Exotic Cascade Production from Photo-nucleon Interactions

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Introduction

- Observation of a baryon resonance with S=+1 and Q=+1 in six experiments

- Other exotic states should be possible to be found in experiments, two candidate with exotic quantum numbers are Ξ^{+} and Ξ^{--}.

- NA49 reported observation of Ξ^{--} and Ξ^{0} in p-p collision, it is also possible to find Cascade in photon-nucleon collisions.

Cascade photoproduction

- Exotic quantum numbers

  Ξ^{--} (S= -2, Q=-2) and Ξ^{+} (S= -2, Q=+1)

- Possible Cascade photoproduction reactions

$$\gamma p \to K^0 K^0 \Xi^+, \quad \gamma n \to K^+ K^+ \Xi^{--}$$

- Using SU(3) hadronic model with photon introduced as U(1) gauge particle

- SU(3) hadronic model

$$L = i\mathrm{Tr}(\bar{\mathrm{B}}\partial\cdot\gamma\mathrm{B}) + \mathrm{Tr}(\partial_\mu \mathrm{P}^+ \partial^\mu \mathrm{P})$$
$$+ \mathrm{g}'\{\mathrm{Tr}[(1-\alpha)\bar{\mathrm{B}}\gamma_5\mathrm{BP} + (1+\alpha)\mathrm{P}\bar{\mathrm{B}}\gamma_5\mathrm{B}]\}$$

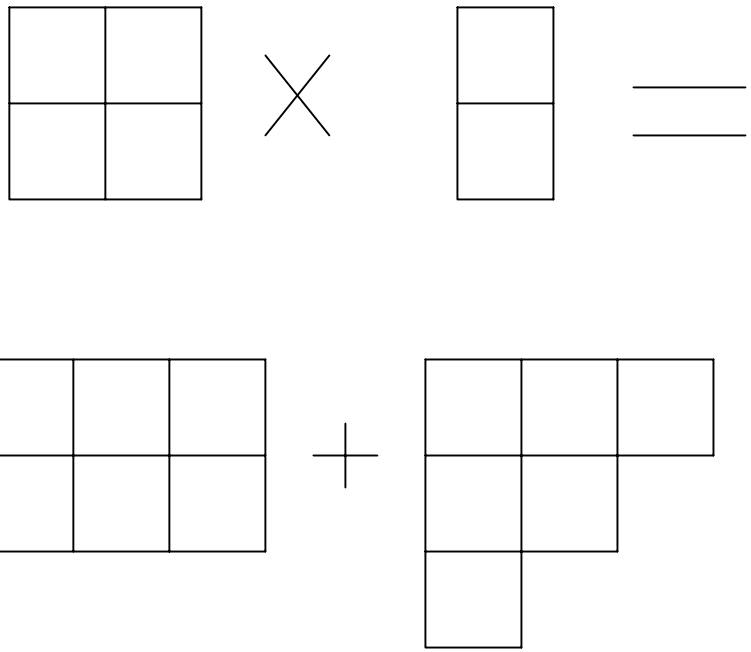
Where B and P are 3 x 3 matrix of octet baryons and pseudoscalar mesons and α denotes the ratio of the F type coupling to D type coupling.

