From hydro to jet quenching, coalescence and hadron cascade: a coupled approach to solving the $R_{AA} \otimes v_2$ puzzle in high-energy heavy-ion collisions

Hydrodynamic expansion and jet quenching are responsible for the production of low and high transverse-momentum (p_T) particle in heavy-ion collisions, respectively. However, it is still a challenge to simultaneously describe hadron nuclear modification factor R_{AA} and elliptic flow v_2, especially in the intermediate p_T region of $2<p_T<10$ GeV/c. In this talk, besides hydrodynamics and jet quenching, we also study the effects of the quark coalescence and the hadron cascade on hadron spectra and flow. We find the key to solving the $R_{AA} \otimes v_2$ puzzle is the incorporation of quark coalescence into the state-of-the-art event-by-event simulations of heavy-ion collisions. Specifically, our new theoretical framework combines 1) the Coupled Linearized Boltzmann Transport and Hydrodynamic (CoLBT-Hydro) model, 2) a hadronization model including Cooper-Frye sampling, quark coalescence and string fragmentation, and 3) a hadron cascade model. For the first time, we can consistently describe and understand the experimental data on R_{AA} and v_2 along with their flavor dependence and hadron chemistry (proton-to-pion and kaon-to-pion ratios) from low to intermediate p_T and high p_T in high-energy heavy-ion collisions. We also predict a novel consequence of the strangeness enhancement and the quark coalescence that kaon v_2 larger than the pion v_2 in the transverse momentum region of $3<p_T<5$ GeV/c. Our prediction is an example of high-precision tests of the quark coalescence model in nuclear collisions.

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