The elliptic flow of D^0 (B) meson in pA collisions from initial state

Cheng Zhang[1,2], Cyrille Marquet[3], Guang-You Qin[1], Yu Shi[1], Lei Wang[1], Shu-Yi Wei[3,4], Bo-wen Xiao[1,3]

[1] *Key Laboratory of Quark and Lepton Physics (MOE) and Institute of Particle Physics, CCNU, Wuhan 430079, China*
[2] *Key Laboratory of Particle Physics and Particle Irradiation (MOE) and School of physics, Shandong University, Jinan 250100, China*
[3] *Centre de Physique Theorique, Ecole Polytechnique, CNRS, Universite Paris-Saclay, 91128 Palaiseau, France*
[4] *European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*) and Fondazione Bruno Kessler, Strada delle Tabarelle 286, I-38123 Villazzano (TN), Italy*

Motivation

♢ Hydrodynamics can not explain the v_2 of heavy mesons in small systems.
♢ Calculations on the elliptic flow of open charm and bottom mesons are still lacking in CGC framework.

2-particle correlation method

The flow v_n is defined as:

$$v_n\{2\} = \sqrt{\langle\{e^{in(\phi_1-\phi_2)}\}\rangle}$$

where

$$\left\{e^{in(\phi_1-\phi_2)}\right\} = \frac{\int \mathrm{d}\Delta\phi \cos(n\Delta\phi)\frac{\mathrm{d}N}{\mathrm{d}y_1\mathrm{d}y_2\mathrm{d}\Delta\phi}}{\int \mathrm{d}\Delta\phi\frac{\mathrm{d}N}{\mathrm{d}y_1\mathrm{d}y_2\mathrm{d}\Delta\phi}}$$

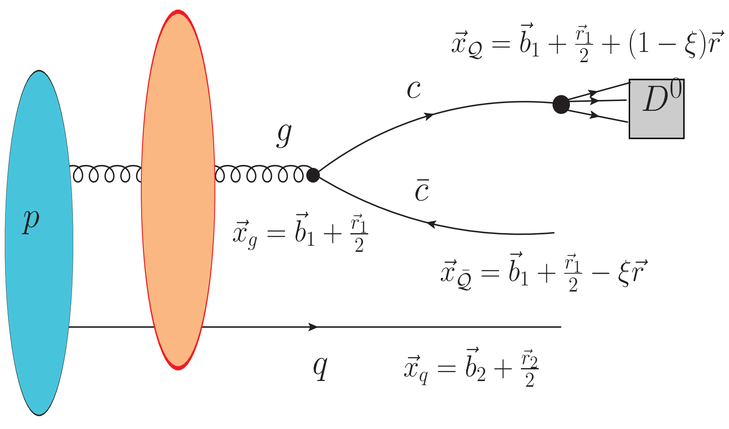
For heavy mesons angular correlations, the nth anisotropic flow of the differential spectrum is written as

$$v_n(y_1,k_\perp) \equiv \frac{\frac{\mathrm{d}\kappa_n}{\mathrm{d}y_1\mathrm{d}k_\perp}}{\frac{\mathrm{d}\kappa_0}{\mathrm{d}y_1\mathrm{d}k_\perp}}\frac{1}{v_n\,[\mathrm{ref}]}$$

v_n [ref] is the integrated flow of the reference quark.