Treat vector mesons as gauge particles by placing ∂_μ by

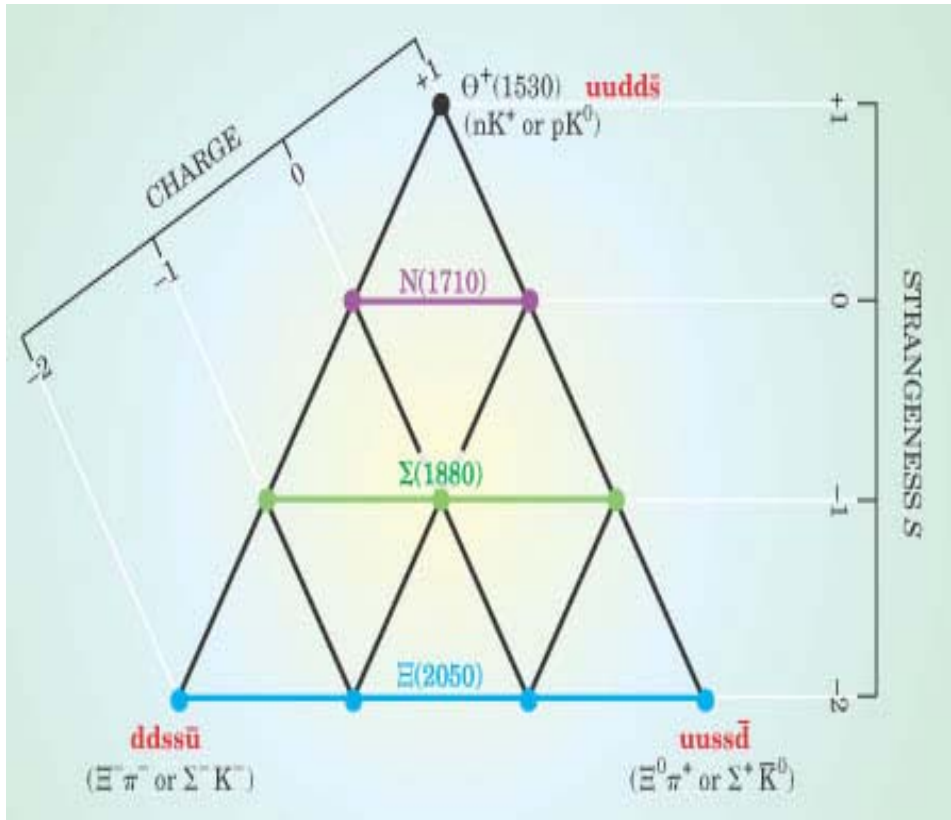
$$\mathrm{D}_\mu = \partial_\mu - \tfrac{\mathrm{i}}{2}\mathrm{g}[\mathrm{V}_\mu, \ ]$$

where V is the 3 x3 matrix of octet vector meson

Mixture of antidecouplet and octet



antidecuplet octet



- SU(3) hadronic model for antidecuplet baryons

$$L = igT^{ljk}\gamma_5 P_m^j B_n^k \varepsilon^{lmn} + \text{H.c.} \qquad \text{(Y. Oh)}$$

$$L = g_2 T^{ljk}\gamma\cdot V_m^j B_n^k \varepsilon^{lmn} + \text{H.c.}$$

With T^{ljk}: anti-decuplet baryon; P_m^j :octet pseudoscalar meson;

B_n^k: octet baryon; V_m^j : octet vector meson

- Coupling constant

$g_{KN\Theta} \approx 3.0$ from decay width N(1710)→KΛ for positive parity which corresponds to $\Gamma_\Theta = 9\text{MeV}$

$g_{KN\Theta} \approx 0.42$ for negative parity

$g_{K^*N\Theta} = 1.8$ from decay width N(1710)→Nρ by treating N(1710) as ideal mixed states of antidecuplet and octet

other coupling constants can be gotten from SU(3) relations

- Form factor

$$F(x) = \frac{\Lambda^4}{\Lambda^4 + (x - m_x^2)^2}$$

- Gauge invariant with form factors

$$F(t)M_t + F(s)M_s + F(u)M_u + M_c$$

with

$$M_c = \frac{A}{t - m_t^2}(\hat{F} - F(t)) + \frac{B}{s - m_s^2}(\hat{F} - F(s)) + \frac{C}{u - m_u^2}(\hat{F} - F(u))$$

and

$$\hat{F} = F(t) + F(s) + F(u) - F(t)F(s) - F(t)F(u) - F(s)F(u)$$

- Coupling constants and cutoff parameter

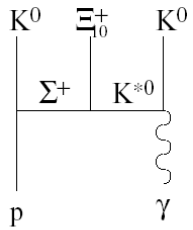
$$g_{K^*\Sigma\Xi} = g_{K^*N\Theta} = 3g_{\rho NN(1710)} = 1.8;$$

$$g_{K\Sigma\Xi} = g_{KN\Theta} = 3.0.$$

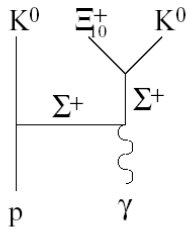
with a relative sign unknown.

Cutoff parameter is set to Λ=1.2 GeV determined from charm photoproduction on protons at center mass energy of 6 GeV.

