TMDs studies with RF-separated beams

November 7 2017

Oleg Teryaev

JINR, Dubna

TMDs /beams

- TMDs of various (unpolarized) hadrons
- ----//----- of valence antiquarks
- Universality of TMDs of (polarized) target
- Flavour separation

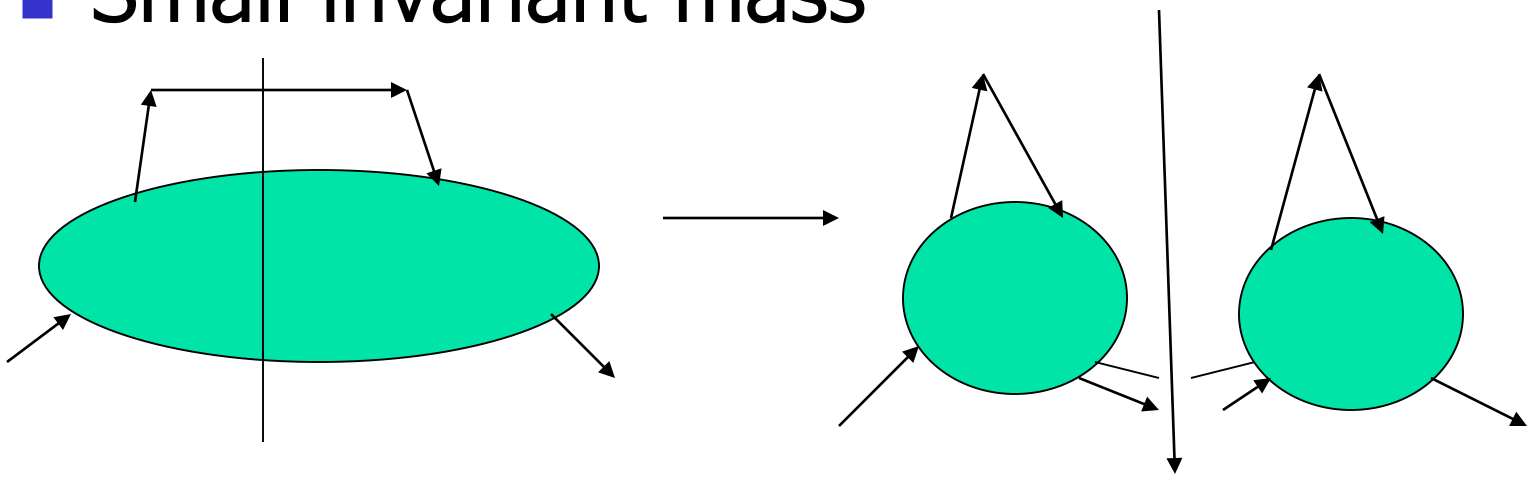
TMDs vs GPDs

- Theoretically: Sivers f(x)~L(x)E(x)–Lensing function
- Σ <x E(x)>=0 -> Ji’s SR’s (=Equivalence principle: AGM=0; Kobzarev, Okun’62)
- Σ <x f(x)>= 0 –Burkardt SR
- Conjecture(OT’06):<x f(x)>~<x E(x)>
- L(x)??

- TMDs vs FFs?
- Large x?!

