Dennis SIVERS

Portland Physics Institute

BREMSSTRAHLUNG MODEL FOR GLUON POLARIZATION

There are several "models" for the spin-weighted gluon density, $\Delta G(x,t)$. However, it is worthwhile to present here another approach to modelling this distribution because the arguments involved are instructive on a couple of levels. This dynamic approach takes seriously the results of the nonrelativistic quark model for the hadronic spectrum and addresses the question of how these results constrain parton spin densities at low values of Q^2. It also explicitly embodies the constituent-counting rule predictions at large x.

The model is defined by taking as input the Q^2 stability of the gluon polarization asymmetry,

$$\partial/\partial t\,(A^\circ(x,t)) = 0 \qquad \text{where} \quad A(x,t) = \Delta G(x,t)/G(x,t)$$

and assuming that this stability holds in a region where the Altarelli-Parisi evolution equations are valid. The shape of the Q^2 independent asymmetry, $A^\circ(x)$, is determined by the "measured" distributions , $q(x,t)$, $\Delta q(x,t)$ and $G(x,t)$.

$$A^\circ(x) = \frac{\Delta P_{Gq}\otimes \Delta q + \Delta P_{GG}\otimes (A^\circ(x)\cdot G)}{P_{Gq}\otimes q + P_{GG}\otimes G}$$

We call this a Bremsstrahlung model because, at large x, it is equivalent to the assumption that intrinsic gluonic degrees of freedom are absent so that gluons are "radiated" from valence quarks. It extends the Close-Sivers perturbative Bremsstrahlung model to other values of x with a minimum of additional dynamical assumptions. The model can be solved recursively by Newton's method

$$A^\circ_1(x) = \frac{\Delta P_{Gq}\otimes \Delta q}{P_{Gq}\otimes q} \qquad A^\circ_n(x) = \frac{\Delta P_{Gq}\otimes \Delta q + (A^\circ_{n-1}\cdot G)\otimes P_{GG}}{P_{Gq}\otimes q + P_{GG}\otimes G}$$

At low x where gluon densities dominate the requirement of Q^2 independence for the asymmetry corresponds to self-similarity of the fractal structure of the branching in terms of spin content. It therefore provides a "natural" extrapolation to small x.

Partons Revisited

Proton structure

Picture of proton at rest clouded by relativistic motion of constituents

transverse motion of constituents "slowed" by Lorentz contraction

If we want to take a snapshot of the proton it helps to look in infinite momentum frame

This is the start of the parton model

II. The non-relativistic quark model

By any objective measure. one of the most successful approaches to hadron spin structure (H. Lipkin + ... + N. Isgur...

The spin & flavor degrees of freedom of low-lying hadrons are well-described by the restricted basis

$Q_i \bar{Q}_j$ {mesons}

$Q_i Q_j Q_k$ {baryons}

P. Geiger & N. Isgur (PR D55, 299, 1977)

"The first major degree-of-freedom problem is the absence of any sign of gluon-degrees of freedom in the low-lying spectrum".

III. Brems. Model & Condition

$$\partial/\partial(\ln Q^2)\left[\Delta G/G\right] = 0$$

The approximate stability of the quark asymmetry

$$A_q = \Delta q/q$$

with Q^2 variation and the absence of any gluon structure in spectrum suggests that

$$\partial/\partial\ln(Q^2)\left[\Delta G/G\right] = \frac{G\Delta G' - \Delta G G'}{G^2} = 0$$

Spin Stability

$$G\{\Delta G' - a_G G'\} = 0$$

$$a_G^0 = \frac{\Delta G'}{G'}$$

DGLAP evolution equations

$$A_G^0(x) = \frac{\Delta P_{Gq} \otimes \Delta q + \Delta P_{GG} \otimes (a_G \cdot G)}{P_{GG} \otimes q + P_{GG} \otimes G}$$

this nonlinear equation can be solved for $a^{o}_{G}(x)$ given parameterization of