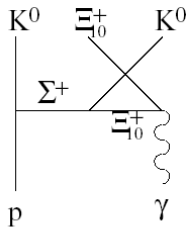
- # Feynman diagrams for Cascade photoproduction



(1a)



(1b)



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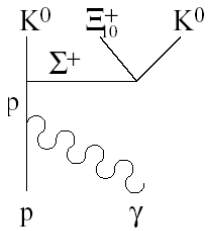

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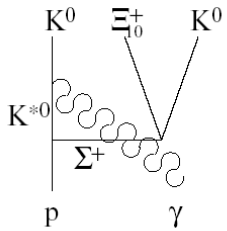
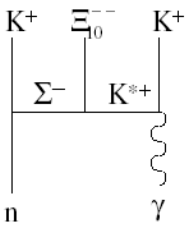


(1e)



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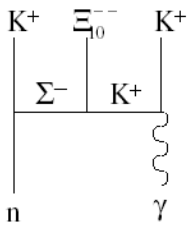

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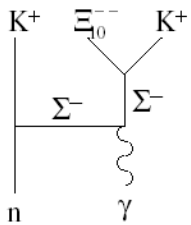
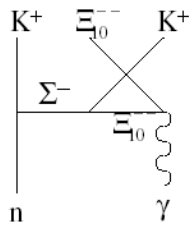
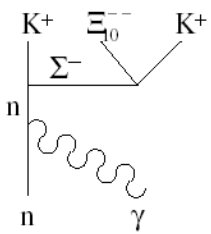


(2c)



(2d)



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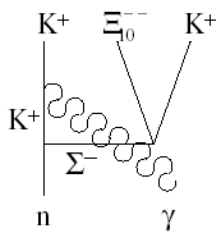
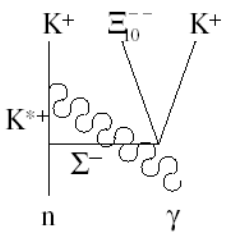
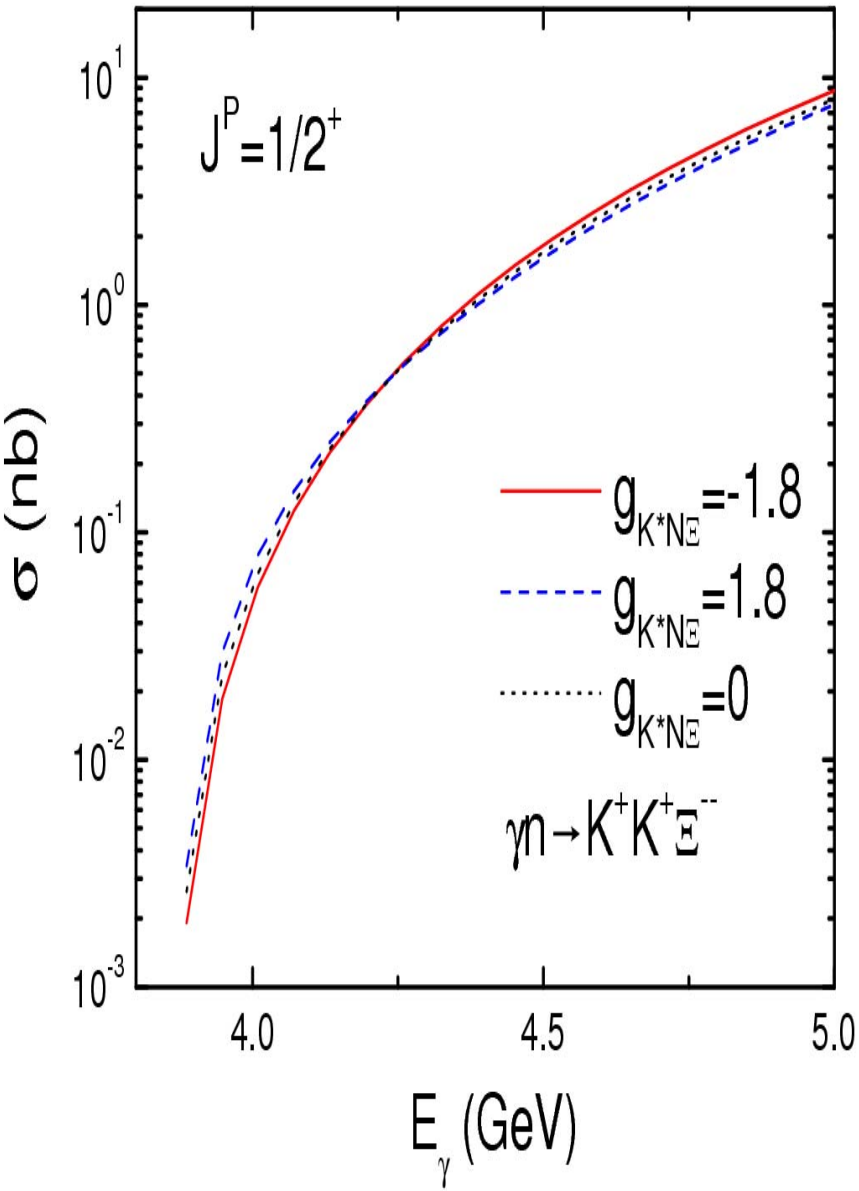


