Theoretical analysis of π- p ---> D* Λc reaction using Regge approach

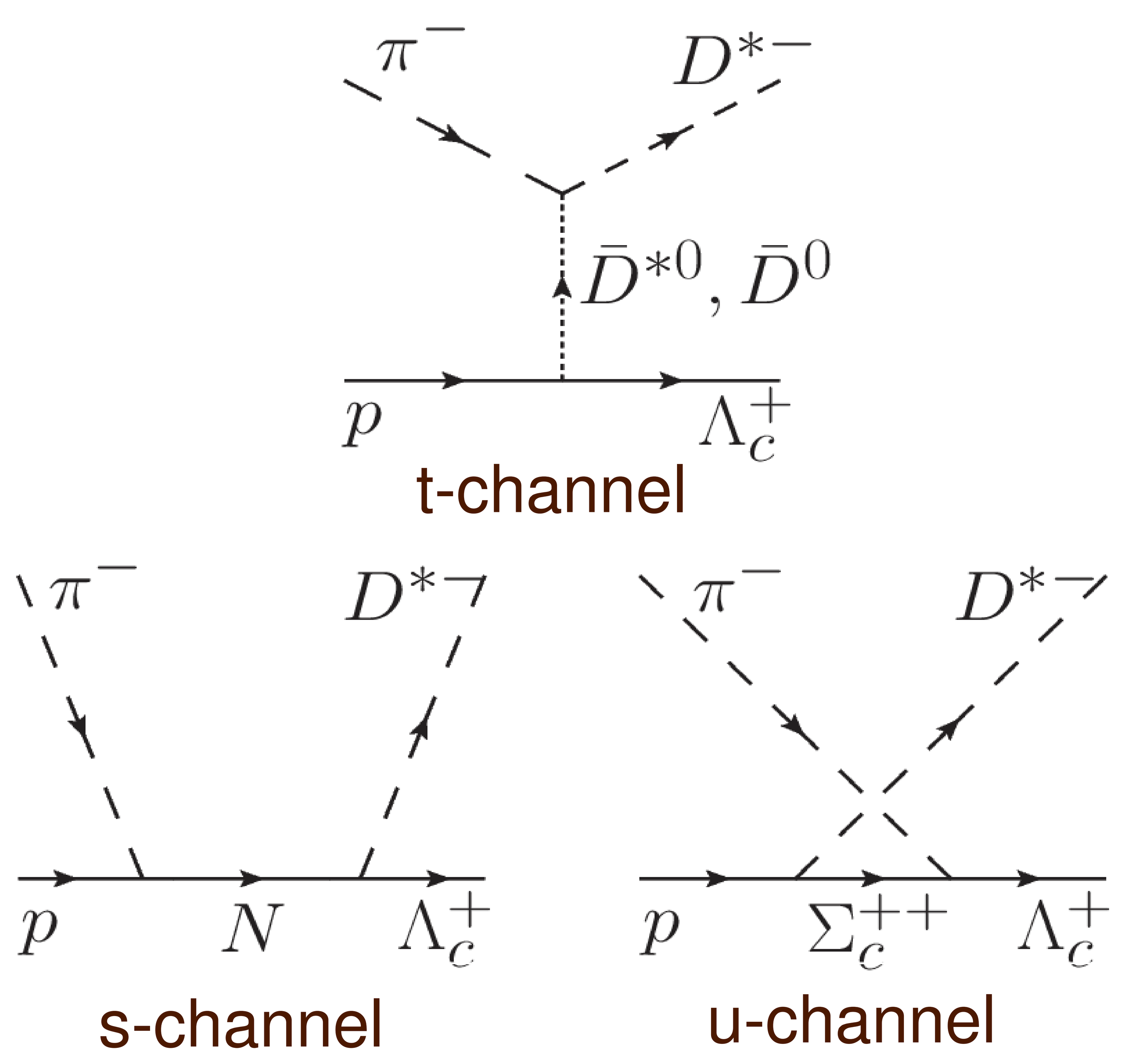
Sang-Ho Kim(金相鎬)
Research Center for Nuclear Physics (RCNP), Osaka University