$$q(x,Q^2) = u(x,Q^2) + d(x,Q^2) + s(x,Q^2)$$

$$\Delta q(x,Q^2) = \Delta u(x,Q^2) + \Delta d(x,Q^2) + \Delta s(x,Q^2)$$

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

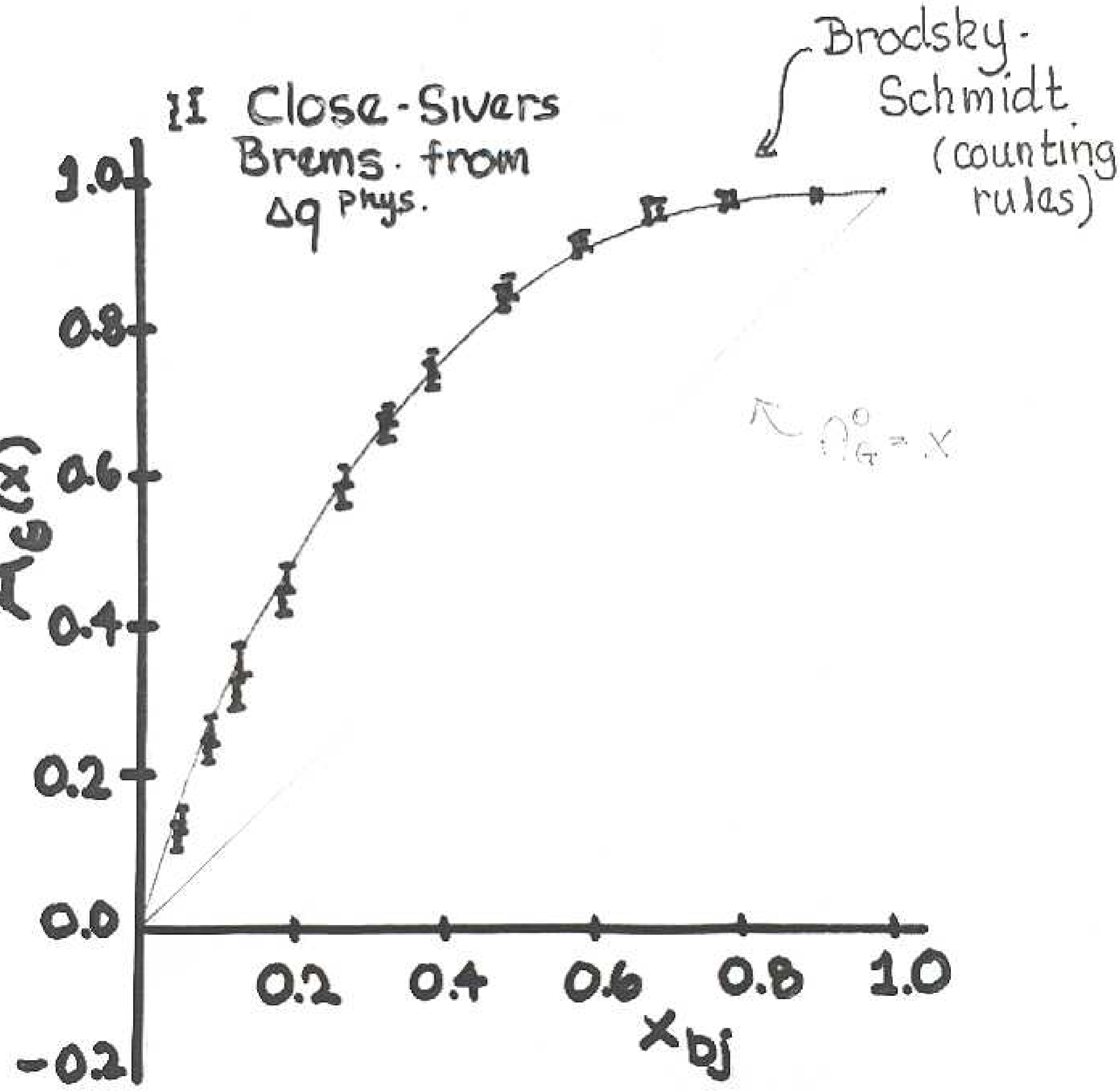
$$a^{o(1)}(x) = \frac{\Delta P_{Gq} \otimes \Delta q}{P_{Gq} \otimes q}$$

$$a^{o(n)}(x) = \frac{\Delta P_{Gq} \otimes \Delta q + \Delta P_{GG} \otimes (a^{o(n-1)}\, G)}{P_{Gq} \otimes q + P_{GG} \otimes G}$$

newton's meth.

convolutión

$$C(x) = A \otimes B = \int_x^1 dy\, A(y)\, B(x/y)$$



Brodsky-Schmidt (counting rules)
Close-Sivers Brems. from Δq phys.
A°G(x)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0.2
0.4
0.6
0.8
1.0
xbj
A°G = x

for the quark paramoterizations studied so far

$$A_G^{\text{Close-Sivers}}(x, Q_0^2 \simeq 2) \cong A_G^{\text{Brodsky-Schmidt}}(x)$$

$$x \geq 0.1$$

brems   intrinsic

The low-Q^2 asymmetry insensitive to the relative amounts of intrinsic vs. radiated gluons for $x \geq 0.1$

The difference between our model & Brodsky Schmidt parameterization comparable to experimental errors on planned experiments

$\Delta G/G \simeq .05$ "future" plans

This is still incomplete since integrals have only been done with "leading-order" ΔP, P ... & no attention paid to quark factorization prescription & NLC parameterizations

$$\langle \Delta G \rangle \big|_{Q_0^2 = 4} \cong 0.8 \pm 0.2$$