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Probing initial longitudinal geometry and electromagnetic field with directed flows of soft and heavy flavor hadrons

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Relativistic heavy-ion collisions provide a unique opportunity to investigate properties of nuclear matter under extremely strong electromagnetic field. Using a heavy quark transport model that includes both collisional and radiative energy loss of heavy quarks, coupled to a (3+1)-dimensional viscous hydrodynamic model CLVisc, we study the initial longitudinal energy density distribution and the time evolution of electromagnetic field via both soft and heavy flavor hadron observables. With a systematic comparison between three different initial energy density profiles –Bozėk-Wyskiel, CCNU and Shen-Alzhrani, we find a counter-clockwise tilt of the initial geometry in the reaction plane is crucial for understanding the rapidity dependence of directed flow (v1) of both soft hadrons and D mesons at RHIC and LHC. Meanwhile, the difference of v1 between D and Dbar is shown to be sensitive to the time evolution behavior of the electromagnetic field that generates opposite forces on c and cbar. This time evolution behavior is shown to be further constrained by the elliptic flow (v2) of soft hadrons due to the force density (squeezing effect) induced by the magnetic field inside the paramagnetic QGP medium. Therefore, a simultaneous description of soft and heavy flavor hadron v1 and v2 is required for a stringent constraint on the properties of electromagnetic field produced in high-energy nuclear collisions. Additional observables, such as the angular dependence of heavy meson RAA, and v1 of heavy flavor decayed leptons are predicted, which can be tested by experimental measurements in the near future.

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