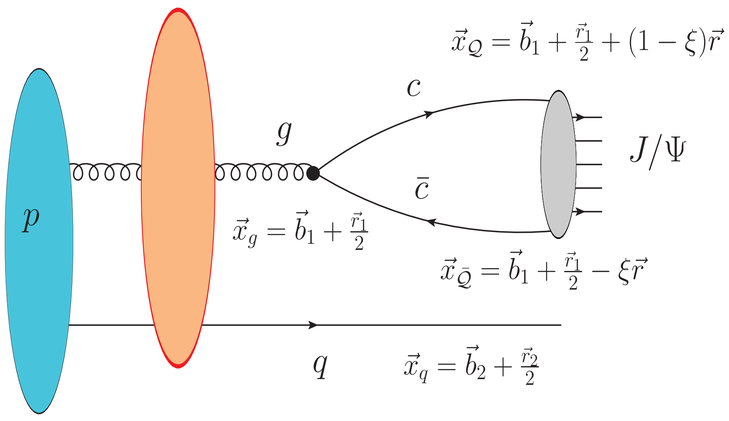
Diagrams in CGC framework

The D^0 meson (or J/Ψ) and light quark production



$c \to D^0$

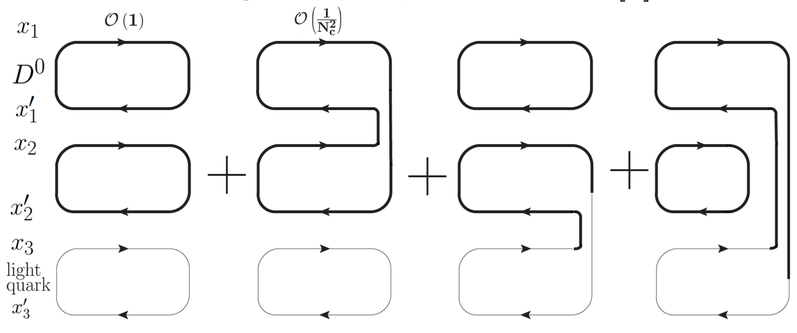
VS



$c\bar{c} \to J/\Psi$

Correlator in CGC framework

The color average of multipole correlator[2]



$$\langle DDD\rangle = e^{-\frac{Q_s^2}{4}\left[(\boldsymbol{x}_1-\boldsymbol{x}_1')^2+(\boldsymbol{x}_2-\boldsymbol{x}_2')^2+(\boldsymbol{x}_3-\boldsymbol{x}_3')^2\right]} \times \left[1 + F(\boldsymbol{x}_1,\boldsymbol{x}_1',\boldsymbol{x}_2,\boldsymbol{x}_2') + F(\boldsymbol{x}_2,\boldsymbol{x}_2',\boldsymbol{x}_3,\boldsymbol{x}_3') + F(\boldsymbol{x}_1,\boldsymbol{x}_1',\boldsymbol{x}_3,\boldsymbol{x}_3')\right]$$

Only the last two diagrams (or last two terms in equation) contain azimuthal angular correlations.

