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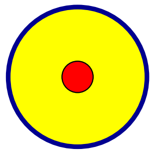
# Transversity in hard scattering of polarized protons and antiprotons in PAX

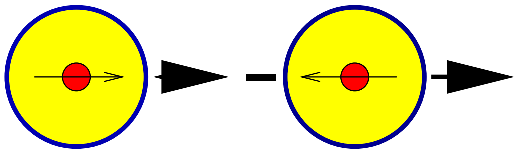
1. Some introduction
2. Chiral quark-soliton model prediction for $h_1^a(x)$
3. Predictions for PAX

# Short Introduction

There are three main (twist-2) parton characteristics of a hadron.



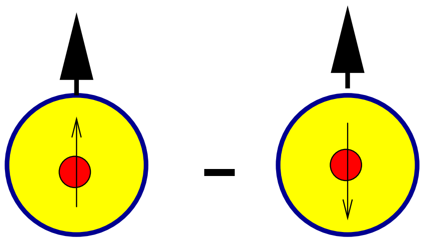
- Non-polarized PDF $f_1^a(x, Q^2)$.
  - — Measured for decades. Rather well known.
  - — $Q^2$-evolution, $\alpha_s(Q^2)$ extraction
  - — Problem of very small $x$ behavior (bare Pomeron, BFKL-equation)



- Longitudinal spin distribution.

$$\Delta f^a \equiv f_{\rightarrow}^{a\rightarrow} - f_{\rightarrow}^{a\leftarrow} \equiv g_1^a(x, Q^2) \ .$$

  - — Parton content of proton spin. Main problem $\Delta G$. Dedicated experiments (e.g. COMPASS, RHIC).
  - — Sea spin flavour asymmetry. $\Delta\bar{u} \approx -\Delta\bar{d}$ in $\chi QSM$



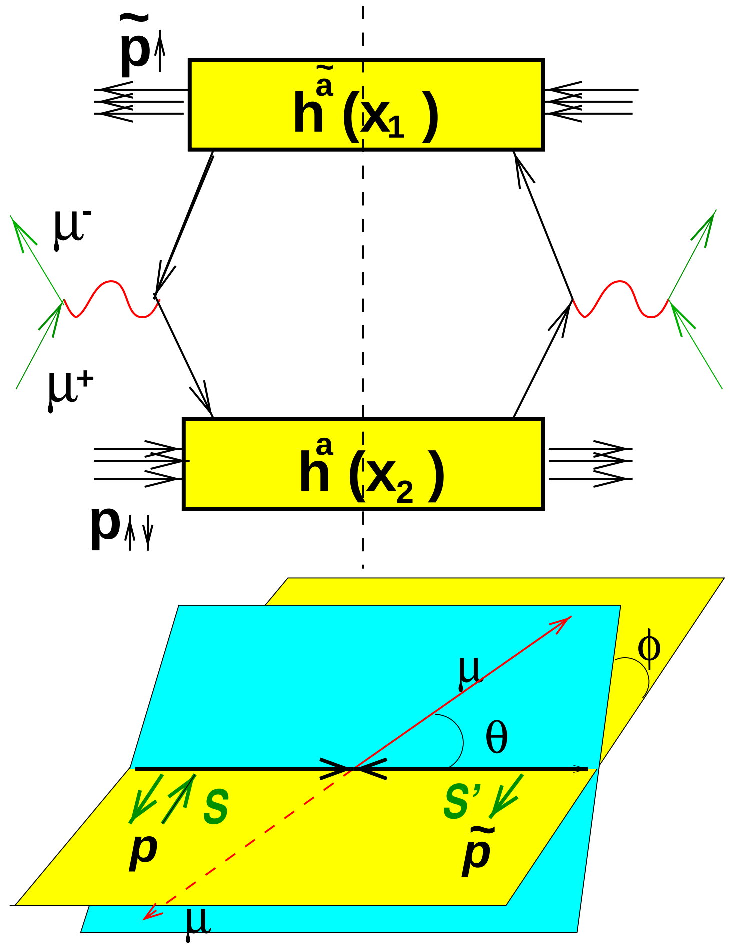
*Polyakov, Pobylitsa, hep/ph/0004094*

- Transverse spin distribution.

