Eur. Phys. J. C (2023) 83:649
https://doi.org/10.1140/epjc/s10052-023-11834-y

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Elliptic flow of identified hadrons in Au+Au collisions at $E_{lab} = 35$ A GeV using the PHSD model

B. Towseef[1], **M. Farooq**[1], **V. Bairathi**[2,a], **B. Waseem**[1], **S. Kabana**[2], **S. Ahmad**[1]

[1] University of Kashmir, Srinagar 190006, India
[2] Instituto de Alta Investigación, Universidad de Tarapacá, Casilla 7D, 1000000 Arica, Chile

Received: 24 February 2023 / Accepted: 11 July 2023

Abstract We present predictions of elliptic flow (v_2) of identified hadrons at mid-rapidity ($|y| < 1.0$) in Au+Au collisions at $E_{lab} = 35$ A GeV using the Parton Hadron String Dynamics (PHSD) model. The transverse momentum (p_T) dependence of identified hadron v_2 in minimum bias (0–80%) and three different centrality intervals (0–10%, 10–40%, and 40–80%) are presented. A clear centrality dependence of $v_2(p_T)$ is observed for particles and anti-particles. We also present the p_T dependence of v_2 difference (Δv_2) between particles and corresponding anti-particles. A significant difference in v_2 values for baryons and anti-baryons is observed. Constituent quark scaling (NCQ) of v_2 is investigated in Au+Au collisions. We also present a $v_2(p_T)$ ratio between the HSD and PHSD modes to explore the effect of hadronic and partonic interactions in the medium. These predictions are useful for interpreting the data measured in the Beam Energy Scan (BES) program at RHIC. They will also be useful for the future Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) and Multi-Purpose Detector (MPD) at the Nuclotron-based Ion Collider facility (NICA).

1 Introduction

One of the primary goals of the relativistic heavy-ion experiments is the study of quark-gluon plasma (QGP), and the quantitative mapping of the QCD phase diagram [1,2]. The experiments at the Relativistic Heavy-Ion Collider (RHIC) [3,4], and the Large Hadron Collider (LHC) [5–7], have explored the QCD phase diagram in the region of high temperatures and vanishing baryon densities. RHIC has also performed a Beam Energy Scan (BES), including fixed target heavy-ion collisions that access high baryon density regions at small collision energies. The future CBM experiment at FAIR aims to investigate the region of the QCD phase diagram at high net baryon densities and moderate temperatures [8,9]. Also, the future MPD experiment at NICA plans to study collisions of heavy ions in the center-of-mass energy range between 4 and 11 GeV per nucleon to investigate the matter within high net-baryon densities [10,11].

The anisotropic flow of produced particles has long been considered a probe to study properties of the QCD matter created in heavy-ion collisions [12,13]. The anisotropic flow appears as a momentum-space anisotropy in the final states, and develops due to the pressure gradient resulting from the initial spatial anisotropy of the collision. Therefore, it is sensitive to the very early stages of the collision. Azimuthal anisotropy can be studied by the Fourier expansion of the azimuthal angle distribution of produced particles with respect to the reaction plane angle [14],

$$E\frac{d^3N}{dp^3} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\left(1 + 2\sum_{n=1}^{\infty} v_n \cos[n(\phi - \psi_{RP})]\right). \tag{1}$$

Here, n denotes the harmonic order, ϕ is the particle's azimuthal angle, and ψ_{RP} is the reaction plane angle made by the impact parameter vector and the beam direction. The n^{th} order flow coefficient v_n is given by the equation,

$$v_n = \langle \cos[n(\phi - \psi_{RP})]\rangle, \tag{2}$$

where $\langle\,\rangle$, represents an average over particles and events. The second order Fourier coefficient, also known as the elliptic flow (v_2). Due to the self-quenching nature of the initial spatial anisotropy that appears in the early stage of the collision, the elliptic flow v_2 remains conserved during the evolution of the system, therefore offers details on the dynamics at the beginning of the collision [15–17]. However, hadronic re-

[a] e-mail: vipul.bairathi@gmail.com (corresponding author)

Published online: 22 July 2023