Exclusive limit : DIS and space-like (transitional and elastic) FFs

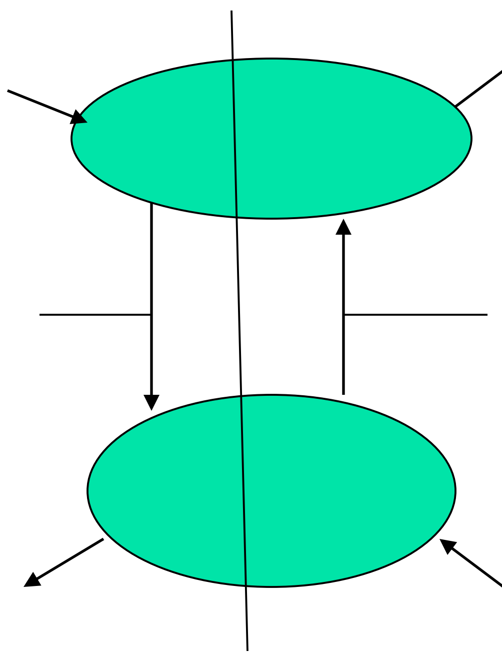
- Small invariant mass

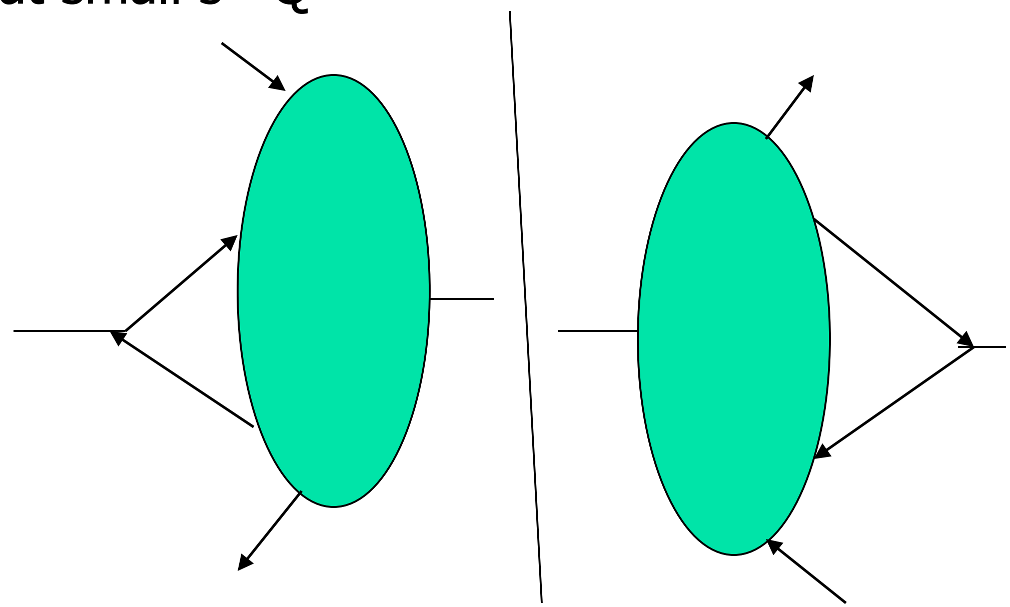


- BG duality and DYW relation
- Relation between x ->1 and large Q^2
- pdf ~ $(FF)^2$

Exclusive limit of DY and time-like FFs (OT'14)

- (Proton-antiproton) DY at small s - Q^2





(pdf)^2~ (Dirac) (FF)^2

- Other beams – baryon number conservation – time-like transition FFs

Comparing space-like and time-like FFs

- "Duality intervals" - from mass to x-space
- DIS: $(P+q)^2 = (P_f + \delta P_{DIS}))^2 = (M + \mu_{DIS})^2$ μ_{DIS} ~ pion related scale
- Deviation of $x_B(\equiv 1 - \delta_{DIS})$ from 1

$$\delta_{DIS} \sim 2M\mu_{DIS}/Q^2.$$

- DY: $(P_1 + P_2)^2 = (q + \delta P_{DY})^2$
- Deviation of $\tau = Q^2/s(\equiv 1 - \delta_{DY})$ from 1

$$\delta_{DY} \sim 2\mu_{DY}/Q$$

DR: FFs from duality intervals

- DIS: $$F^2_{SL} \sim \int_0^{\delta_{DIS}} d\bar{x} f(\bar{x}) \quad x = 1 - \bar{x}$$

- DY: $$F^2_{TL} \sim \int_0^{\delta_{DY}} d\bar{x}_1 d\bar{x}_2 f(\bar{x}_1) f(\bar{x}_2) \delta(\delta_{DY} - \bar{x}_1 - \bar{x}_2)$$
- Proton-antiproton DY –same parton distributions $f(\bar{x}) = C\bar{x}^a$

$$F^2_{SL}(Q^2) \sim \frac{C}{a+1}\left(\frac{2M\mu_{DIS}}{Q^2}\right)^{a+1} ; \; F^2_{TL}(Q^2) \sim \frac{C^2}{2(a+1)}\left(\frac{4\mu^2_{DY}}{Q^2}\right)^{a+1}$$

- Pion: a=1 ('effective' pdf) supported !

SL vs TL

- Same Q-dependence
- Normalization –defined by distribution scale (~5) and duality intervals
- Asymptotically coincide – scales close to QCDSR pion duality interval (rather than pion mass) similar (equal?!) for DIS and DY)!?

Sivers function and formfactors

- Relation between Sivers function and AMM known on the level of matrix elements (Brodsky, Schmidt, Burkardt)
- Phase?
- Duality for observables?

BG/DYW type duality for DY SSA in exclusive limit

- Proton-antiproton DY – valence annihilation – analyticity - cross section is described by Dirac FF squared
- The SSA similar to Sivers one- due to interference of Dirac and Pauli FF's with a phase shift (Rekalo,Brodsky)
- Exclusive large energy limit; x -> 1 : f(x)/q(x) -> Im F2/F1($Q^2 \sim M^2(1-x)$)
- Both directions – estimate of Sivers at large x and explanation of phases in FF's