Transverse polarization of Λ^0 hyperons in quasi-real photoproduction: Quark Recombination Model

I. ALIKHANOV

Saint Petersburg State University, Russia

O. GREBENYUK

Petersburg Nuclear Physics Institute, Russia

XII Workshop on High Energy Spin Physics

Dubna, September 3-7, 2007

OUTLINE

- √ Introduction
- √ Experimental Field
- √ Quark Scattering Model (QSM)
- √ Quark Recombination Model (QRM)
- √ Calculations and Results
- √ Conclusion

INTRODUCTION

- √ Among the hyperons, Λ^0 fills a special place due to the spin-flavor structure of its wave function within the SU(6) symmetry

$$|\Lambda\rangle_{\frac{1}{2}} = |ud\rangle_0 |s\rangle_{\frac{1}{2}}.$$

- √ In unpolarized reactions $ab \to \Lambda X$, the direction of the polarization is defined by

$$\mathbf{n} \propto [\mathbf{p}_a \times \mathbf{p}_\Lambda].$$

- √ The polarization sign

$$\mathbf{P} \cdot \mathbf{n} < 0 \qquad pp \to \Lambda X,$$

$$\mathbf{P} \cdot \mathbf{n} > 0 \qquad K^- p \to \Lambda X.$$

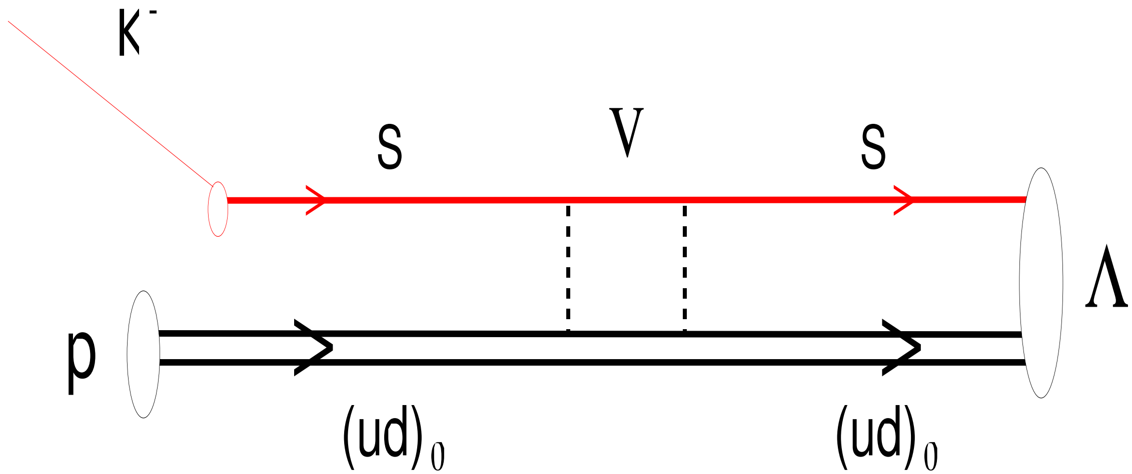
EXPERIMENTAL FIELD

The recent HERMES results [arXiv:0704.3133] are qualitatively similar to the polarization in $K^- p$.

- √ the positive sign has been observed in both the reactions.
- √ similarity in the p_T dependence.

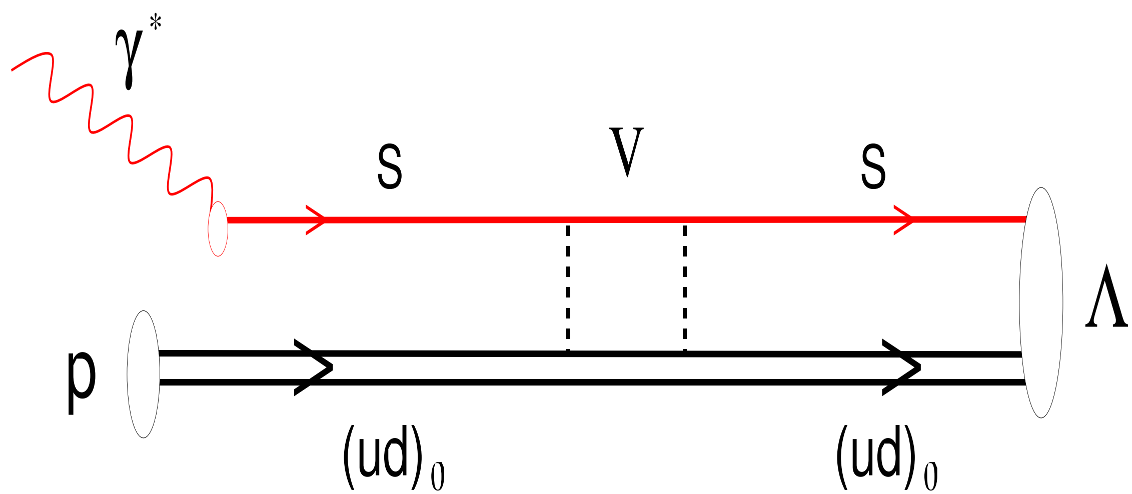
In the current fragmentation region ($x_F > 0$), the Λ kinematic is mostly determined by the strange quark.

