Search for the Chiral Magnetic Effect in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7–200 GeV at STAR

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Abstract

In high-energy heavy-ion collisions, the chiral magnetic effect (CME) may arise from the interplay between domains of chirality imbalanced quarks in the quark-gluon plasma and the strong magnetic field ($\vec{B}$) generated by spectator protons. The CME is predicted to induce an electric charge separation along the $\vec{B}$ direction, manifestly violating local $\mathcal{P}$ and $\mathcal{CP}$ symmetries. We use the $\Delta\gamma^{112}$ correlator based on pairs of same- and opposite-sign charged hadrons to detect such a charge separation along the $\vec{B}$ direction. To mitigate the background induced by elliptic flow (v_2), we adopt a novel event shape selection (ESS) approach that classifies events based on their shapes and allows us to determine $\Delta\gamma^{112}_{\rm ESS}$ at the zero-v_2 limit. Furthermore, we use the spectator information to reconstruct the $\vec{B}$ direction, thereby minimizing nonflow backgrounds. We report the measurements of $\Delta\gamma^{112}$ and a background indicator $\Delta\gamma^{132}$ in Au+Au collisions from the RHIC Beam Energy Scan phase II and at the top RHIC energy. After background suppression, $\Delta\gamma^{132}_{\rm ESS}$ is consistent with zero, and $\Delta\gamma^{112}_{\rm ESS}$ is reduced from inclusive $\Delta\gamma^{112}$ by more than five-fold. The measured $\Delta\gamma^{112}_{\rm ESS}$ value in the 20%–50% centrality range is positively finite with an over 3σ significance at each of center-of-mass energies 11.5, 14.6, and 19.6 GeV, whereas the corresponding values at other beam energies are consistent with zero within uncertainties. Our results provide important constraints on the observability of the CME over a wide range of energies at RHIC.