Tracking the baryon quantum number with heavy-ion collisions

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Abstract

The baryon number is a conserved quantity in quantum chromodynamics (QCD), which is conventionally thought to be shared equally among the valence quarks in baryonic matter. However, an alternative theory suggests that the baryon number is carried by a non-perturbative, Y-shaped topology of gluons connecting to three quarks. This topology is called the baryon junction. Neither theory has been experimentally verified yet. The STAR Collaboration reports here two pieces of experimental evidence which collectively indicate that valence quarks do not carry baryon numbers.

We report our first finding based on data from isobar collisions ($^{96}_{44}$Ru+$^{96}_{44}$Ru and $^{96}_{40}$Zr+$^{96}_{40}$Zr) at $\sqrt{s_{NN}}$ = 200 GeV. The result shows that at mid-rapidity ($|y| < 0.5$), the ratio of net baryon (B) to the net charge difference (ΔQ) between the two systems is roughly twice the ratio of mass number to atomic number differences (i.e. 96/4) in central collisions. If both charge and baryon numbers are carried by the valence quarks, $B/\Delta Q$ should be close to 96/4. Moreover, results from semi-inclusive photonuclear Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV show baryon stopping (an excess of baryons compared to anti-baryons) with a significant rapidity asymmetry. The rapidity dependence of the measured baryon stopping is comparable to that observed in hadronic nucleus-nucleus collisions and to the baryon junction prediction.