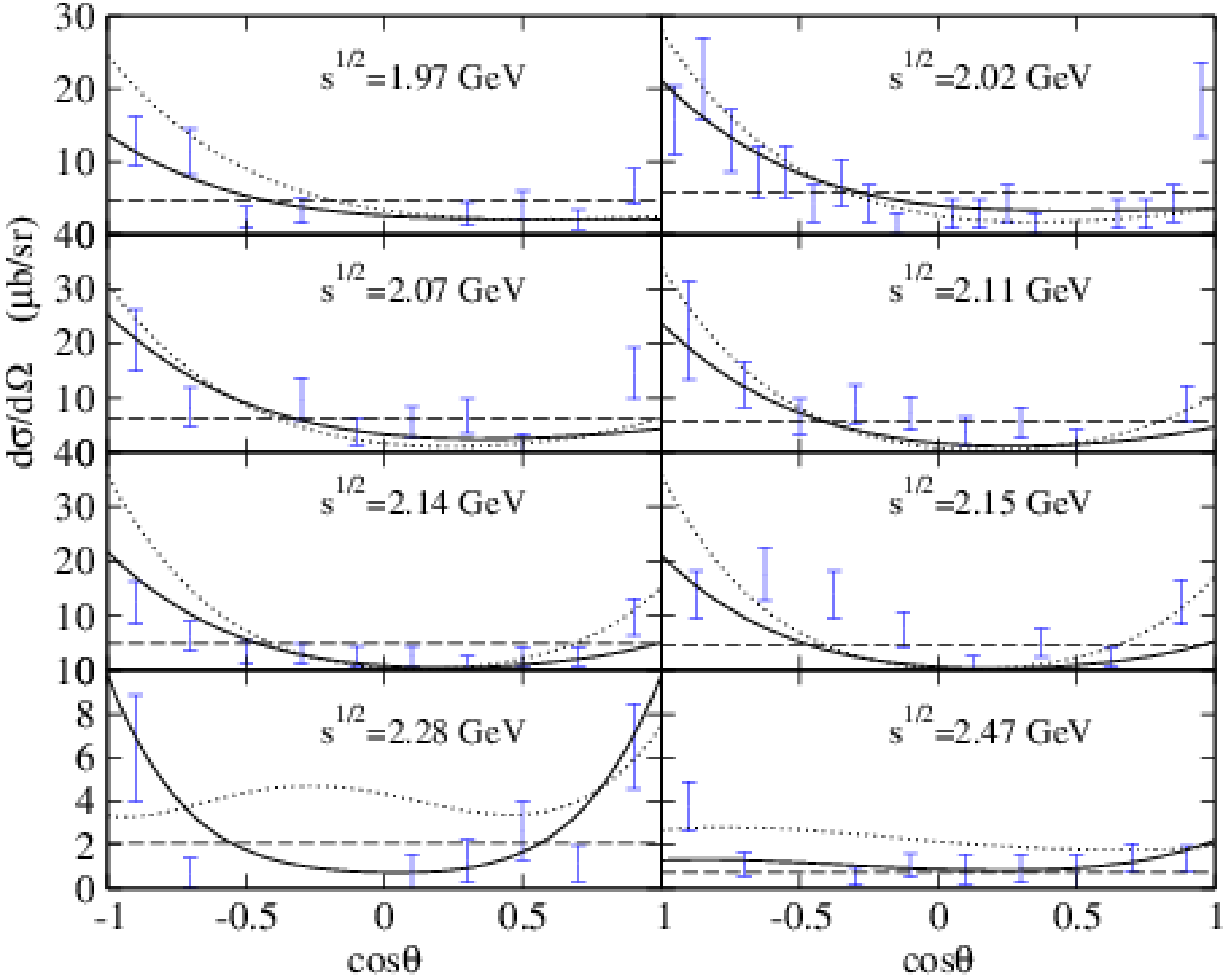
	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
WT (no $K\Xi$)	2.37	0.191	0.665	$-0.76 + i\,0.79$	316	511
NLO (no $K\Xi$)	2.36	0.188	0.662	$-0.67 + i\,0.84$	290	559
WT	2.36	0.192	0.667	$-0.76 + i\,0.84$	318	543
NLO	2.36	0.189	0.664	$-0.73 + i\,0.85$	310	557
Exp.	2.36	0.189	0.664	$-0.66 + i\,0.81$	283	541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