Superviser : Prof. Atsushi Hosaka

1.Theoretical Framework

Tree Diagram

$$\pi^- p \to D^{*-}\Lambda_c^+$$



Effective Lagrangian

$$\mathcal{L}_{\pi DD^*} = ig_{\pi DD^*} D^*_\mu (\bar{D}\partial^\mu \pi - \partial^\mu \bar{D}\pi)$$
$$\mathcal{L}_{\pi D^* D^*} = -g_{\pi D^* D^*}\varepsilon^{\mu\nu\alpha\beta}\partial_\mu D^*_\nu \pi \partial_\alpha \bar{D}^*_\beta$$

Summary of estimates for $g_{D^*D\pi}$ and $g_{B^*B\pi}$. These couplings refer to charged mesons $\pi^\pm$.

Approach	$g_{D^*D\pi}$	$g_{B^*B\pi}$
QCDSR [58]	9 ± 2	20 ± 4
QCDSR [58]	7 ± 2	15 ± 4
LCSR [59]	11 ± 2	28 ± 6
QCDSR [60]	6.3 ± 1.9	14 ± 4
LCSR [41]	10.5 ± 3	22 ± 9
QCDSR [20]	14.0 ± 1.5	42.5 ± 2.6
QCDSR plus meson loops [55]	17.5 ± 1.5	44.7 ± 1.0
LQCD [61]	20 ± 2	
LQCD [62]	$18.8^{+2.5}_{-3.0}$	
Dispersive quark model [63]	18 ± 3	32 ± 5
Dyson–Schwinger equations [64]	$15.8^{+2.1}_{-1.0}$	$30.0^{+3.2}_{-1.4}$

M. Bracco et al., Prog.Nucl.Part.Phys. 67, 1019 (2012)

$$\mathcal{L}_{\pi\Sigma_c\Lambda_c} = g_{\pi\Sigma_c\Lambda_c}\bar{\Lambda}_c\gamma_\mu\gamma_5\pi\partial^\mu\Sigma_c + \text{h.c.}$$
$$\mathcal{L}_{\pi NN} = \bar{N}\gamma_\mu\gamma_5\boldsymbol{\tau}\cdot\boldsymbol{\pi}\partial^\mu N$$

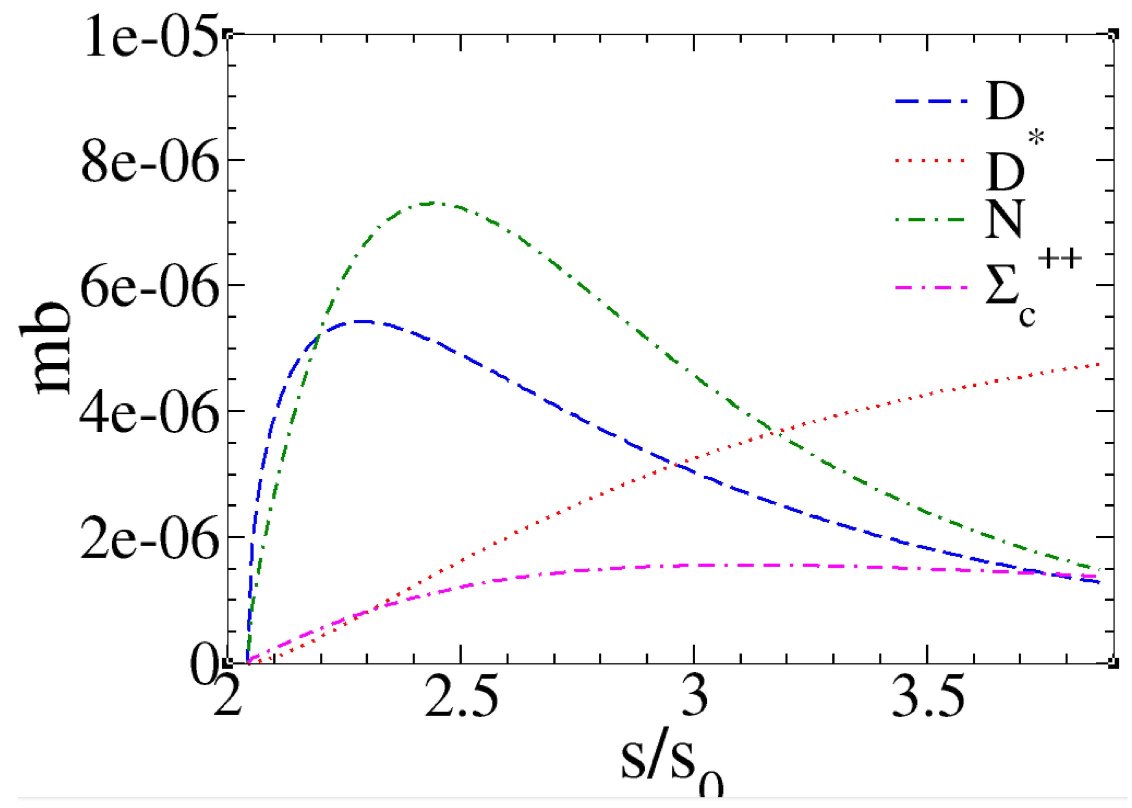
$$\mathcal{L}_{DN\Lambda_c} = -ig_{DN\Lambda_c}\bar{N}\gamma_5\Lambda_c D + \text{h.c.}$$
$$\mathcal{L}_{D^*N\Lambda_c} = -\bar{\Lambda}_c\left[g^V_{D^*N\Lambda_c}\gamma^\mu - \frac{g^T_{D^*N\Lambda_c}}{M_{\Lambda_c}+M_N}\sigma^{\mu\nu}\partial_\nu\right]D^*_\mu N + \text{h.c.}$$