$$\delta f^a \equiv f_{\uparrow}^{a\uparrow} - f_{\uparrow}^{a\downarrow} \equiv h_1^a(x, Q^2)$$

  - — Not measured in DIS ($\chi$-odd).
  - — Density matrix positivity, Soffer inequality $|h_1(x)| \leq \frac{1}{2}[f_1(x) + g_1(x)]$ or $2|h_1(x)| \leq \frac{1}{3}f_1(x) + g_1(x)$ (large $N_c$).

- Drell-Yan process is cleanest and safest way to access $h_1^a(x)$.
- Planned at RHIC but access of is very difficult ($h_1^{\bar{a}}$ is very small).
- Can be circumvented by using an antiproton beam. Recently suggested in PAX at GSI
- We shall make quantitative estimates for $A_{TT}$ in kinematics of PAX using predictions from the chiral quark soliton model.




## Asymmetry

$$\frac{N^{\uparrow\uparrow} - N^{\uparrow\downarrow}}{N^{\uparrow\uparrow} + N^{\uparrow\downarrow}} = D_S \frac{\sin^2\theta}{1+\cos^2\theta} \cos 2\phi \, A_{TT}(y,Q^2) \, ,$$

$$A_{TT}(y,Q^2) = \frac{\Sigma_a e_a^2 h_1^a(x_1,Q^2) h_1^a(x_2,Q^2)}{\Sigma_b e_b^2 f_1^b(x_1,Q^2) f_1^b(x_2,Q^2)} \, , \quad x_{1/2} = \sqrt{\frac{Q^2}{s}} e^{\pm y} \, .$$

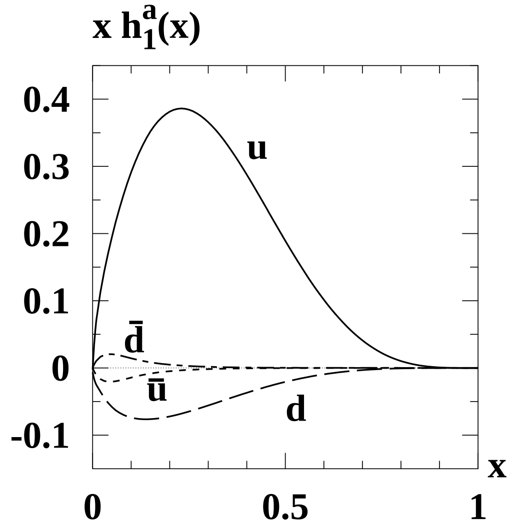
# Chiral quark-soliton model prediction for $h_1^a(x)$

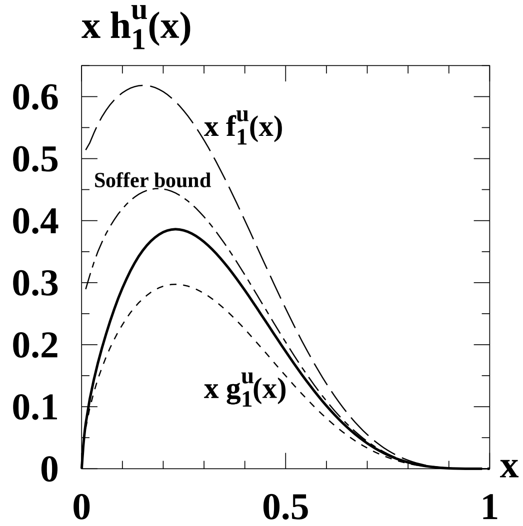
*e.g. Diakonov, Prog.Part.Nucl. Phys.* **51** *(03)173*