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

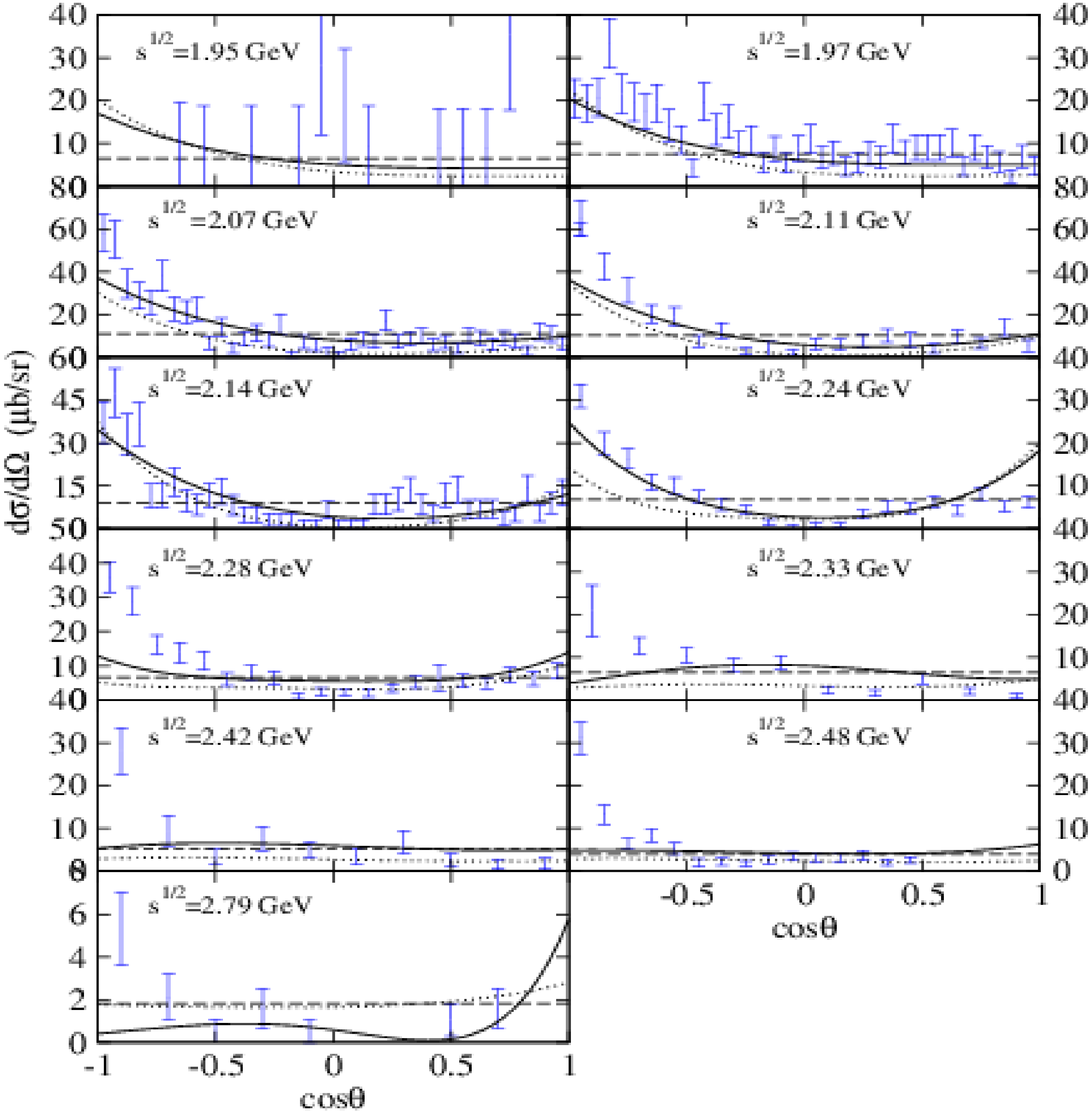


	γ	R_n	R_c	$a_p(K^-p \to K^-p)$	ΔE_{1s}	Γ_{1s}
NLO*	2.37	0.189	0.664	$-0.69 + \mathrm{i}\,0.86$	300	570
WT+RES	2.37	0.193	0.667	$-0.73 + \mathrm{i}\,0.81$	307	528
NLO+RES	2.39	0.187	0.668	$-0.66 + \mathrm{i}\,0.84$	286	562
Exp.	2.36	0.189	0.664	$-0.66 + \mathrm{i}\,0.81$	283	541
	± 0.04	± 0.015	± 0.011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

