Elliptic Flow Splitting Between Particles and Antiparticles in Au+Au Collisions from the AMPT Model

Zhenyu Xu (徐振宇)
Advisor: Lei Huo (霍雷)
Introduction

• Larger $\nu_2$ values are found for particles than for antiparticles, except for pions

• A monotonic increase of the magnitude of $\Delta \nu_2 = \nu_2(X) - \nu_2(\bar{X})$ with decreasing beam energy is observed

• Works on the origination of $\Delta \nu_2$

  Dunlop J C, et al. PRC 84, 044914 (2011)
  … …

• A significant difference in the $\nu_2$ values between proton and antiproton is observed at all BES energies

Motivation: Search for possible origination of $\Delta \nu_2$ between proton and antiproton
The AMPT model

- The initial conditions are obtained from the HIJING model
- Scatterings among partons are modeled by ZPC
- A quark coalescence model is used in the combination of partons into hadrons
- The dynamics of the hadronic matter is described by a hadronic cascade, which is based on the ART model


“coordinate coalescence”
• Elliptic flow splitting in the AMPT model

- **Real plane** is used in the calculation for the effect of event plane fluctuation to $\Delta v_2$ is small
- $\Delta v_2$ of $\pi^+$ and $\pi^-$, $K^+$ and $K^-$ are not obvious
- A significant $\Delta v_2$ between $p$ and $\bar{p}$ is observed
- $\Delta v_2$ of $p$ and $\bar{p}$ is caused by quark coalescence process

CPL, 2017, 34: 062501
The Changes in the Quark Coalescence Model

- “The current quark coalescence model in AMPT searches for a meson partner before searching for baryon or antibaryon partners”

  He Y, Lin Z W. PRC 96, 014910 (2017)

- Do some changes on the quark coalescence process
  - Adjust the formation order of mesons and (anti)baryons
  - “coordinate coalescence” but with momentum limit $\Delta p_0$

$$\begin{cases} 
\Delta r_{\text{new}} < \Delta r_{\text{old}} \\
\Delta p_{\text{new}} < \Delta p_0
\end{cases}$$

Structure of the AMPT model with string melting
Results -- Transverse Momentum Spectra

• For charged pions, the slope of the $p_T$ spectra decreases for the yields increases at $p_T$ range of (~0.8, 2GeV)
• The transverse momentum spectra of antiproton is improved

• The charged particle yield and the slopes of the $p_T$ spectra will be affected by Lund symmetric fragmentation function:

$$f(z) \propto z^{-1}(1 - z)^a \exp(-b \frac{m_T^2}{z})$$

Lin Z W. PRC 90, 014914 (2014)

• Here we use the value of $a=2.2$, $b=0.5$
Results -- Elliptic flow

- $v_2$ of hadrons are not rely on the formation order of mesons and (anti)baryons
- $v_2$ become small when formation order and momentum limit are added into the quark coalescence process

![Graphs showing $v_2$ vs $p_T$ for different particles with STAR data]
Results -- Elliptic flow

- $v_2$ results for charged pions and kaons from the changed model (6mb) are generally consistent with the experimental data.
Results -- $\Delta v_2$

- $\Delta v_2$ from the AMPT with the change of formation order and momentum limit
- Elliptic flow of proton is larger than antiproton
- $\Delta v_2$ of proton and antiproton is increasing with the decreasing energy
- Shows consistent tendency with experimental result
Summary

• **Transverse momentum spectra** of charged pions and antiproton are generally consistent with experimental data after changing the quark coalescence model in the AMPT model

• **Elliptic flow** of changed pions, charged kaons and antiproton become smaller with the changed model
  • For changed pions, $\nu_2$ values are more close to the results of experiment at $p_T$ range of ($\sim 0.8$, 2GeV)

• With a smaller $\nu_2$ of antiproton, **elliptic flow difference $\Delta \nu_2$** of proton and antiproton shows consistent trend to the experimental result

Future work

• Why $\Delta \nu_2$ between proton and antiproton will behave like this, future study needs to be done

• Quark pairs with $\Delta p > \Delta p_0$ must be treated properly to make the coalescence process more physical
Thank you!

xuzy@stu.hit.edu.cn
Back-up

- Experimental data @STAR
Back-up

- Elliptic flow splitting in the present AMPT model
Back-up

- Chemical freeze out time

- Elliptic flow of constituent quarks of proton and antiproton
Results – Mass ordering of $v_2$

$\text{Au+Au, 14.5GeV}$

**Unchanged model**

- $\pi^+$
- $K^+$
- $\rho$

**Changed model**

- $\pi^-$
- $K^-$
- $\bar{\rho}$