Left-right splitting of elliptic flow v_2 due to directed flow v_1 in heavy ion collisions

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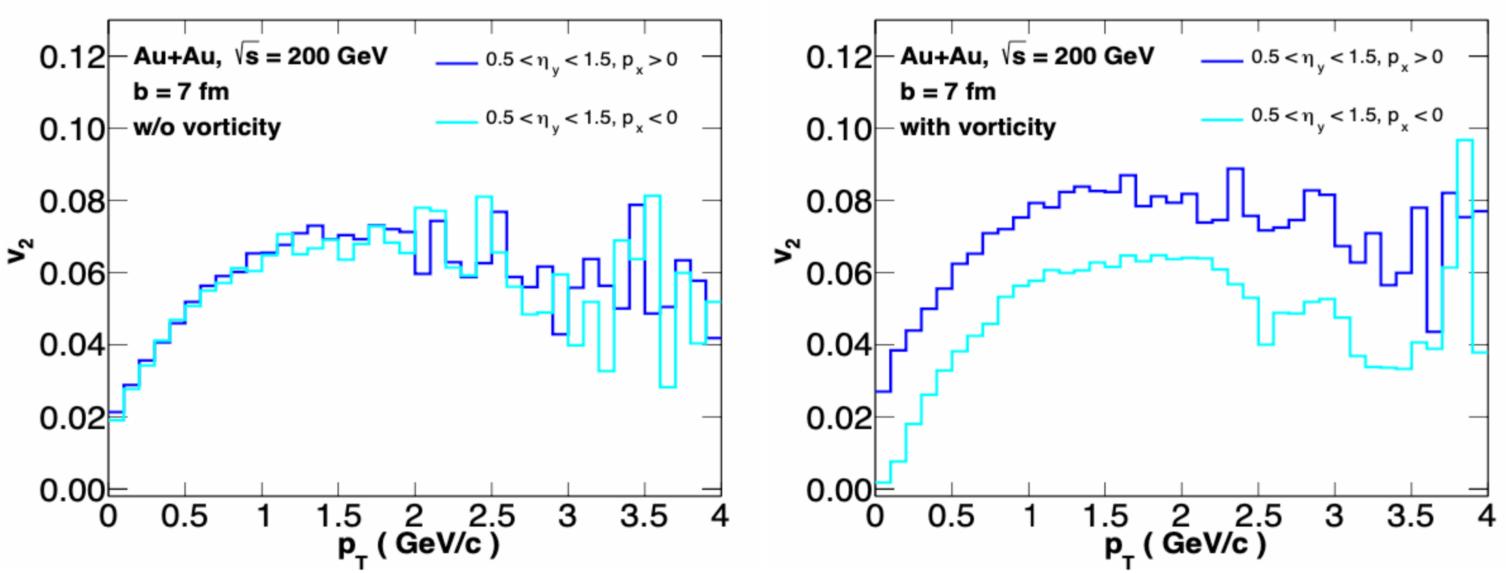
Background

- Recently the splitting of elliptic flow v_2 at finite rapidities has been proposed to be the result of global vorticity in non-central relativistic heavy ion collisions.

Z. Chen, Z. Wang, C. Greiner, and Z. Xu, arXiv:2108.12735



- Here we study the origin of this left-right v_2 splitting *(on opposite sides of the impact parameter axis).*

C. Zhang and Z.W.L., arXiv:2109.04987

v_2 Splitting versus the Theoretical Reaction Plane

Starting from a general azimuthal distribution in momentum
for particles in a given phase space (such as a given pT or η range):

$$f(\phi) = \frac{1}{2\pi}\left(1 + \sum_{n=1}^{\infty}\left[c_n \cos(n\phi) + s_n \sin(n\phi)\right]\right)$$

we get

$$v_2(p_x{>}0) \equiv \frac{\int_{-\pi/2}^{\pi/2} \cos(2\phi) f(\phi) d\phi}{\int_{-\pi/2}^{\pi/2} f(\phi) d\phi} = \frac{v_2 + \frac{4v_1}{3\pi} + \frac{6c_3}{5\pi}}{1 + \frac{4v_1}{\pi} - \frac{2c_3}{3\pi}}$$

right-side

$$v_2(p_x{<}0) \equiv \frac{\int_{\pi/2}^{3\pi/2} \cos(2\phi) f(\phi) d\phi}{\int_{\pi/2}^{3\pi/2} f(\phi) d\phi} = \frac{v_2 - \frac{4v_1}{3\pi} - \frac{6c_3}{5\pi}}{1 - \frac{4v_1}{\pi} + \frac{2c_3}{3\pi}}$$

left-side

- For symmetric A+A collisions, over a symmetric y or η range (say -2 to +2),
  $c_1=0$, $c_2/2==v_2$, $c_3=0$ (after event-averaging)
- In this study, we look at an asymmetric y or η range (say -2 to 0, or 0 to 2),
  then $c_1/2 == v_1$, $c_2/2 == v_2$,

but $c_3/2$!= v_3 (*the traditional triangular flow, which correlates little with the reaction plane*),
instead c_3 represents a triangular flow within an asymmetric y or η range
that correlates with the reaction plane.