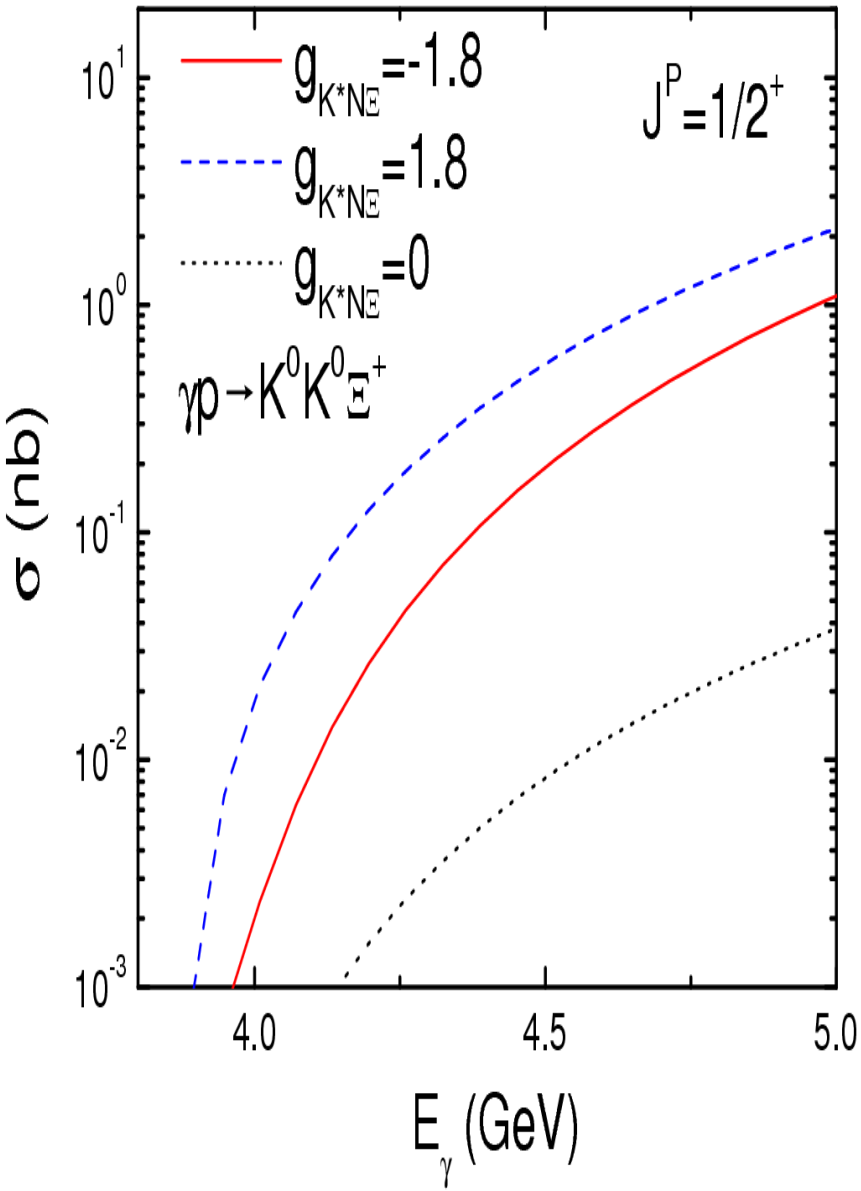
(2f)



(2g)

- Cross sections for Cascade Photoproduction





Summary

- We studied the cross sections of cascade production from photon-nucleon interactions within SU(3) hadronic model.

- The results are sensitive to the cutoff parameter in the form factors. Coupling constants are also important in determining the cross sections.

- Ξ^{--} production has a much larger cross section than that of Ξ^{+} production.