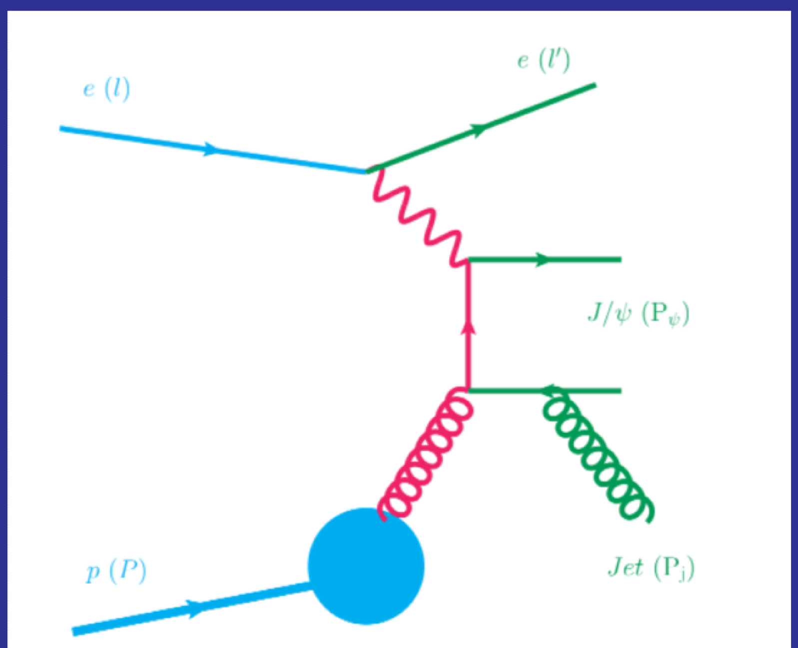
$\cos 2\phi_t$ azimuthal asymmetry in back-to-back J/ψ -jet production in $e\,p \to e\,J/\psi\;Jet\;X$ at the EIC

Amol Pawar[1], Asmita Mukherjee[1], Mariyah Siddiquah[1], Raj Kishore[2]
[1]IIT Bombay, [2]IIT Kanpur

Introduction

- We present the $\cos 2\phi_t$ azimuthal asymmetry in $e\,p \to e\,J/\psi\;Jet\;X$, where the J/ψ-jet pair is almost back-to-back in the transverse plane, within the framework of the generalized parton model(GPM).
- We use non-relativistic QCD(NRQCD) to calculate the J/ψ production amplitude and incorporate both color singlet(CS) and color octet(CO) contributions to the asymmetry.
- We estimate the asymmetry using different parameterizations of the gluon TMDs in the kinematics that can be accessed at the future electron-ion collider (EIC) and also investigate the impact of transverse momentum dependent (TMD) evolution on the asymmetry.

Calculation



$e^-(l) + p(P) \to e^-(l') + J/\psi(P_\psi) + Jet(P_j) + X$

In small-x $\to\ \gamma^* + g\ \to\ c\bar{c}({}^{2S+1}L_J^{(1,8)}) + g$
D'Alesio (2019)

virtual photon and Proton along $\pm z$ axis

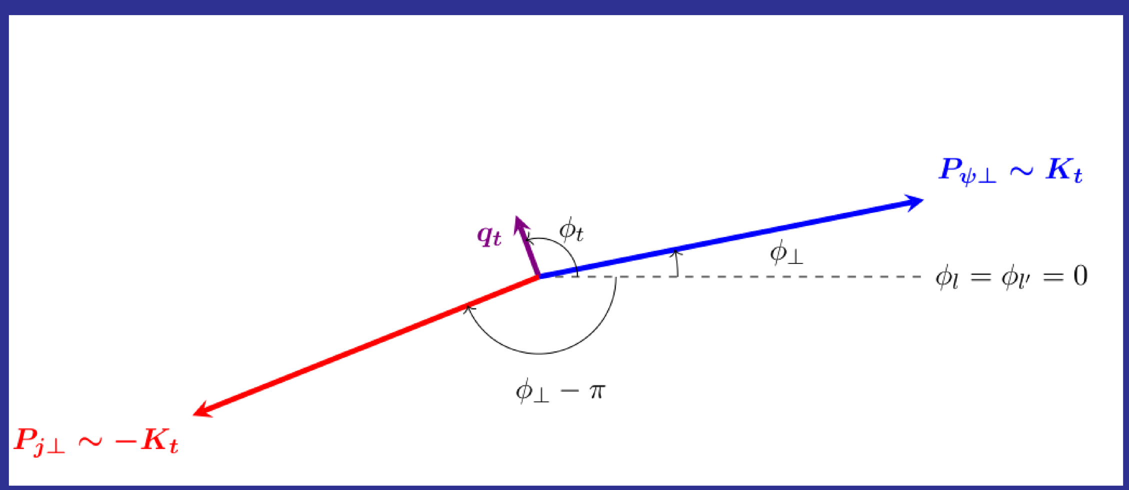
Leptonic plane $\Rightarrow$ measuring azimuthal angles