*Pobylitsa, Polyakov at al, PL*B**389***(96); PR*D**59***(99)034024*

*Schweitzer at al. PR*D**64***(01)034013*

- Derived from instanton model of QCD vacuum.
- Describes numerous nucleonic properties without adjustable parameters to within $(10-30)\%$ accuracy.
- Good ($\approx 20\%$) describes non-polarized and longitudinal spin PDF's.
- Satisfies all general QCD requirements.
- Obey hierarchy $h_1^u(x) \gg |h_1^d(x)| \gg |h_1^{\bar{u}}(x)|$, and "maximal sea flavour asymmetry" $h_1^{\bar{d}}(x) \approx -h_1^{\bar{u}}(x) > 0$.
- Soffer bound $|h_1^u(x)| \leq (f_1^u + g_1^u)(x)/2$ is nearly saturated.

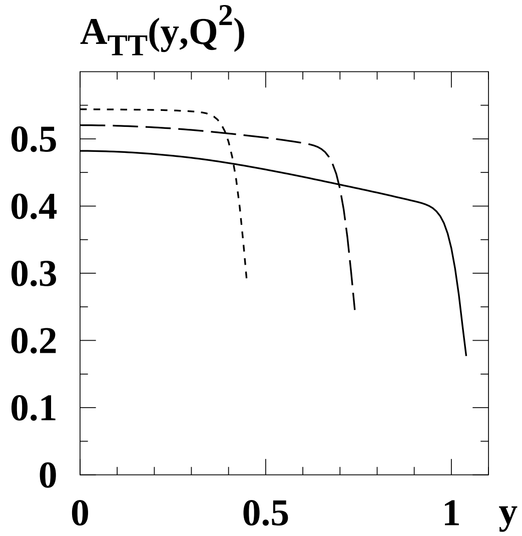


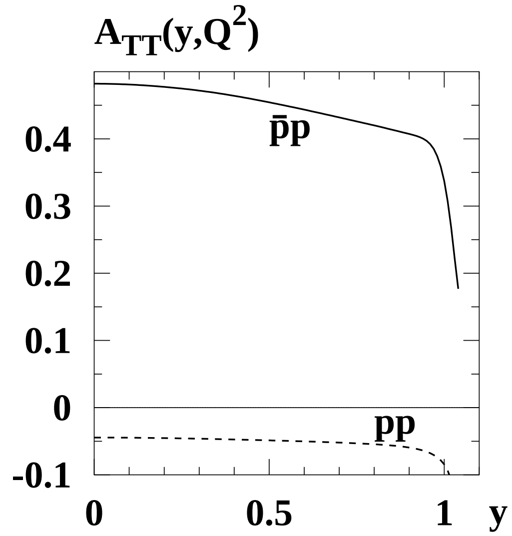



# Predictions for PAX

PAX (GSI): $(p \uparrow + \bar{p} \downarrow \to \mu^+\mu^- + X,\ E_{\bar{p}} = 15 \div 25\, GeV,\ )$ Region $1.5\,\mathrm{GeV} < Q < 3\,\mathrm{GeV}$ the most preferable (counting rate)
With $h_1^a(x)$ from chiral-quark soliton model

*A.E., Goeke, Schweitzer EPJC35:207(04)*




- $p\bar{p}$ is an order of magnitude larger than $pp$. Partially compensated by smaller $\bar{p}$ polarization ($(5-10)\%$), but counting rates is much higher.
- Explorable rapidity range shrinks with $Q^2$. For $s = 45\,\mathrm{GeV}^2$ and $Q^2 = 5\,\mathrm{GeV}^2$ ($16\,\mathrm{GeV}^2$) one probes $x > 0.3$ ($x > 0.5$).
- Mostly sensitive to $h_1^u(x)$.
- Allow discriminate different models (e.g. popular guess $h_1^a(x) \approx g_1^a(x)$ would give $A_{TT} \approx 30\%$)

*Anselmino, at al. hep/ph/0403114*