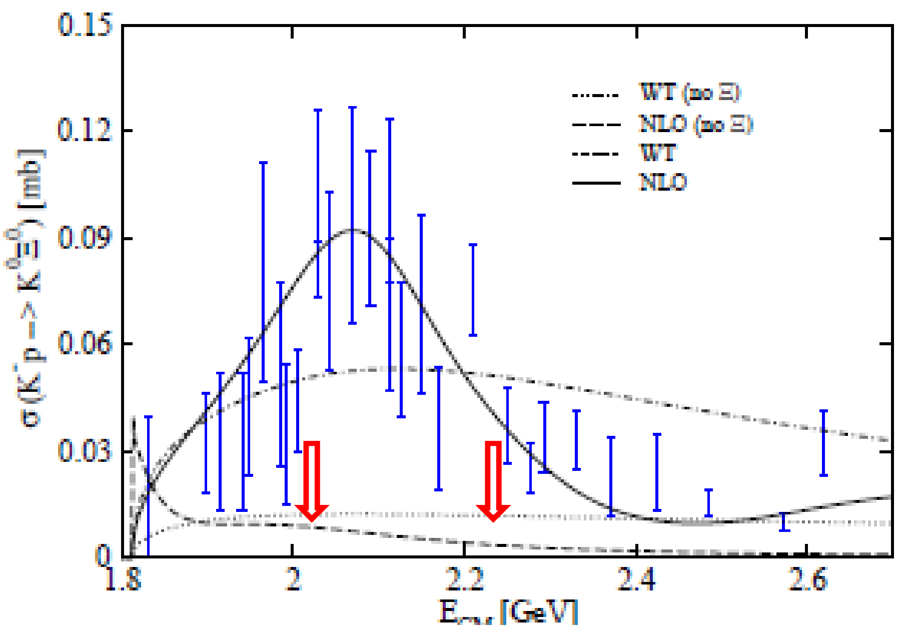
Differential cross section of the $\bar{K}N \longrightarrow K^0\Xi^0$

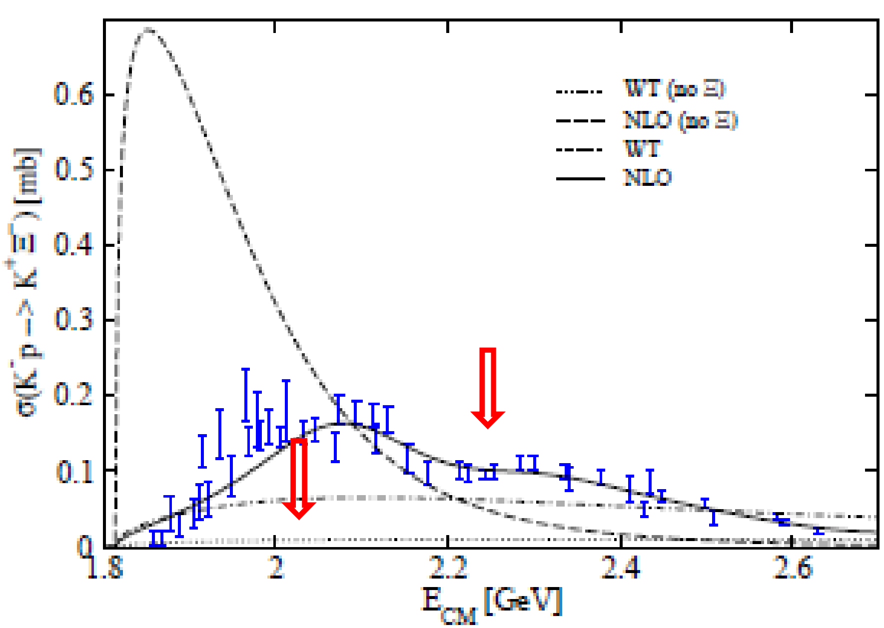


Differential cross section of the $\bar{K}N \longrightarrow K^+\Xi^-$



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 $\Longrightarrow$

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

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

Or in a equivalent manner:

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

On going work …

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

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

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