$Q^2 = -q^2,\ s = (P+l)^2,\ x_B = \frac{Q^2}{2P\cdot q},$
$y = \frac{P.q}{P.l},\ z = \frac{P.P_\psi}{P\cdot q}.$

back to back scattering $\Rightarrow |\mathbf{q}_t|^2 \ll |\mathbf{K}_t|^2 \sim M_\psi^2$
$\Rightarrow$ TMD factorization.

ϕ_t and $\phi_\perp$

$$\mathbf{q}_t \equiv \mathbf{P}_{\psi\perp} + \mathbf{P}_{j\perp}\,, \quad \mathbf{K}_t \equiv \frac{\mathbf{P}_{\psi\perp} - \mathbf{P}_{j\perp}}{2}$$



small transverse momentum allows us to factorize the TMDs

J/ψ production

$$d\sigma^{ab\to J/\psi} = \sum_n d\sigma[ab \to c\bar{c}\left({}^{2S+1}L_J^{(1,8)}\right)]\ \langle 0|\mathcal{O}^{J/\psi}\left({}^{2S+1}L_J^{(1,8)}\right)|0\rangle$$

$d\sigma[ab \to c\bar{c}\left({}^{2S+1}L_J^{(1,8)}\right)]$: High energy perturbative part.
$\langle 0|\mathcal{O}^{J/\psi}\left({}^{2S+1}L_J^{(1,8)}\right)|0\rangle$: Non perturbative Long Distance Matrix Element. $c\bar{c}\left({}^{2S+1}L_J^{(1,8)}\right)$ to J/ψ
Bodwin, Braaten, Lepage (1994)

Differential corss-section and $\cos 2\phi_t$ asymmetry

$$\frac{d\sigma}{dz\,dy\,dx_B\,d^2\mathbf{q}_t\,d^2\mathbf{K}_t} = d\sigma^U + d\sigma^T$$

$$\frac{d\sigma}{dz\,dy\,dx_B\,d^2\mathbf{q}_t\,d^2\mathbf{K}_t} = \frac{1}{(2\pi)^4}\frac{1}{16sz(1-z)Q^4}\Big\{(\mathbb{A}_0 + \mathbb{A}_1\cos\phi_\perp + \mathbb{A}_2\cos 2\phi_\perp)$$
$$f_1^g(x,\mathbf{q}_t^2) + \frac{\mathbf{q}_t^2}{M_P^2}h_1^{\perp g}(x,\mathbf{q}_t^2)\big(\mathbb{B}_0\cos 2\phi_t + \mathbb{B}_1\cos(2\phi_t - \phi_\perp) + \mathbb{B}_2\cos 2(\phi_t - \phi_\perp)$$
$$+\mathbb{B}_3\cos(2\phi_t - 3\phi_\perp) + \mathbb{B}_4\cos(2\phi_t - 4\phi_\perp)\big)\Big\}$$

$$\langle\cos 2\phi_t\rangle \equiv A^{\cos 2\phi_t} = 2\frac{\int d\phi_t d\phi_\perp \cos 2\phi_t d\sigma(\phi_t,\phi_\perp)}{\int d\phi_t d\phi_\perp d\sigma(\phi_t,\phi_\perp)}$$