Experimental field



We consider the $x_F > 0$ region only.

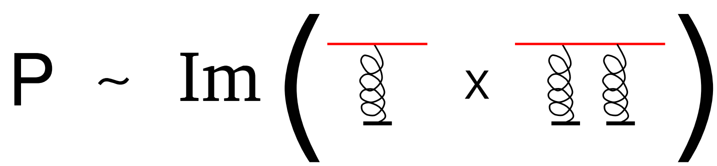
EXPERIMENTAL FIELD



We consider the $x_F > 0$ region only.

Quark Scattering Model

An explanation based on the quark scattering in the color field given by J. Szwed [Phys. Lett., B105(1981)403] has been applied to $K^- p$ by J.M. Gago, R. Vilela Mendes and P. Vaz [Phys. Lett., B183(1987)357].



QSM FOR THE Λ PHOTOPRODUCTION

Since the polarization at HERMES is available versus ζ and p_T, the QSM has been rewritten in terms of the variables

$$\zeta_{i(f)} = \frac{E_{i(f)} + p_{zi(f)}}{E_b + p_{zb}},$$

$$P\left(\frac{\zeta_f}{\zeta_i}, p_T\right) = -\frac{2C\alpha_s V}{1 + V^2\cos^2\theta/2}\,\frac{\sin^3\theta/2\ln(\sin\theta/2)}{\cos\theta/2},$$

$$V = V\left(\frac{\zeta_f}{\zeta_i}, p_T\right), \quad \theta = \theta\left(\frac{\zeta_f}{\zeta_i}, p_T\right)$$

QSM FOR THE Λ PHOTOPRODUCTION

We consider the $\zeta > 0.25$ region only, which presumably relates to the current fragmentation.

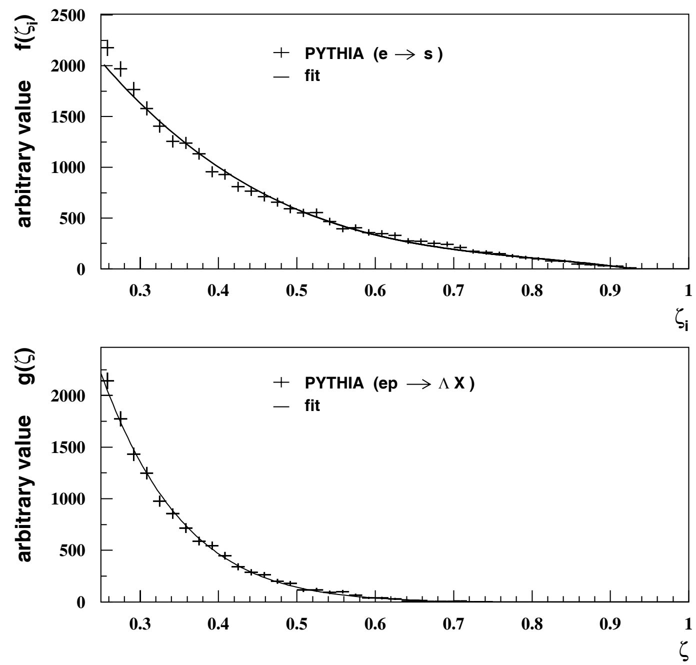
One needs to know the ζ_i as well as the ζ_f distributions.

$$\zeta_f = \frac{m_s}{m_\Lambda}\zeta, \qquad p_T = \frac{m_s}{m_\Lambda}p_T.$$

$$P_\zeta = \int d\zeta_i dp_T \; h(p_T)\, P\left(\frac{\zeta}{\zeta_i}, p_T\right) f(\zeta_i),$$

$$P_{p_T} = \int d\zeta_i d\zeta \; g(\zeta)\, P\left(\frac{\zeta}{\zeta_i}, p_T\right) f(\zeta_i).$$