Strong coupling (charmed)	LCSR estimate	Strong coupling (strange)	LCSR estimate	Ratio of couplings $\left(\frac{\text{charmed}}{\text{strange}}\right)$	LCSR estimate
$g_{\Lambda_c ND}$	$10.7^{+5.3}_{-4.3}$	$g_{\Lambda NK}$	$7.3^{+2.6}_{-2.8}$	$\frac{g_{\Lambda_c ND}}{g_{\Lambda NK}}$	$1.47^{+0.58}_{-0.44}$
$g^V_{\Lambda_c ND^*}$	$-5.8^{+2.1}_{-2.5}$	$g^V_{\Lambda NK^*}$	$-6.1^{+2.1}_{-2.0}$	$\frac{g^V_{\Lambda_c ND^*}}{g^V_{\Lambda NK^*}}$	$0.95^{+0.35}_{-0.28}$
$g^T_{\Lambda_c ND^*}$	$3.6^{+2.9}_{-1.8}$	$g^T_{\Lambda NK^*}$	$12.8^{+5.8}_{-5.2}$		
$\frac{g^T_{\Lambda_c ND^*}}{g^V_{\Lambda_c ND^*}}$	$-0.63^{+0.16}_{-0.28}$	$\frac{g^T_{\Lambda NK^*}}{g^V_{\Lambda NK^*}}$	$-2.1^{+0.5}_{-0.6}$		
$g_{\Sigma_c ND}$	$1.3^{+1.0}_{-0.9}$	$g_{\Sigma NK}$	$1.1^{+0.6}_{-0.5}$		
$g^V_{\Sigma_c ND^*}$	$1.0^{+1.3}_{-0.6}$	$g^V_{\Sigma NK^*}$	$1.7^{+0.9}_{-0.8}$	$\frac{g^V_{\Sigma_c ND^*}}{g^V_{\Sigma NK^*}}$	$0.56^{+0.42}_{-0.20}$
$g^T_{\Sigma_c ND^*}$	$2.1^{+1.9}_{-1.0}$	$g^T_{\Sigma NK^*}$	$3.6^{+1.5}_{-1.2}$		
$\frac{g^T_{\Sigma_c ND^*}}{g^V_{\Sigma_c ND^*}}$	2.1 ± 0.5	$\frac{g^T_{\Sigma NK^*}}{g^V_{\Sigma NK^*}}$	$2.1^{+0.6}_{-0.3}$		