Formalism in CGC framework

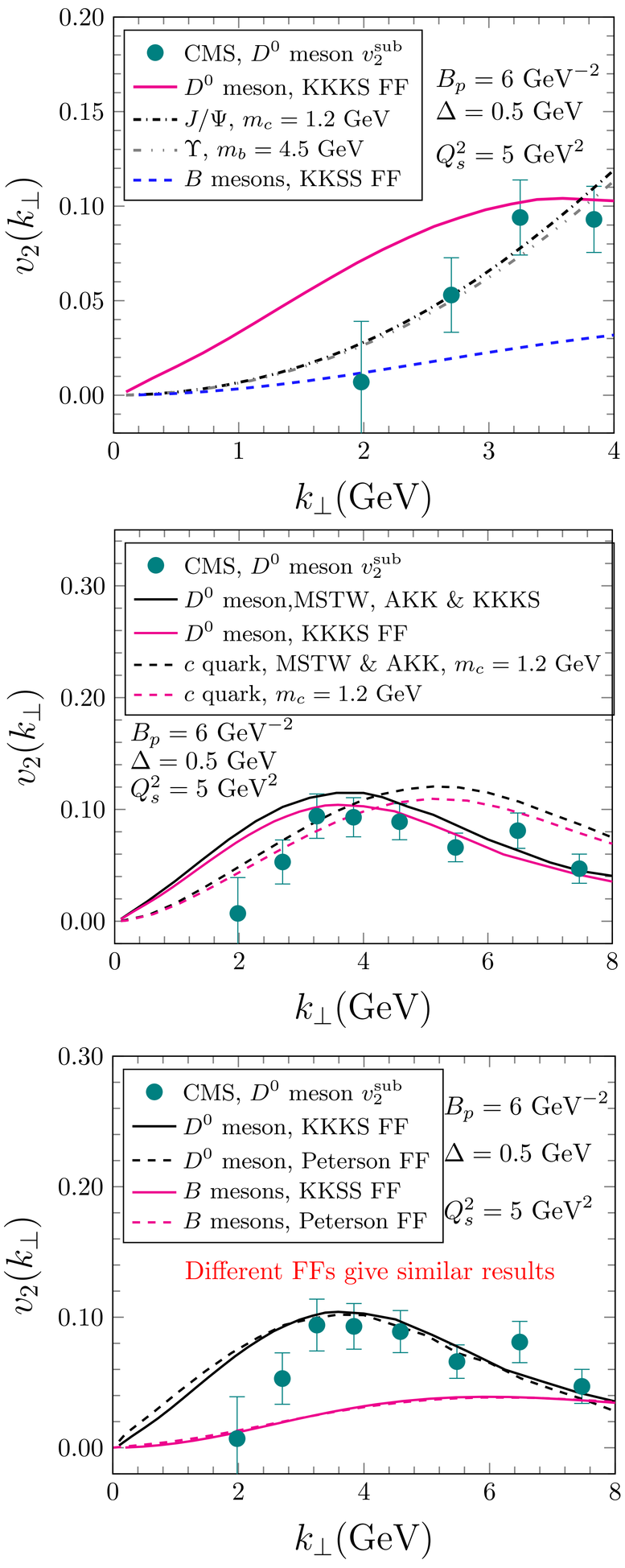
The differential spectrum of D^0 meson accompanied by a reference quark[1]