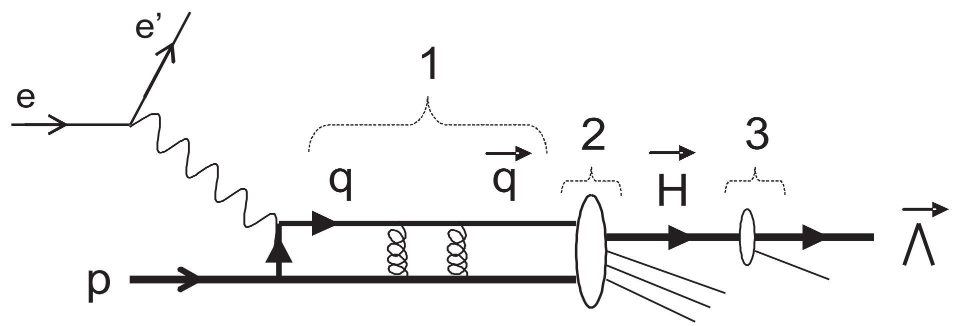
CALCULATIONS



$$h(p_T) \propto \exp\left(-4.2 p_T^2\right), \quad [\text{Acta. Phys. Polon., B33(2002)3785}].$$

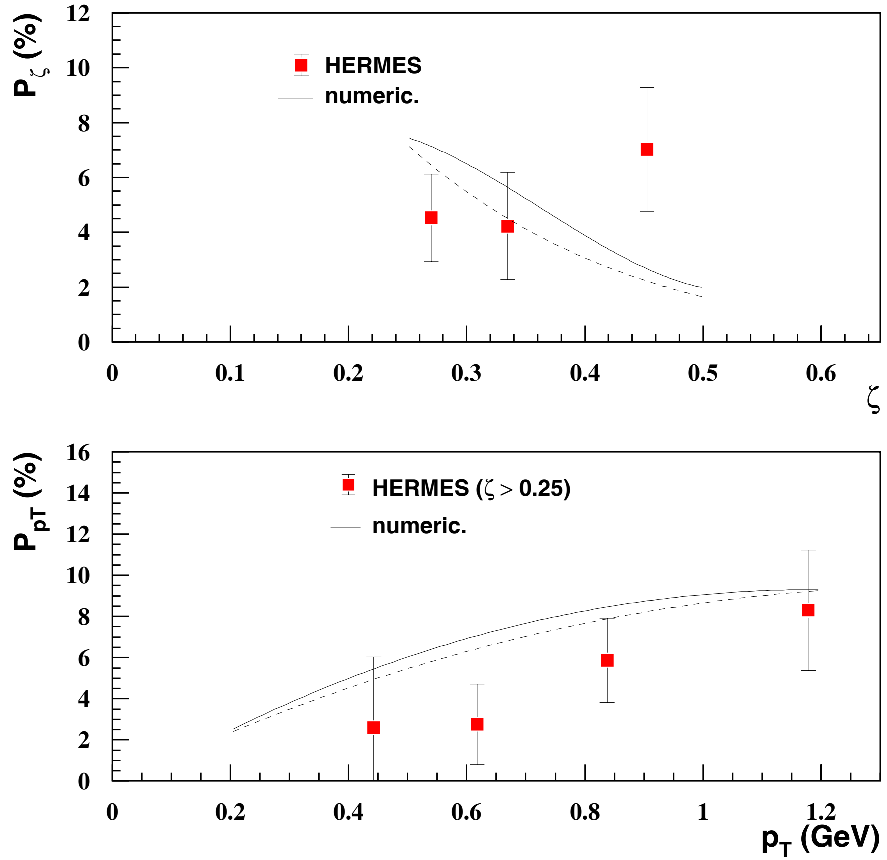
CALCULATIONS

$$m_{u,d} = 0.3 \text{ GeV}, \quad m_s = 0.5 \text{ GeV}, \ 2C\alpha_s = 2.5.$$



H	Decay mode	Fraction (%)
Σ^0	$\Lambda + \gamma$	22.8
Σ^*	$\Lambda + \pi$	23.1
Ξ	$\Lambda + \pi$	5.5

RESULTS



P_ζ (%)
HERMES
numeric.
12
10
8
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
ζ
P_{pT} (%)
HERMES ($\zeta > 0.25$)
numeric.
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
p_T (GeV)