$$\langle\cos 2\phi_t\rangle \equiv A^{\cos 2\phi_t} = \frac{\int q_t\,dq_t\,\frac{\mathbf{q}_t^2}{M_p^2}\,\mathbb{B}_0\,h_1^{\perp g}(x,\mathbf{q}_t^2)}{\int q_t\,dq_t\,\mathbb{A}_0\,f_1^g(x,\mathbf{q}_t^2)}$$

$$U = \frac{2*|\mathbb{B}_0|}{\mathbb{A}_0}\Bigg|_{\frac{\mathbf{q}_t^2}{2M_p^2}|h_1^{\perp g}(x,\mathbf{q}_t^2)| = f_1^g(x,\mathbf{q}_t^2)}$$

D'Alesio (2019)

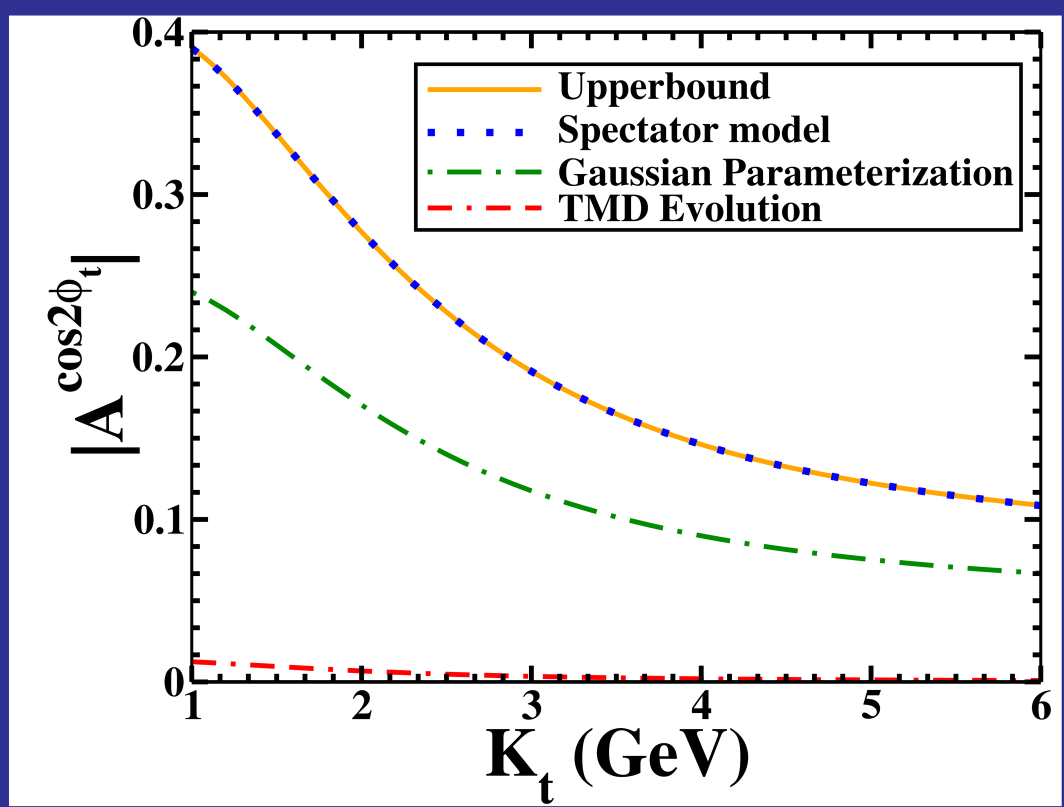
TMD parameterizations

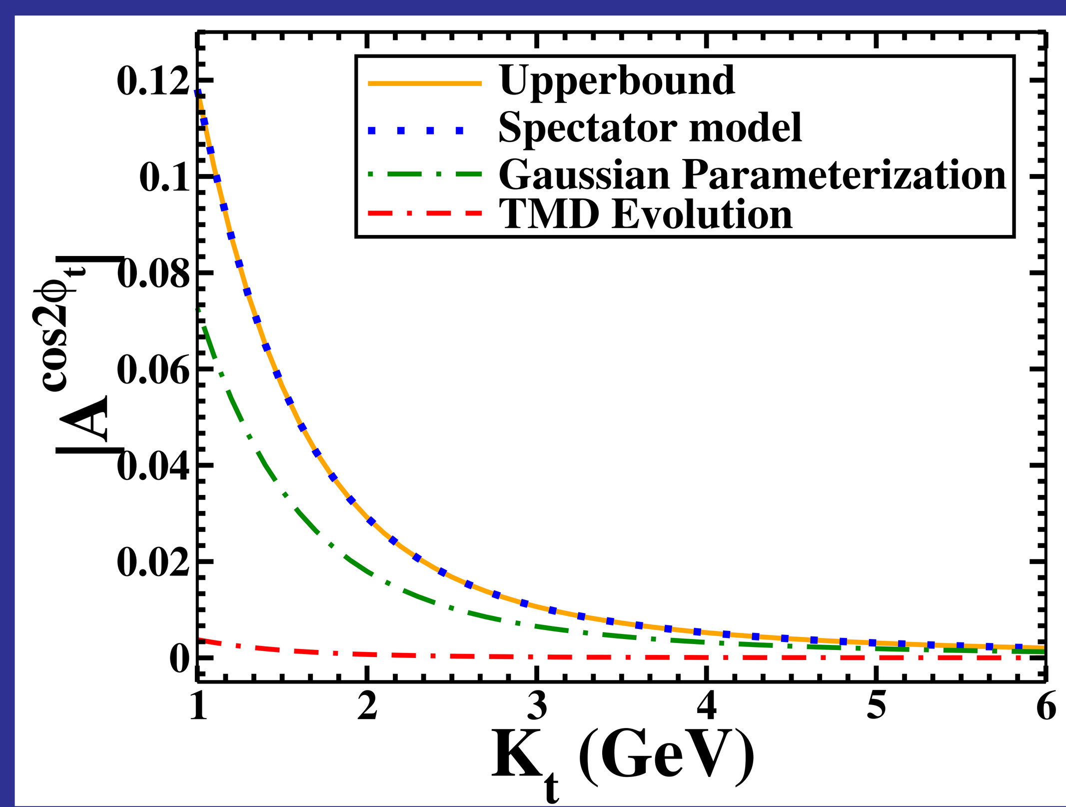
Gaussian parameterization : Transverse momentum dependent part is gaussian in nature. C. Pisano, et. al. (2012)

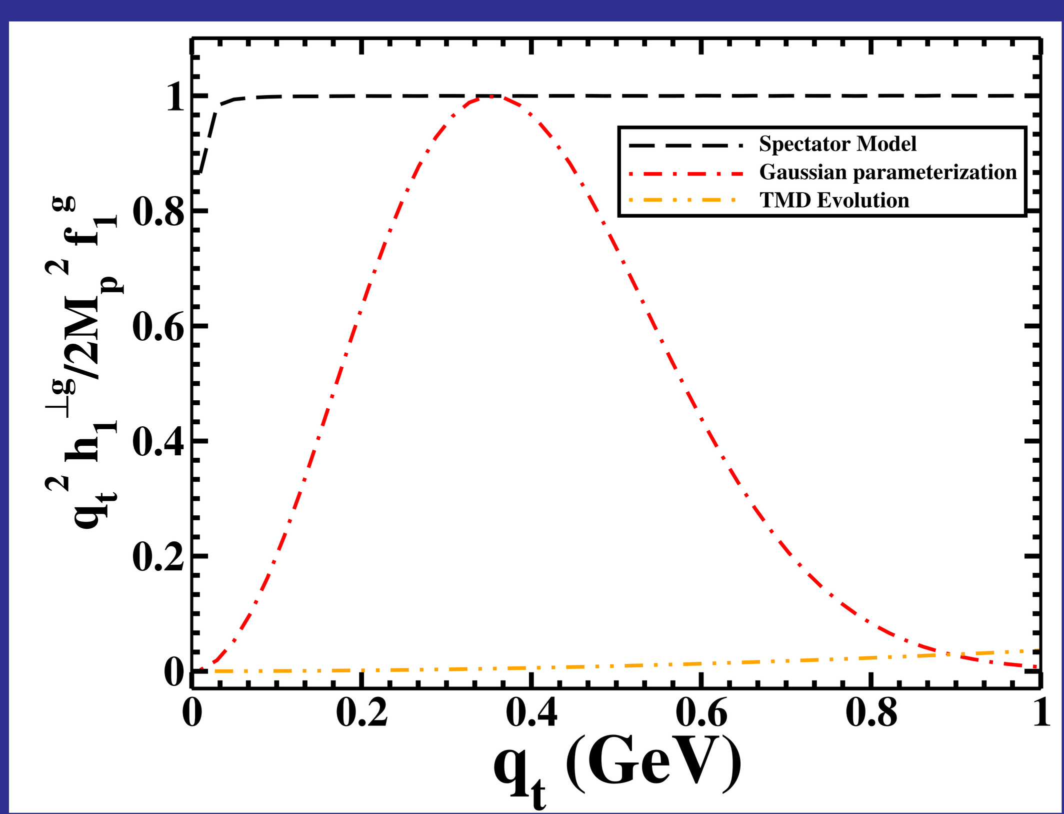
Spectator model : It is a numerical model to describe TMDs in small-x region. P. Taels., et.al. (2020)

