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Phenomenology of baryon stopping and diffusion at RHIC BES

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A baryon-rich medium is created in low-energy heavy-ion collisions. Using a hydrodynamic model that incorporates finite baryon density, we investigate the role of baryon stopping and diffusion in RHIC-BES phenomenology, focusing on the directed flow (v_1) observable. The v_1 splitting between protons and anti-protons has been an elusive observable for a long time, primarily due to improper modeling of initial baryon stopping. We propose an initial baryon deposition model capable of reproducing the v_1 of protons and anti-protons across collision energies $\sqrt{s_{\rm NN}} = 7.7$–200 GeV. Notably, we find that the sign change of proton v_1 at $\sqrt{s_{\rm NN}} = 7.7$ GeV arises from a combined effect of initial baryon stopping and strong baryon diffusion—previously interpreted as a signature of a first-order phase transition. Using this baryon stopping model, we provide the first estimate of the baryon diffusion coefficient in the baryon-rich QGP medium.
Furthermore, leveraging our phenomenologically successful model, which accurately describes bulk observables at STAR BES energies, we explore the centrality-dependent splitting of the $v_1(y)$ slope, $\Delta(dv_1/dy)$, between positively and negatively charged hadrons. This splitting, recently measured by the STAR collaboration, has been suggested as a potential signature of the electromagnetic field generated during collisions. However, our calculations—accounting solely for baryon diffusion and not electromagnetic field effects—effectively reproduce the centrality trend of the v_1 slope splitting between protons and anti-protons. In this context, I will discuss how initial-stage baryon stopping provides a substantial background to electromagnetic field signals. Additionally, we demonstrate the significance of measuring rapidity-even v_1 splitting between baryons and anti-baryons, shedding light on the baryon junction conjecture, which has garnered considerable interest.

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