Interplay between core and corona from small to large systems

Yuuka Kanakubo, Yasuki Tachibana, Tetsufumi Hirano

Sophia University, Akita International University
Comprehensive picture from pp to AA

Dynamical Core-Corona Initialization framework (DCCI)

Core: fluids (equilibrated matter)  Corona: non-equilibrated partons

➔ From low to high $p_T$, from forward to backward, and from pp to AA
Model flowchart of DCCI\textsuperscript{2}
Y. Kanakubo \textit{et al.}, Phys. Rev. C 105 (2022) 2, 024905

**Initial partons:** PYTHIA8/PYTHIA8 Angantyr
C. Bierlich \textit{et al.}, JHEP 1610 139 (2016)

**Dynamical initialization of QGP fluids based on core-corona**

**Equilibrated matter (core)**
(3+1)-D hydro with source terms
iS3D \textit{(thermal hadron sampling)}

**Non-equilibrated partons (corona)**
PYTHIA8 \textit{(string fragmentation)}

**Hadronic afterburner: JAM**
Dynamical initialization framework

Two-component picture ➔ fluids and partons

Continuum eq. for fluid+parton
\[ \partial_\mu \left( T^{\mu\nu}_{\text{fluid}} + T^{\mu\nu}_{\text{parton}} \right) = 0 \]

Hydrodynamic eq. with source term
\[ \partial_\mu T^{\mu\nu}_{\text{fluid}} = J^\nu \]

Gaussian profile \( G \) and straight trajectory for a parton
\[ J^\nu \rightarrow - \sum_i \left( \frac{dp_i^\nu(t)}{dt} \right) G(x - x_i(t)) \]

"Sources of fluids" ➔ "Four-momentum deposition from partons"
Dynamical core-corona picture

Multiple scatterings among partons $\rightarrow$ partial equilibration

$$\frac{dp_i}{d\tau} = -\sum_j^{N_{\text{scat}}} \rho_{i,j} \sigma_{i,j} |v_{\text{rel},i,j}| p_i$$

Defined at a co-moving frame with $\eta_{s,i}$

Energy-momentum deposition

$\rightarrow$ # of scatterings with partons (non-equilibrated and equilibrated)

Low $p_T$ and/or dense region $\rightarrow$ Core (fluids)

High $p_T$ and/or dilute region $\rightarrow$ Corona (non-equilibrated partons)
**Dynamical core-corona initialization**

Transverse plane \(|\eta_s| < 0.5\)

**pp 7 TeV**

**PbPb 2.76 TeV**

Dynamical core-corona separation

+ energy-momentum conservation respecting beam energy
Results from DCCI2
Take-home message!

QGP properties from experiment?

⇒ Need both equilibrated and non-equilibrated matter in **both pp and AA**
\(\Omega/\pi\) ratio from pp to PbPb

Fixing parameters to control fraction of core/corona

Smooth enhancement of \(\Omega/\pi\) ➔ smooth increase of core contribution

Starting point

☑ Describe composition of matter
Fraction of core and corona in pp and PbPb

**pp: core/corona ~ 50% at the highest multiplicity class (0-0.95%)**

**PbPb: corona ~ 20% at intermediate centralities (40-60%)**
Fraction of core and corona in pp and PbPb

Need both equilibrated and non-equilibrated matter in both pp and AA
Onset $\langle dN_{ch}/d\eta \rangle$ of core dominance

Clear scaling with multiplicity

Onset of core dominance at $\langle dN_{ch}/d\eta \rangle \sim 20$
Fraction of core and corona vs. $p_T$

Charged $\pi$, PbPb 2.76 TeV, 20-40%

Low $p_T$: core dominance

high $p_T$: corona dominance

Core-corona picture

From low to high $p_T$ within one framework

Core

Corona

20-40%, $\pi^\pm$
Fraction of core and corona vs. $p_T$

Charged $\pi$, PbPb 2.76 TeV, 20-40%

- Very low $p_T (< 1$ GeV)
- Slight enhancement of corona components
- Non-equilibrium corrections to core (equilibrium)
Corona corrections to flow

\[ c_2\{4\} \text{ from PbPb } 2.76 \text{ TeV} \]

\[ 0.2 < p_T < 3.0 \text{ GeV, } |\eta| < 0.8 \]

\[ c_2\{4\}_\text{core} \neq c_2\{4\}_\text{tot} \]

\[ \rightarrow \text{ Diluted by corona} \]

\[ \text{Conventional Hydro model} \]

\[ \text{Comparison} \]

\[ \text{Experiment} \]

\[ \rightarrow \text{ Need both equilibrated and non-equilibrated matter} \]
Summary

Dynamical core-corona initialization (DCCI2)

- Respect beam energy in initialization of QGP
- Both equilibrated and non-equilibrated matter
  ➔ From low to high $p_T$, from forward to backward, and from pp to AA

Yield ratios of strange hadrons from pp to PbPb

Onset of core dominance at $\langle dN_{ch}/d\eta \rangle \sim 20$

Non-equilibrium corrections to core (equilibrium)

Proper extraction of QGP properties from experiment?

➔ Need both equilibrated and non-equilibrated matter in both pp and AA

2022/06/15    Yuuka Kanakubo, Sophia Univ.
The 20th International Conference on Strangeness in Quark Matter, Busan, Republic of Korea
Thank you!