v_2 Splitting versus the Theoretical Reaction Plane

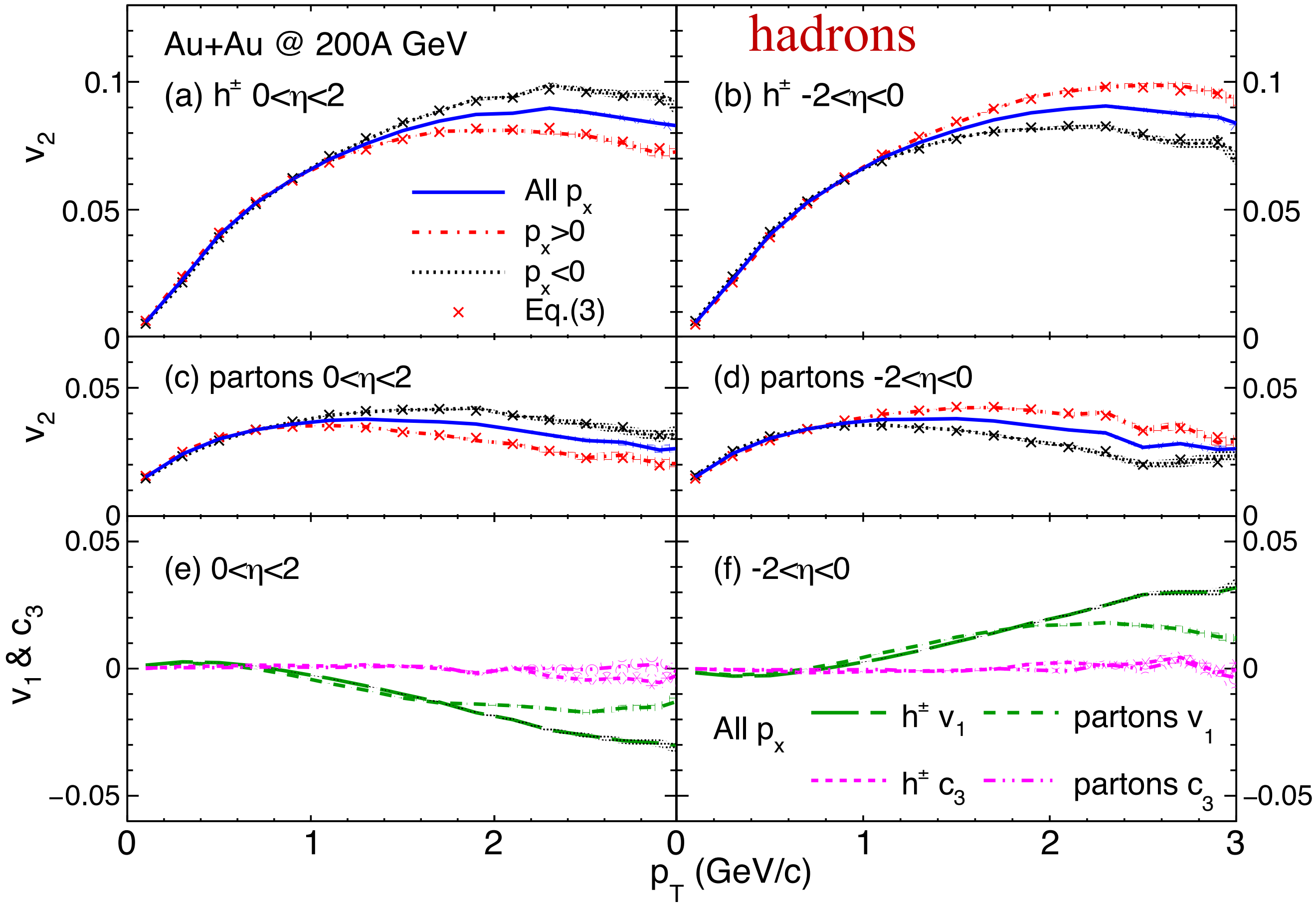
When $c_3 \ll c_1$, we get Eq.(3):

to page 2

$$v_2(p_x\!>\!0) = \frac{v_2 + \frac{4v_1}{3\pi}}{1 + \frac{4v_1}{\pi}} \simeq v_2 + \frac{4v_1}{3\pi}$$

$$v_2(p_x\!<\!0) = \frac{v_2 - \frac{4v_1}{3\pi}}{1 - \frac{4v_1}{\pi}} \simeq v_2 - \frac{4v_1}{3\pi}$$

Results from the string melting AMPT model for minimum bias Au+Au collisions at 200A GeV:



The left-right v_2 splitting is confirmed,

but it is mostly due to the directed flow v_1.

