Tracing the baryon number carrier and its transport from STAR

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Baryon transport creates baryon-rich matter in heavy-ion collisions, providing access to regions of the QCD phase diagram at high baryon chemical potential, which is essential for the manifestation of critical phenomena. However, the microscopic mechanism of baryon transport remains unknown. We utilize the STAR detector to measure net-baryon transport in isobaric, gold-gold, and photon-gold collisions, aiming to identify the baryon number carrier and its mechanism of transport.

Baryon number is stringently tested to be conserved quantity that has been proposed to be carried by valence quarks or string junctions, Y-shaped gluon fields with three quarks. However, no experiments have verified either scenario. While it is well established that electric charge is carried by valence quarks, the question remains as to whether they also carry the baryon number. To address this, we compare the baryon number and electric charge transport at midrapidity in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}} = 200$ GeV. We find significantly larger baryon transport than charge transport, suggesting different carriers involved in the two processes. We further investigate the baryon carrier and its transport using ultra-peripheral Au+Au collisions at $\sqrt{s_{NN}} = 54$ GeV, where low-energy photons from one ion interact with the other ion to produce a baryon. These photons, due to their low stopping power, lead to fewer net-protons at midrapidity if the carrier is a high-momentum valence quark. Conversely, gluons in string junctions, with their lower momentum, are readily stopped by these photons. We measure the net-proton yield as a function of rapidity loss $y - Y_{\rm beam}$ in γ+Au and Au+Au collisions, and test different models of baryon carrier.

Our results provide an important insight into the true nature of the baryon number carrier and the baryon-rich matter creation in high-energy collisions. They also lay the foundation for future measurements at RHIC and other experimental facilities.