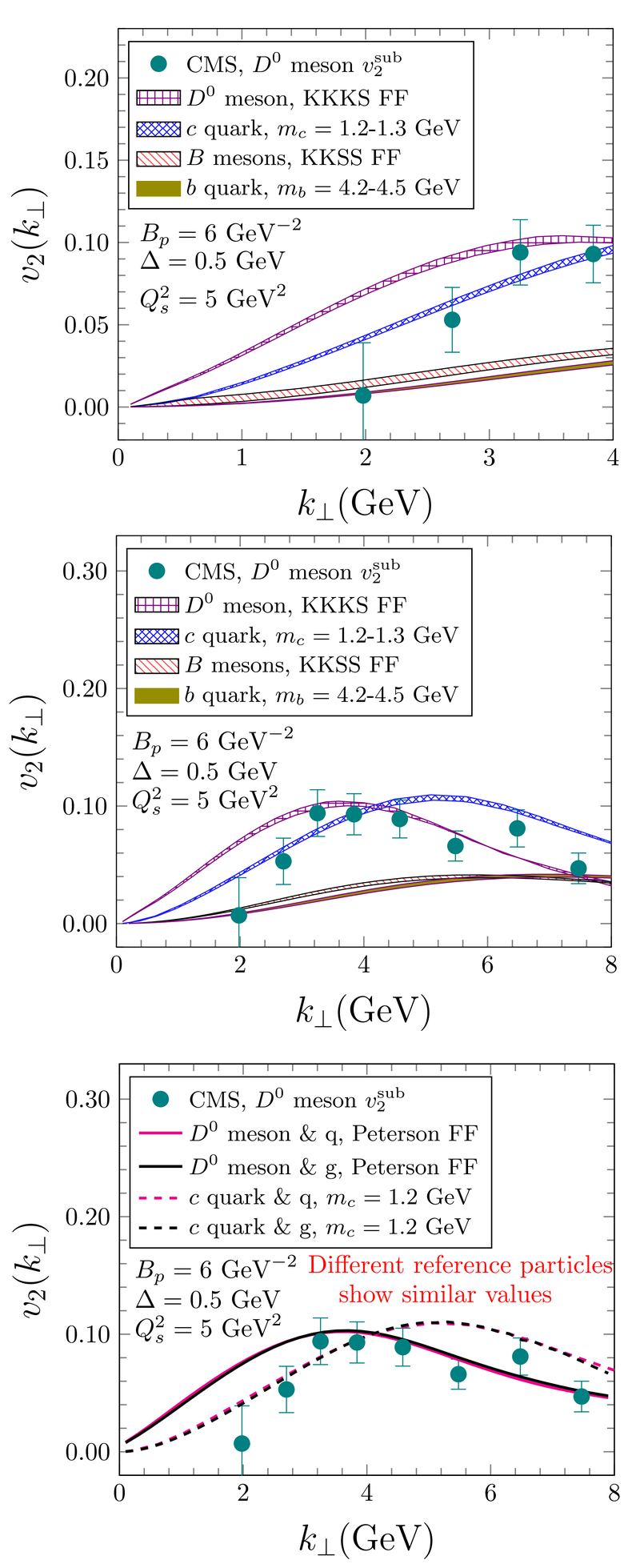
$$\frac{\mathrm{d}N^{\mathrm{pA}\to D^0\mathrm{qX}}}{\mathrm{d}y_1\mathrm{d}^2\boldsymbol{k}_{D^0}\mathrm{d}y_2\mathrm{d}^2\boldsymbol{k}_2} = \mathcal{N}\int\frac{\mathrm{d}z}{z^2}\int\mathrm{d}\xi\int\frac{\mathrm{d}^2\boldsymbol{r}\mathrm{d}^2\boldsymbol{r}_1\mathrm{d}^2\boldsymbol{b}_1\mathrm{d}^2\boldsymbol{r}_2\mathrm{d}^2\boldsymbol{b}_2}{(2\pi)^4} \times D_{D^0/\mathcal{Q}}(z)k_{\mathrm{g}}^+\prod_{i=1}^{2}x_i f_i(x_i)W(\boldsymbol{b}_i,\boldsymbol{r}_i)e^{-\mathrm{i}\boldsymbol{k}_{\boldsymbol{\mathcal{Q}}}\cdot\frac{\boldsymbol{r}_1}{\xi}-\mathrm{i}\boldsymbol{k}_{\boldsymbol{q}}\cdot\boldsymbol{r}_2}\langle DDD\rangle\,\psi(\boldsymbol{r})\psi^*(\boldsymbol{r}-\frac{\boldsymbol{r}_1}{\xi})$$

♢ $\psi(\boldsymbol{r})\psi^*(\boldsymbol{r}')$: the gluon splitting wave function $\mathrm{g}\to\mathcal{Q}\bar{\mathcal{Q}}$.
♢ $W(\boldsymbol{b},\boldsymbol{r})$: Gaussian type Wigner function.

Numerical Results

Comparison the elliptic flow of D^0 meson with the CMS D^0 meson v_2^{sub} data and predictions for v_2 of B mesons[1, 3]





Conclusions

♢ The observed large v_2 can be naturally explained as the initial state effect in the CGC formalism.
♢ The v_2 of heavy mesons has an interesting mass dependence.

References

[1] C. Zhang, C. Marquet, G. Y. Qin, Y. Shi, L. Wang, S. Y. Wei and B. W. Xiao, in preparation.
[2] C. Zhang, C. Marquet, G. Y. Qin, S. Y. Wei and B. W. Xiao, Phys. Rev. Lett. 122, no. 17, 172302 (2019).
[3]A. M. Sirunyan et al. [CMS Collaboration], Phys. Rev. Lett. 121, no. 8, 082301 (2018).