Success and perspectives of parton distributions inspired by quantum statistics.

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This work began many years agon together with :

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After many years of research in 2002 (BBS) the quantum statistical parton distributions have been proposed to account for these experimental facts

1) the inequality d bar > u bar in the proton sea, advocated as a consequence of Pauli principle many years ago by Niegawa, Sisiki, Feynman and Field, confirmed by the defect in the Gottfried sum rule and by the asymmetry in Drell Yan mu+ mu- production in pp and pn

2) The increasing width x of A1p(x) and the x dependence of g1n(x), negative at small x and positive at high x

3) the dramatic fall at high x of the ratio F2n(x) /F2p(x) and of all the structure functions

- These fact motivated the choice of Fermi Dirac functions for the partons responsible for the non-diffractive part of deep inelastic scattering at Q0^2= 4 Gev^2

$$xq^{\uparrow}(x) = \frac{Ax^{b}\tilde{x}(q^{\uparrow})}{e^{\frac{x-\tilde{x}(q^{\uparrow})}{\bar{x}}}+1}$$

$$x\bar{q}^{\downarrow}(x) = \frac{\bar{A}x^{2b}\frac{1}{\tilde{x}(q^{\uparrow})}}{e^{\frac{x+\tilde{x}(q^{\uparrow})}{\bar{x}}}+1}$$

- The factors xbar^4_0q in the numerators may be accounted by the extension to the transverse degrees of freedom and A x^b and Abar x^2b are weigth functions

The guess for the diffractive part is a Fermi-Dirac expression with vanishing potential

For the chromomagnetic field

$$xG(x) = \frac{A_G \, x^{b_G}}{e^{\frac{x}{\bar{x}}} - 1}$$

$$xp(x) = \frac{\tilde{A} x^{b_G - 1}}{e^{\frac{x}{\bar{x}}} + 1}$$

the vanishing of the gluon potential and the opposite signs of Xq ↑ and Xqbar(↓) are dictated by the demand of equilibrium with respect to the QCD elemntary processes:

$q^{\uparrow(\downarrow)} \rightarrow q^{\uparrow(\downarrow)} + G^{\uparrow}\ (G^{\downarrow})$

$G^{\uparrow}\ (G^{\downarrow}) \rightarrow q^{\uparrow(\downarrow)} + qbar^{\downarrow(\uparrow)}$

With the following values questa for the parameters:

.461	.302	.298	.228	for the potenzials of
u↑	d↓	u↓	d↑	and .1 per xbar

And the esponents: b=.4 2b=.8 e bG= -.25

A=1.75, Abar = 1.91 and Ag=14.3

$\hat{\lambda}$

We have faced successfully the comparison with following experiments

It is instructive the comparison of fig 23 of our 2005 paper Eur Phys J C 41 327 (2005) with MRST and CTEQ, which shows

the same x > or equal .2 for d and x > or equal .4 for u behaviour (for us it comes from the Boltzmann behaviour in the small degeneracy limit),

smaller x d(x) and x u(x) at intermediate x for ours and higher at small x.

As long as for the gluons, the 3 descriptions coincide for x > or equal 0.05 (again the exponential behaviour predicted in the small degeneracy limit), while at small x our distribution is larger.

Of course a better agreement may be obtained by changing the exponent for the low x behaviour, as it has already been done by (BS) for the gluons, getting good agreement with H1

Conclusions

The successful aspects of our approach, the description of the shapes of the valence partons in terms of Fermi Dirac functions (apart a common power behaviour), the relations with non-diffractive qbar contribution, which implies

dbar > ubar

Positive Delta ubar

Negative Delta dbar

Delta ubar – Delta dbar > or equal dbar –ubar

Even the simple guesses for the gluons and the diffractive part, are promising to consider the statistical inspired parton distributions.

Conclusions

Of course one should, if necessary, up-to-date the parameters (f.i. the factor 2 in the exponents of qbar and q, 2 b and b, is empirical) as well as the power assumption for the weight function (anyway the brilliant description of shapes of the Fermi-Dirac functions may not require this modification)

Finally the "valence" qbar description might be modified by the extension to the transverse degree of freedom, keeping the qualitative properties just described.