QUARK RECOMBINATION MODEL

Y. Yamamoto, K. Kubo and H. Toki [Prog. Theor. Phys. 98(1997)95].

The polarization is standardly given by

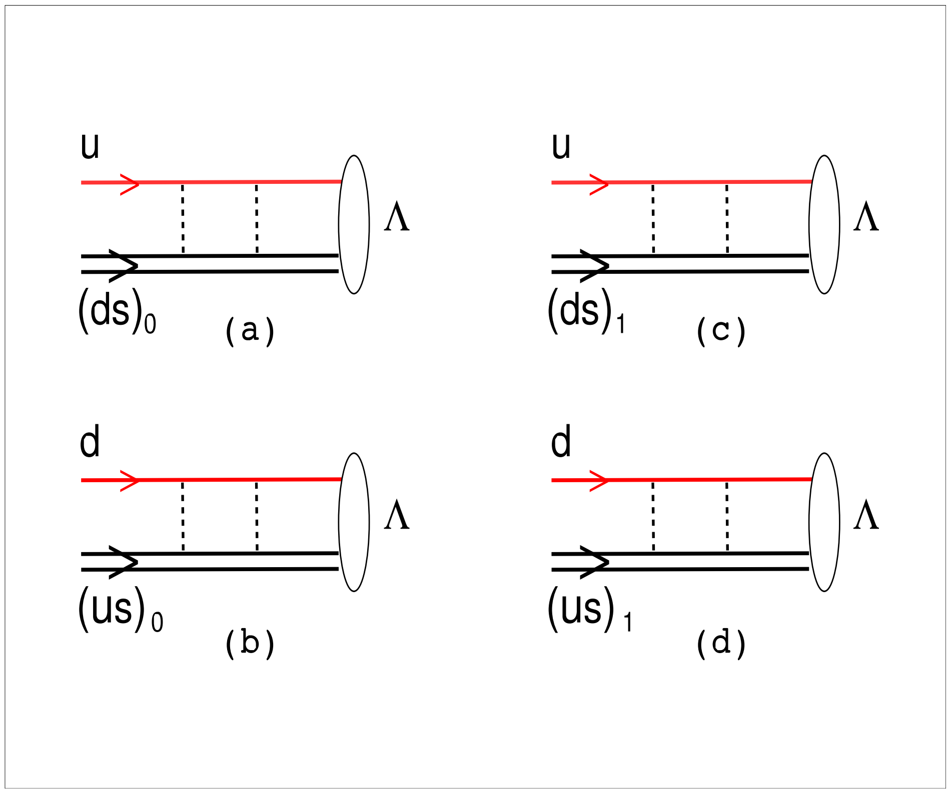
$$P = \frac{\sum\limits_{M_i} |\langle +1/2|S|M_i\rangle|^2 - \sum\limits_{M_i} |\langle -1/2|S|M_i\rangle|^2}{\sum\limits_{M_i} |\langle +1/2|S|M_i\rangle|^2 + \sum\limits_{M_i} |\langle -1/2|S|M_i\rangle|^2}.$$

$$|\langle M_f|S|M_i\rangle|^2 = \sum\!\!\!\!\!\!\!\int \; G^{M_f}(r_f)|M(r_f, r_i)|^2 G^{M_i}(r_i).$$

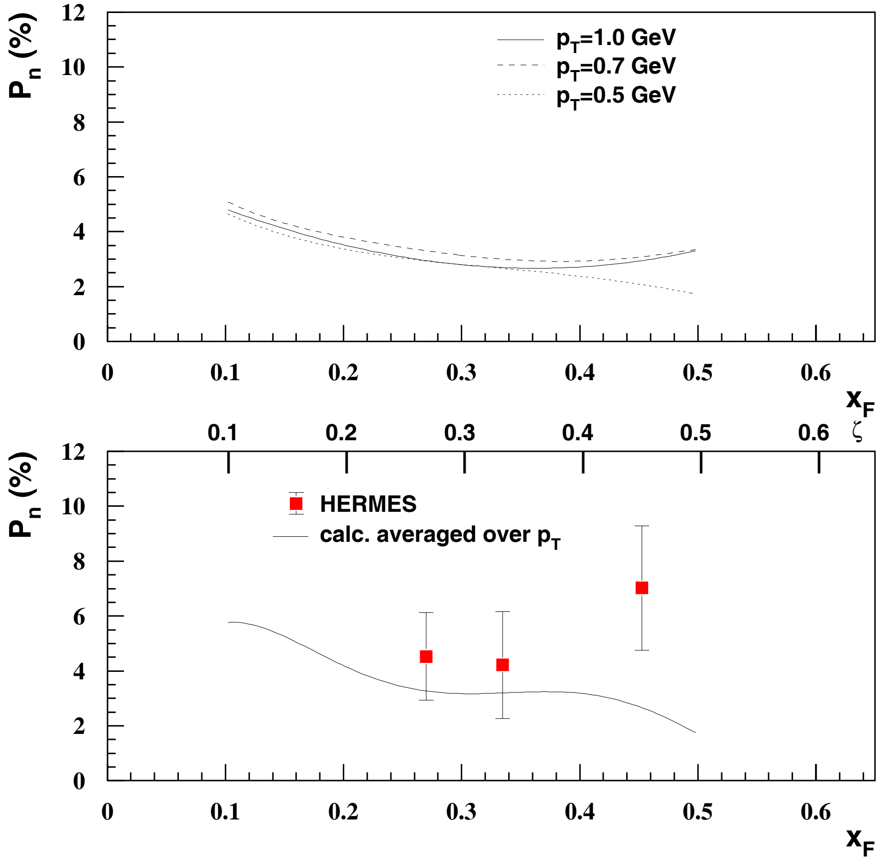
The interaction is assumed to be scalar.