A. Khodjamirian et al., Eur.Phys.J.A 48, 31(2012)

2.Nemerical Results

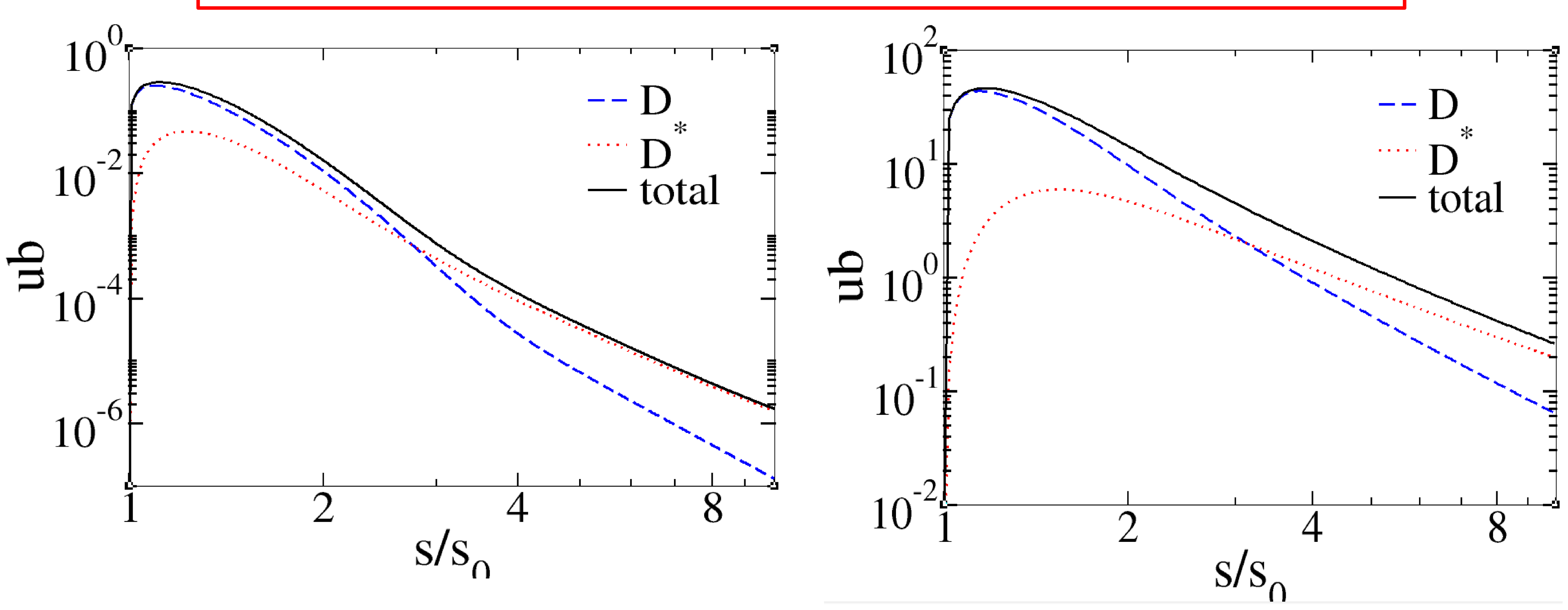
Feynman Model



There exist ambiguities in Feynman model such as form factors and cutoff values. We can reduce them in Regge model because the Regge trajectories are well known for charm production as well as for strange one.

Regge Model

$$\frac{1}{t-M_D^2} \to P^D_{Regge} = \left(\frac{s}{s_0}\right)^{\alpha_D(t)}\Gamma(-\alpha_D(t))$$
$$\frac{1}{t-M_{D^*}^2} \to P^{D^*}_{Regge} = \left(\frac{s}{s_0}\right)^{\alpha_{D^*}(t)-1}\Gamma(1-\alpha_{D^*}(t))$$



Charm production → Strange production

$\pi^- p \to D^{*-}\Lambda_c^+$ $\qquad$ $\pi^- p \to K^{*0}\Lambda$

3. Conclusion

We can find that the total cross section for the charm production is approximately 100~1000 times smaller than for the strange one.
We will extend these (preliminary) results to the production of excited Λ and Σ states.