Search for the Chiral Magnetic and Vortical Effects Using Event Shape Selection with BES-II data at STAR

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Abstract

Quark chirality effects can provide unique opportunities to probe the topological sector of the Quantum Chromodynamics (QCD) and continue to be a stimulating subject of intensive theoretical and experimental investigations in heavy-ion collisions. Experimental observables related to the predicted Chiral Magnetic/Vortical Effect (CME/CVE) are, however, overwhelmed by elliptic flow and/or nonflow-induced backgrounds. Recently, the STAR experiment measured significant background contributions to the CME observables in isobar collisions, preventing an unambiguous observation of the signal difference between the two isobars. We propose an improved Event Shape Selection (ESS) technique and application to the STAR Beam Energy Scan II data in search of the CME and CVE. The Au+Au system produces stronger magnetic fields than the isobars, and collisions at lower beam energies have the advantage of longer-lasting magnetic fields and greater vorticities than higher energies. Utilizing pair particle information, we developed four ESS approaches that allowed us to systematically evaluate residual flow strength in particles of interest when extrapolating the CME/CVE observable to the apparent zero-flow background limit. We report the $\Delta\gamma$ measurements using h-h (excluding protons) and Λ-p correlations in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 7.7, 11.5, 14.6, 19.6, and 27 GeV, and have achieved over the five-fold reduction of background. The STAR Event Plane Detector (EPD) enabled us to measure the spectator plane with much better resolution than the Zero Degree Calorimeter and also effectively suppressed the nonflow background. We will discuss the physics implications of the new results in CME/CVE searches at low energies with BES-II data.