Experimental Informations on the Gluon Polarization from Deep Inelastic Scattering

T.-A. Shibata [1]

Tokyo Institute of Technology / RIKEN

Deep inelastic scattering of charged leptons is an effective and well defined method to study the parton structure of the nucleon. Longitudinally polarized lepton beam and targets enable us to measure the spin dependent structure function $g_1(x)$. The EMC result in 1987 showed that only a small fraction of the nucleon spin is carried by the quarks, contrary to the expectation. The analyses showed that up quark is polarized in the same direction with the proton spin while down quark is oppositely polarized. Furthermore, strange quark is also polarized in the direction opposite to the proton spin. This result attracted much attentions and new several experiements were carried out to further study this problem with the proton and neutron targets.

In this talk two topics concerning the gluon polarization are presented. The first one is the polarized gluon distribution function derived by the $g_1(x)$ analysis with DGLAP Q^2 evolution equation. A few groups have studied the polarized parton distribution functions $\Delta u(x), \Delta d(x), \Delta G(x)$ etc. with this method. In view of recently increased data set and to investigate the problems in a systematic way in terms of choice of R-parameter etc., we have set up a program of the DGLAP Q^2 evolution and function parameterization. The result is that the integral of the polarized gluon distribution function $\Delta G(x)$ is positive. However, the size of the error is large.

The second topic is the measurement of $\Delta G(x)$ with charm productions in deep inelastic scattering. The charm production in the deep inelastic scattering goes through the photon-gluon fusion process where a gluon is dissociated to charm and anticharm, and one of them absorbs the virtual photon emitted by the lepton. The open charm, namely D^0 production and decay in the $K\pi$ channel is the cleanest signal. The excited states of D^0 can also be used. Other possibility is a bound charm system J/ψ. J/ψ production is dominated with the color singlet mechanism at small z where z is the energy carried by the hadron divided by the energy of the virtual photon. The asymmetry in J/ψ production at small z can be related to the gluon polarization. On the other hand, at high z, J/ψ production contains the color octet mechanism in which the relation with the gluon polarization is theoretically unclear. HERMES at DESY-HERA and COMPASS at CERN, among other planned experiments, are scheduled to take data of charm productions in the next years.

[1] shibata@nucl.phys.titech.ac.jp

Polarized Parton Distribution Function Working Group at RIKEN

Y. Goto, N. Hayashi, H. Horikawa, M. Hirai, S. Miyama, T. Morii, S. Kumano, N. Saito, T.-A. Shibata, E. Taniguchi

RIKEN, Kobe U, Saga U, TITech

Experimental Data Set

⇓

$\Delta u_v(x, Q^2)$, $\Delta d_v(x, Q^2)$, $\Delta S(x, Q^2)$

$\Delta G(x, Q^2)$

$\begin{pmatrix} \text{electron} \\ \text{muon} \end{pmatrix}$ - nucleon deep inelastic scattering

$$A^{\gamma N} = \frac{\sigma^{\rightleftarrows} - \sigma^{\rightrightarrows}}{\sigma^{\rightleftarrows} + \sigma^{\rightrightarrows}} \quad \propto \quad \frac{g_1(x)}{F_1(x)}$$

$$g_1(x) = \frac{1}{2} \sum_i e_i^2 \left(q_i^{\uparrow}(x) - q_i^{\downarrow}(x)\right)$$

$$= \frac{1}{2} \left[\frac{4}{9}\left(u^{\uparrow}(x) - u^{\downarrow}(x)\right) + \frac{1}{9}\left(d^{\uparrow}(x) - d^{\downarrow}(x)\right) + \frac{1}{9}\left(s^{\uparrow}(x) - s^{\downarrow}(x)\right) \right]$$

: proton

$$\int_0^1 g_1(x)\,dx = \frac{1}{2}\left(\frac{4}{9}\Delta u + \frac{1}{9}\Delta d + \frac{1}{9}\Delta s\right)$$

$$\Delta u \equiv \int_0^1 dx \left(u^{\uparrow}(x) - u^{\downarrow}(x)\right)$$

$$= \frac{1}{12}\left[(\Delta u - \Delta d) + \frac{1}{3}(\Delta u + \Delta d - 2\Delta s) + \frac{4}{3}(\Delta u + \Delta d + \Delta s)\right]$$

$(\Delta u - \Delta d)$ ↑ neutron β-decay

$(\Delta u + \Delta d - 2\Delta s)$ ↑ hyperon decay

$(\Delta u + \Delta d + \Delta s)$ ↓

$$\langle S_z \rangle = \frac{1}{2}(\Delta u + \Delta d + \Delta s)$$

Glück, Reya, Vogt 88
Z. P. C67 (1995)
433

$$\Delta u_v(x, Q_0^2) = \eta_u A_u x^{\alpha_u}(1 + \gamma_u x^{\lambda_u}) u_v(x, Q_0^2)$$

$1\ GeV^2$

$$\Delta d_v(x, Q_0^2) = \quad \vdots$$

$$\Delta \bar{q}(x, Q_0^2) = \quad \vdots$$

$$\Delta g(x, Q_0^2) =$$

16 parameters − 2 $\quad \eta_u \quad 0.918$

$\eta_d \quad -0.339$

DGLAP Evolution Equation couples Quarks and Gluon Distribution Functions

$$\eta_{\bar{q}} = -0.081 \pm 0.003$$

$$\eta_g = 2.00 \pm 1.01$$

from LO

Integral

NLO program is ready

Open Charm

$$D^0 \longrightarrow K^-\pi^+$$
$$\bar{D}^0 \longrightarrow K^+\pi^-$$

2 body decay, all charged

$\pi^\pm$, $K^\pm$ identification

$$D^0, \bar{D}^0 \longrightarrow K \mu X$$

semi leptonic decay

$X = \nu + \cdots$ μ identification

$$D^{*0} \to D^0\pi^0$$
$$\to D^0\gamma$$
$$D^{*+} \to D^0\pi^+$$
$$\to D^+\pi^0$$

γ detection

Bound $c\bar{c}$

J/ψ

low z color singlet model

$$0 < z = \frac{E_{J/\psi}}{\nu} < 1 \qquad \propto \frac{\Delta G(x)}{G(x)}$$

high z color octet model

theoretically uncertain

Conclusions

- Gluon Polarization Measurements with D.I.S. were presented.

- Efforts are being made in order to have a combined view of the spin-dependent **Quark** and **Gluon** distribution functions

- Analyses of g_1 data with DGLAP evolution equation provide a positive integral $\int_0^1 \Delta G(x)dx$ though the error is large

- Open Charm and J/ψ productions are access to Gluon polarization.
  HERMES and COMPASS plan to measure.
  Theoretical clarifications are needed.