Search for evidence of the baryon junction in photonuclear processes and heavy-ion collisions at STAR

Nicole Lewis, Yang Li, and Chun Yuen Tsang
(for the STAR Collaboration)

Baryon number is a strictly conserved quantity in QCD and is conventionally assumed to be divided equally among the three valence quarks in baryonic matter. An alternative model is the baryon junction: a Y-shaped configuration of nonperturbative gluons that is connected to all three valence quarks and carries the baryon number. Neither of these theories has been experimentally verified. Because valence quarks carry the baryon's electric charge, we can test if they also carry the baryon number by comparing baryon stopping to charge stopping. This is done to high precision using the STAR isobar dataset of ${}^{96}_{44}\mathrm{Ru}+{}^{96}_{44}\mathrm{Ru}$ and ${}^{96}_{40}\mathrm{Zr}+{}^{96}_{40}\mathrm{Zr}$ collisions at $\sqrt{s_{NN}} = 200$ GeV. Results show that at mid-rapidity the ratio of the net-baryon yield, B, to the difference in net-charge yield, $\Delta Q = Q(\mathrm{Ru}) - Q(\mathrm{Zr})$, is roughly twice as large in central collisions as would be expected if the valence quarks carry the baryon number. Another observable that is sensitive to the carrier of the baryon number is the net-proton yield in semi-inclusive photonuclear collisions, a type of ultraperipheral heavy-ion collision where one nucleus emits a quasi-real photon interacting with the other colliding nucleus. We observe significant baryon stopping at low transverse momentum in photonuclear processes using Au + Au collisions at $\sqrt{s_{NN}} =$ 54.4 GeV. Our combined results in isobar collisions and photonuclear processes indicate deviations from the picture of valence quarks as the baryon carrier and favor the baryon junction hypothesis.