Dilepton production in schematic causal viscous hydrodynamics

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We have derived a set of schematic equations from the causal viscous hydrodynamics of Israel-Stewart for central relativistic heavy-ion collisions by assuming that not only the energy density, pressure and entropy density but also the azimuthal and space-time rapidity components of the shear tensor are uniform in the produced fire-cylinder [1]. Solving these equations using the massive quasi-particle model for the equation of state of the quark-gluon plasma (QGP) and the resonance gas model for that of the hadrnoic matter, we have found that the shear viscosity slightly delays the cooling of produced hot matter and enhances somewhat its transverse expansion. Including the shear viscosity also significantly increases the particle distributions at high transverse momentum ($p_{T)}$, compared with those in the ideal hydrodynamics. Using this model, we have investigated thermal dilepton production in relativistic heavy-ion collisions by including contributions from the dominant quark-antiquark and pion-pion annihilations as well as rho meson decay after freeze out. Because of the viscous effect, the dilepton p_T spectrum is enhanced at high p_T as shown in the left window Fig. 1. For the invariant mass spectrum of dileptons, we have found that it differs very little from that in the ideal hydrodynamics. We have also studied the effect of viscosity on the transverse mass scaling of thermal dileptons from the QGP, i.e., the yield is independent of p_T for fixed dilepton transverse mass $M_T = (M_2+p_T^2)^{1/2}$, that has been previously predicted in the ideal hydrodynamics with massless quarks and gluons [2]. As shown in the right window of Fig. 1, our results show that the M_T scaling still holds in the ideal hydrodynamics even if the QGP is composed of massive quarks and gluons resulting from their strong couplings, but is broken in the viscous hydrodynamics due to the enhancement in the number density of quarks and antiquarks at high p_T by the viscous effect.

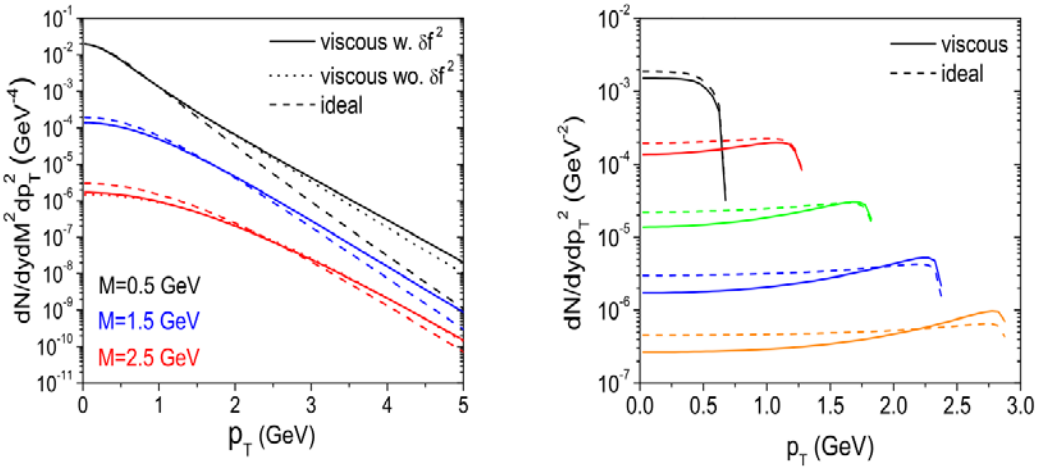

FIG. 1. Left window: Dilepton transverse momentum spectra from viscous (solid line) and ideal hydrodynamics (dashed line). Right window: Transverse momentum dependence of dileptons from QGP with transverse mass M_T = 1, 1.5, 2, 2.5 and 3 GeV from top to bottom. Dashed and solid lines are, respectively, from ideal and viscous hydrodynamics.

[1] T. Song, K.C. Han, and C.M. Ko, Phys. Rev. C **83**, 024904 (2011).
[2] M. Asakawa, C.M. Ko, and P. Levai, Phys. Rev. Lett. **70**, 398 (1993).