Re-evaluation of the Parton Distributions of Strange Quarks in the Nucleon

Uses the final HERMES kaon Multiplicities from SIDIS

[A. Airapetian et al., Phys. Rev. D (in press)]

H. E. Jackson - DIS 2013
Measurement of parton distributions of strange quarks in the nucleon from charged-kaon production in deep-inelastic scattering on the deuteron

HERMES Collaboration

ABSTRACT

The momentum and helicity density distributions of the strange quark sea in the nucleon are obtained in leading order from charged-kaon production in deep-inelastic scattering on the deuteron. The distributions are extracted from spin-averaged \( K^\pm \) multiplicities, and from \( K^\pm \) and inclusive double-spin asymmetries for scattering of polarized positrons by a polarized deuterium target. The shape of the momentum distribution is softer than that of the average of the \( u \) and \( d \) quarks. In the region of measurement \( 0.02 < x < 0.6 \) and \( Q^2 > 1.0 \text{ GeV}^2 \), the helicity distribution is zero within experimental uncertainties.
The strange sea: $S(x)$ from $K^\pm$ multiplicities

\[
\frac{dN^{K^\pm}}{dN^{\text{DIS}}} = \frac{Q(x) \int D_Q^K(z) dz + S(x) \int D_S^K(z) dz}{5 Q(x) + 2 S(x)} \quad x > 0.3 \quad \Rightarrow \quad \int D_Q^K(z) dz = \frac{5}{5} \int D_S^K(z) dz
\]

For the isoscalar deuteron:

$S(x)$ from CTEQ6L with $\int D_Q^K(z)dz$ & $\int D_S^K(z)dz$ as free parameters (dotted) does not fit the data

$S(x)$ much softer than assumed by current PDFs (mainly based on $(\bar{\nu}N \rightarrow \mu^+\mu^-X)$

Take $\int D_S^K(z)dz = 1.27 \pm 0.13$ from de Florian et al.
Signal for $S(x)=0$ at LO

In leading order:

$$M^K_{\pm}(x) \equiv \frac{d^2N^K(x)}{d^2N^{DIS}(x)} = \int f(x)$$

where $f(x) = S(x)/Q(x) \ll 1$.

$$5M^K_{\pm}(x) = \left[ \int D^K_Q(z)dz + f(x) \right]$$

$$\frac{d5M^K_{\pm}(x)}{dx} = \frac{df(x)}{dx} \left[ 1 - \frac{4}{5}f(x) \right]$$

$dM(x)/dx < 0$ if $S(x) \neq 0$

Signature for $S(x)=0 \rightarrow dM(x)/dx \geq 0$
Fit of $Q(x)$ component to $M(x) = p[0] + p[1]x_{bj}$

$M(x) = (0.102 \pm 0.002) + (0.013 \pm 0.010)x$
Revised fit to kaon charged multiplicity

![Graph of dN^K/dN^Dis and Q^2 GeV^2 vs. x]
Fit to Component arising from
\[ S(x) \int D^K(z) dz = x^{-a} e^{-x/b} (1-x) \]

HERMES Preliminary
\[ f(x) = x^{-0.833} e^{-x/0.0337} (1-x) \]
Strange parton distribution $S(x)$ - revised

Fit:\[ xS(x) \]

\[ \text{Fit}(x) = x^{-0.867\pm0.019}e^{-0.331\pm0.014}(1-x) \]

HERMES Preliminary with $\int D_S(z,Q^2)dz=1.27$

$\langle Q^2 \rangle=2.5\text{GeV}^2$
Comparison with prediction of the NNPDF Collaboration

\[ \Delta \text{HERMES Preliminary with } \int D_s(z, Q^2)dz = 1.27 \]
\[ \langle Q^2 \rangle = 2.5 \text{GeV}^2 \]
Summary

- $S(x) \approx 0$ with the measurement error for $x \geq 0.15$, as reported in PLB666, 446 (2008).
- $S(x)$ is similar in shape but $\approx 0.6$ in magnitude of the data reported in 2008.
- In magnitude, but not detailed shape, $S(x)$ as extracted here is close to the recent predictions of the NNPDF collaboration (NPB 855, 153 (2012).

The shape of $S(x)$ suggests the possibility that the strange quark pdf may be a surrogate for a sea dominated by the gluon splitting component (see Chang & Peng, PLB 704, 197 (2011).
Extra’s
Comparison PLB666 with HERMES (2013)