Collective flow in small systems from parton scatterings

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Outline

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  - The AMPT model
- Results
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Long-range correlations in p+p, p+Pb, and Pb+Pb

Are the ‘ridges’ due to the same origin in p+p, p+Pb and Pb+Pb?
A multiphase transport (AMPT) model

(1) initial condition
(2) parton cascade
(3) hadronization
(4) hadronic rescatterings

Default AMPT Model

Melting AMPT Model

(1) initial condition
(2) parton cascade
(3) hadronization
(4) hadronic rescatterings
p+p and p+Pb in the AMPT model

- One hot spot in p+p vs Several hot spots in p+Pb.
- ‘Centrality’ defined by using \( N_{\text{track}} \) distributions as the CMS.

G.-L. Ma and A. Bzdak, PLB 739, 209 (2014)
• No long-range correlation in low-multiplicity p+Pb.
• Clear long-range correlation in high-multiplicity p+Pb.
AMPT results on long-range correlations in p+p and p+Pb

- The two-particle correlations in p+p and p+Pb are well reproduced by AMPT model (1.5 mb).
- Long-range correlation ($\Delta \phi \sim 0$) appears in high-multiplicity p+p and p+Pb.
- For signal strength, p+p < p+Pb.
Cross section dependence of long-range correlation in p+Pb

- The two-particle correlations in p+Pb can be well described by $\sigma = 1.5 - 3$ mb.
- The strength of the signal gradually increases with growing $\sigma$ and the signal vanishes completely for $\sigma = 0$ mb.
- No visible long-range signal in the default AMPT model.
For p+Pb, AMPT (3 mb) reproduces the measured v2 and v3.
For Pb+Pb, AMPT (3 mb) reproduces the measured v3 for all pT, but underestimates v2 especially for high pT.
• For p+Pb, AMPT (3 mb) reproduces the integrated v2 and v3.
• For Pb+Pb, AMPT (3 mb) reproduces the integrated v3, but underestimates the integrated v2 by ~20%.
• AMPT (3 mb) shows similar v3 between p+Pb and Pb+Pb.
AMPT results on PID $v_n$


- $v_2$ mass ordering in p+Pb ~ that in Pb+Pb ==> Collectivity in p+Pb?
- The mass ordering of $v_2$ is observed in p+Pb, as seen in data.
- No such a mass ordering of $v_3$ in p+Pb.

\begin{itemize}
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\end{itemize}
A proposed observable

\[ C(\Delta\phi) \equiv \frac{Y_{\text{Same}}(\Delta\phi)}{Y_{\text{Mixed}}(\Delta\phi)} \times \int \frac{Y_{\text{Mixed}}(\Delta\phi)d\Delta\phi}{Y_{\text{Same}}(\Delta\phi)d\Delta\phi} \]

\[ C(\Delta\phi) = 1 + \sum_n 2\gamma_n^2 \cos(n\Delta\phi) \]

\[ \sum \eta \begin{array}{c|c|c} \hline \eta & \text{bin 1} & \text{bin 2} \\ \hline -8 & [-6.2, -5.8] & [-2.2, -1.8] \\ -4 & [-4.2, -3.8] & [-0.2, 0.2] \\ 0 & [-2.2, -1.8] & [1.8, 2.2] \\ 4 & [-0.2, 0.2] & [3.8, 4.2] \\ 8 & [1.8, 2.2] & [5.8, 6.2] \\ \hline \end{array} \]
A proposed observable

• $v_2$ and $v_3$ increase when going from a proton side to a Pb-nucleus side.

• CGC predictions are warranted.
Summary

• The incoherent elastic scattering of partons, with $\sigma = 1.5\text{-}3\text{mb}$, naturally explains the long-range correlations in $p+p$ and $p+Pb$.

• $v_3$ are in a good agreement with the CMS data. $v_2$ is very well described in $p+Pb$ and underestimated for higher $p_T$ in $Pb+Pb$.

• The mass ordering of $v_2$ is reproduced whereas for $v_3$ such ordering is not observed in $p+Pb$.

• $v_2$ and $v_3$ are gradually growing when going from a proton side to a Pb-nucleus side.

• They indicate an emergence of collectivity in $p+p$, $p+Pb$ and peripheral $Pb+Pb$ from parton scatterings.

Thanks!
Back up
The AMPT model reproduces the CMS data for pT spectra of pion, Kaon, and proton, within the accuracy of 20%.
• Hadron cascade has a negligible effect on the p+Pb results.
• The average number of elastic scatterings per parton is \( \sim 2 \) for \( N_{\text{track}} \sim 200 \) in \( p+Pb \), and changes monotonically with \( N_{\text{track}} \).
• The QGP lifetime is longer for p+Pb than for p+p.