QRM FOR THE Λ PHOTOPRODUCTION

The photoproduction may be fairly expected to be richer with the subprocesses

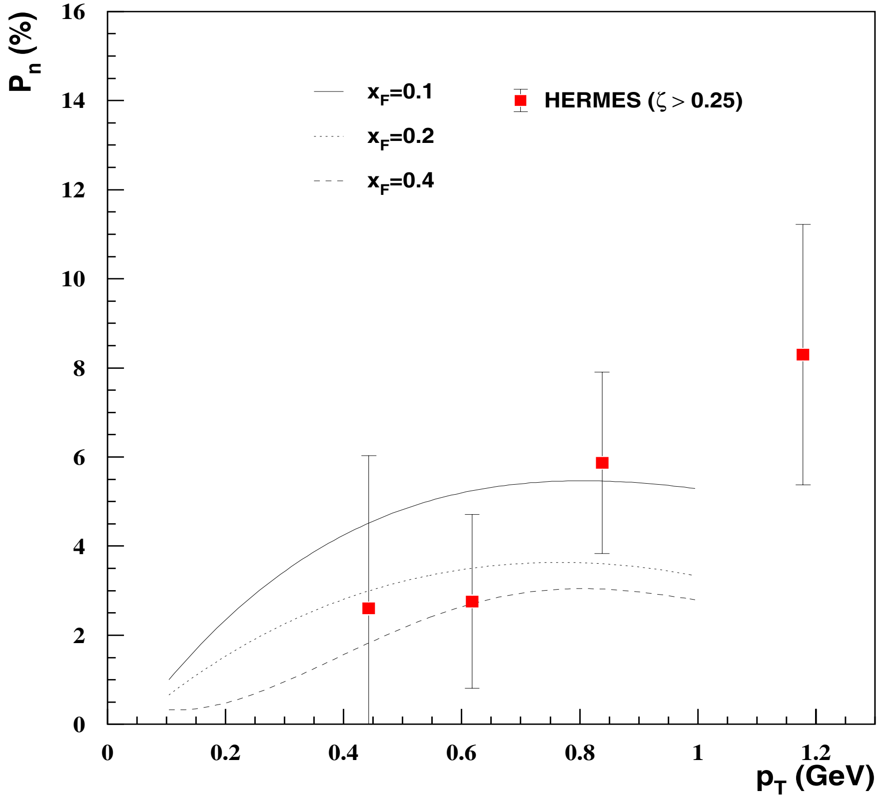


Results



P_n (%)
12
10
8
6
4
2
0
p_T=1.0 GeV
p_T=0.7 GeV
p_T=0.5 GeV
0
0.1
0.2
0.3
0.4
0.5
0.6
x_F
0.1
0.2
0.3
0.4
0.5
0.6
ζ
P_n (%)
12
10
8
6
4
2
0
HERMES
calc. averaged over p_T
0
0.1
0.2
0.3
0.4
0.5
0.6
x_F

RESULTS



P_n (%)
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
p_T (GeV)
x_F=0.1
x_F=0.2
x_F=0.4
HERMES ($\zeta > 0.25$)

Conclusion

- √ The reached reproduction should be regarded only as qualitative
- √ The calculations are based on the SU(6) symmetry, while it is not exact
- √ We used the PYTHIA programm, which gives rather qualitative than quantitative predictions
- √ We assumed the s+$(ud)_0$ to take place only
- √ A large difficulty is the parameter $2C\alpha_s$

Thank You!