The present status of our knowledge of the polarized parton densities, or, why we need a neutrino factory.

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Abstract. The importance of a neutrino factory for the determination of the polarized parton densities is emphasized.

1. NC polarized DIS: $l^{\pm}p \longrightarrow l^{\pm}X$

There are two measurable asymmetries:

$$A_{//} = \frac{d\sigma^{\rightrightarrows} - d\sigma^{\rightleftarrows}}{2d\sigma_{unpold}} \qquad\qquad A_{\perp} = \frac{d\sigma^{\rightarrow\uparrow} - d\sigma^{\rightarrow\downarrow}}{2d\sigma_{unpold}} \tag{1}$$

which are linear combinations of the scaling functions $g_{1,2}$. Information on the polarized parton densities $\Delta q(x, Q^2)$ comes from $g_1(x, Q^2)$:

$$\frac{g_1}{F_1} = \frac{1}{d'} \quad [A_{//} + tan(\theta/2)A_{\perp}] \tag{2}$$

where d' is a kinematical factor. There is not much data on $A_{\perp}$, but this is unimportant for the determination of the $\Delta q(x)$.

2. Present state of the data

After decades of work, the quality of the data is now superb.

BUT

a) There is no CC (neutrino) data. b) The range of Q^2 is small compared to the unpolarized case.

Consequently:

a) The flavour separation is poor. We have no knowledge at all about the light antiquarks. b) The polarized gluon $\Delta G(x)$ is poorly determined.

3. Problems in the analysis of the data

Instead of $\Delta u, \Delta d \cdots$ etc. it is convenient to introduce the flavour combinations:

$$\begin{aligned} \Delta q_3 &= (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d}) \\ \Delta q_8 &= (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) - 2(\Delta s + \Delta\bar{s}) \quad (3) \\ \Delta\Sigma = flavoursinglet &= (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) + (\Delta s + \Delta\bar{s}) \end{aligned}$$

Since Δq_3 changes sign when going from neutron to proton,it is determined by the difference of n and p data, but the separation of Δq_8 from $\Delta\Sigma$ and ΔG depends entirely on evolution. Moreover, manifestly, there is no separate information about the light quark sea.

To help one usually imposes:
a)The Bjorken sum rule

$$\int_0^1 \Delta q_3(x, Q^2)dx = \frac{G_A}{G_V}[1 + \cdots] \tag{4}$$

b) The connection to the Cabbibo theory of weak interactions

$$a_8 \equiv \int_0^1 \Delta q_8(x, Q^2)dx = 3F - D. \tag{5}$$

where the RHS is known from an $SU(3)_{flavour}$ analysis of hyperon $\beta - decay$.

How well are the polarized densities known? The results of three different analyses (see Fig.1) [1] show that Δu_V and Δ_{d_V}, in a convention where $\Delta\bar{u} = \Delta\bar{d} = \Delta\bar{s}$, are well determined. $\Delta s + \Delta\bar{s}$ is fairly well known and ΔG rather poorly, though the first moment of ΔG is significantly positive.

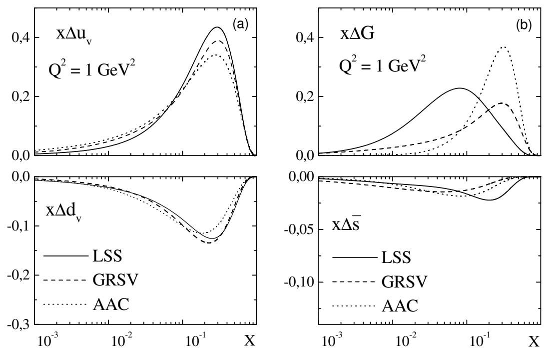

Figure 1. Results of three different analyses of the polarized DIS data. For curves see [1].

HOWEVER

many papers question the use of exact $SU(3)$ symmetry in hyperon $\beta - decay$. We have therefore studied the sensitivity of the densities to the value for a_8 [2], using $a_8 = 0.40, \quad 0.58 \quad (= 3F - D), \quad 0.86$, where the first and last are the extreme values found in the literature, and are probably too pessimistic. Fig.2 show that $\Delta s + \Delta\bar{s}$ and ΔG are highly sensitive !

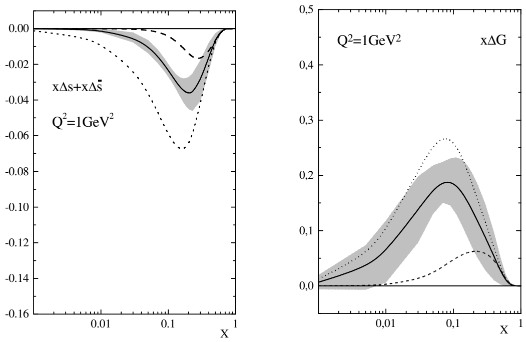

Figure 2. NLO polarized parton densities $x(\Delta s + \Delta\bar{s})$ and $x\Delta G$ at $Q^2 = 1\ GeV^2$ (JET scheme). The solid, short-dashed and long-dashed curves correspond to the values 0.58 (SU(3) limit), 0.86 and 0.40 for the axial charge a_8, respectively. The error band shown refers to the SU(3) case and takes into account the statistical and systematic uncertainties.

4. Conclusions

The superb polarized DIS data yield well determined $\Delta u + \Delta\bar{u}$ and $\Delta d + \Delta\bar{d}$. If we accept $a_8 = 3F - D$ then $\Delta s + \Delta\bar{s}$ is fairly well fixed and ΔG is not too bad, and the first moment of G is positive. However, if we mistrust $a_8 = 3F - D$ then both strange and gluon densities are poorly determined. Moreover, we have, in any case, absolutely no information on $\Delta\bar{u}$ and $\Delta\bar{d}$. Data from a neutrino factory would be invaluable in finally determining the polarized densities !

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References

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