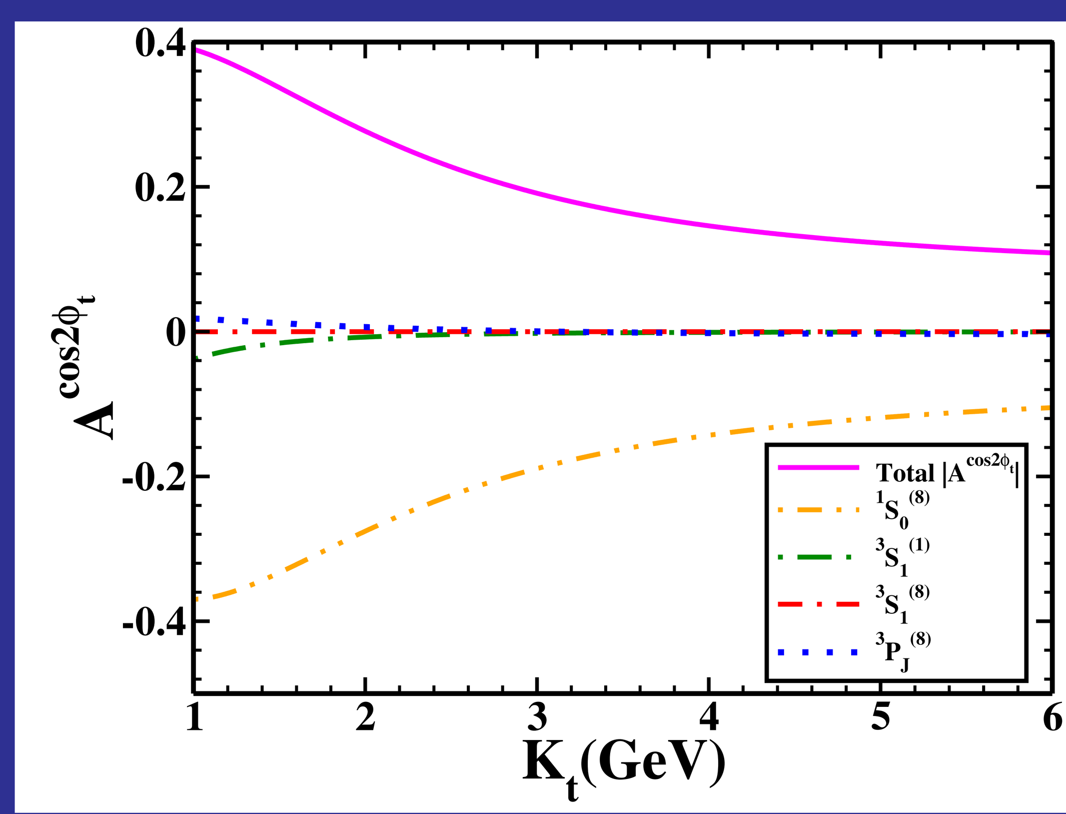
TMD Evolution: In TMD evolution the TMDs are solutions of Collins Soper Sterman evolution equation. D. Boer (2020)

Results and Discussion









arxiv:2203.13516