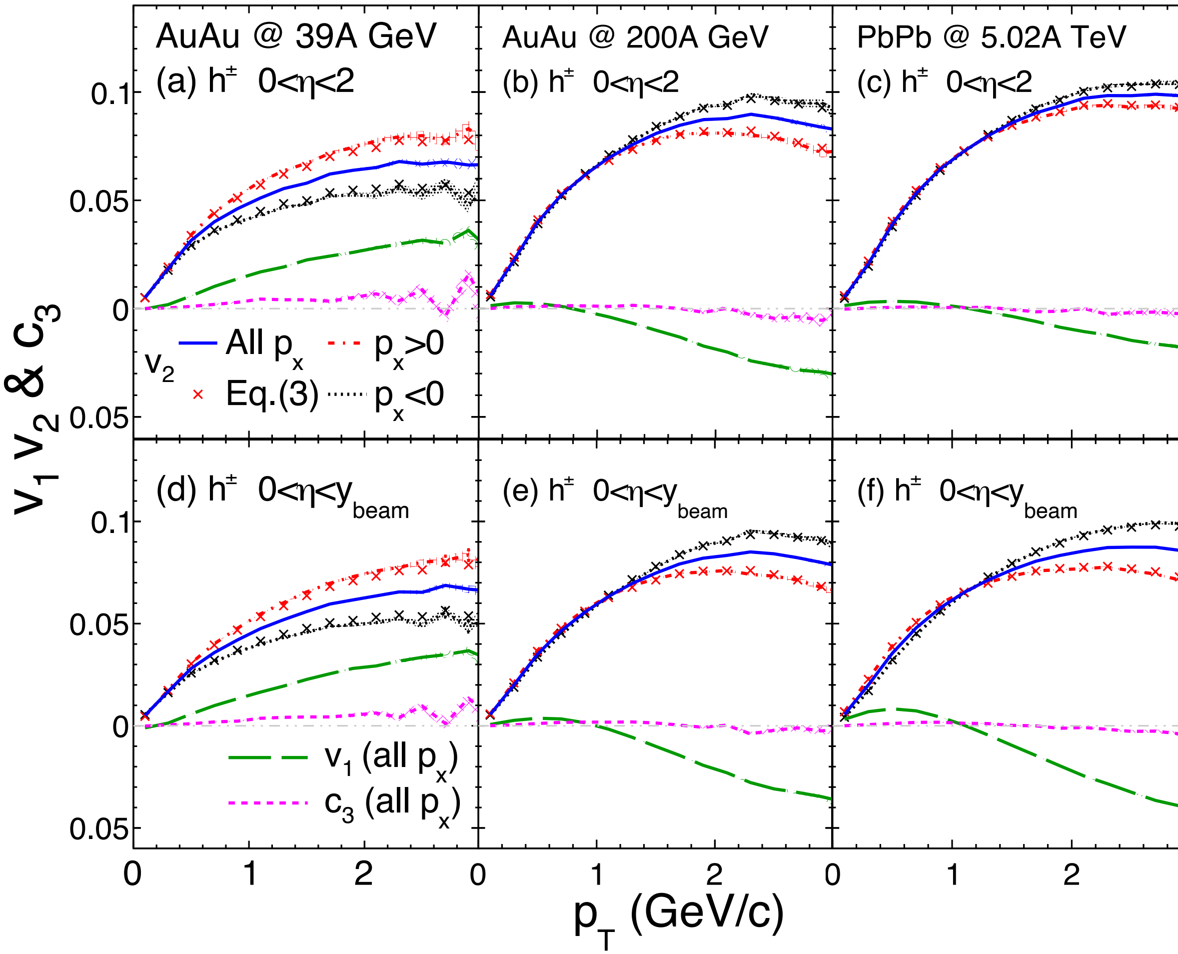
Eq.(3) works well here.

Since both global vorticity and v_1 vanish for central collisions, v_2 splitting correlates *indirectly* with global vorticity.

v_2 Splitting versus the Theoretical Reaction Plane

Splitting is expected to be larger
at lower energies
or larger rapidities
due to the larger v_1 magnitude;

the c_3 term may be more
important at lower energies.



Further questions:

- how about the v_2 splitting versus the event plane reconstructed with the experimental method?
- any advantages over the current separate v_1 & v_2 measurements?