Dilepton production from quark-gluon plasma in the PNJL model

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Using the Polyakov Nambu-Jona-Lasinio model (PNJL) [1], we have studied dilpeton production from a quark-gluon plasma (QGP) [2]. Because the PNJL model allows the existence of pions in a QGP, dileptons can be produced not only from quark-antiquark annihilation but also from pion-pion annihilation to a dilepton pair in the final state. Besides these leading-order processes, dileptons can be further produced from next-to-leading-order processes involving an additional pion in the final state of quark-quark annihilation and from quark or antiqaurk scattering with pions. We have calculated the dilepton production rates from these procsses using the medium-dependent quark and pion masses, which respectively decreases and increases with the themperatuere of the QGP and the quark-pion coupling constant as well as the modified quark Fermi distributions due to the Polyakov loop.

Fig.1 shows the various dilpeton prodution rates in a QGP of zero quark baryon chemical potential for two different temperatures. For the temperature T = 140 MeV (left window), which is below the phase transition temperature T_C = 212 MeV, dileptons of small invariant mass are produced from processes involving pions, while dileptons of large invariant mass are dominately produced from quark-antiquark annihilation, as a result of the large quark constituent mass compared to the small pion mass below T_C. For T = 212 MeV, the relative importance of processes with and without pions is revsersed as shown in the right window of Fig. 1, except for dilpetons of very small invariant mass, which is always dominated by next-to-leading-order processes. Increasing the quark chemical potential does not change much the prodcution rate of dileptons of large invariant mass, although that of small invariant mass is slightly reduced.

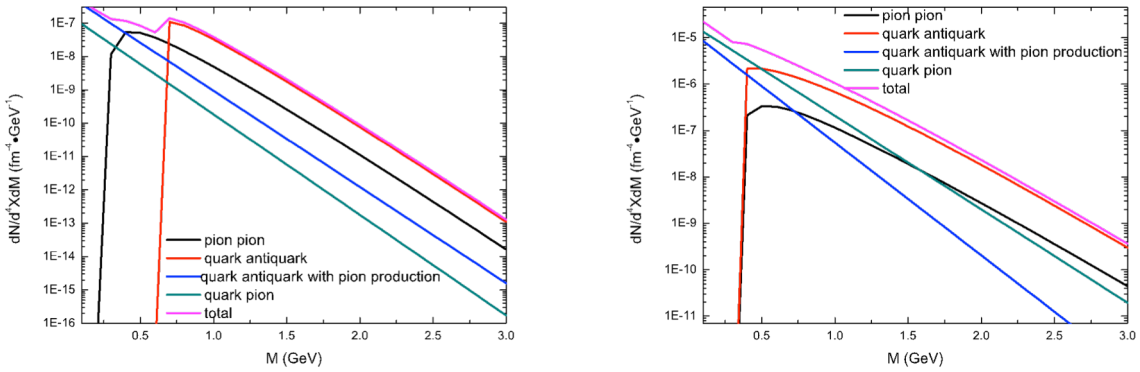

FIG. 1. Dilepton production rates in a QGP of temperature 140 MeV (left window) or 212 MeV (right window) and zero quark baryon chemical potential.

Fig. 2 shows the production rates of dileptons of zero momentum produced from a QGP at temperature T = 240 MeV and zero quark baryon chemical potential, for which results from lattice calculations are available as shown by the black line [3]. Since this temperature is above the Mott

temperature T_M = 230 MeV at which the decay of pion to quark and antiquark becomes possible in the QGP, leading to the disappearance of pions, only quark-antiquark annihilation with and without a pion in the final state contribute to dilepton production.

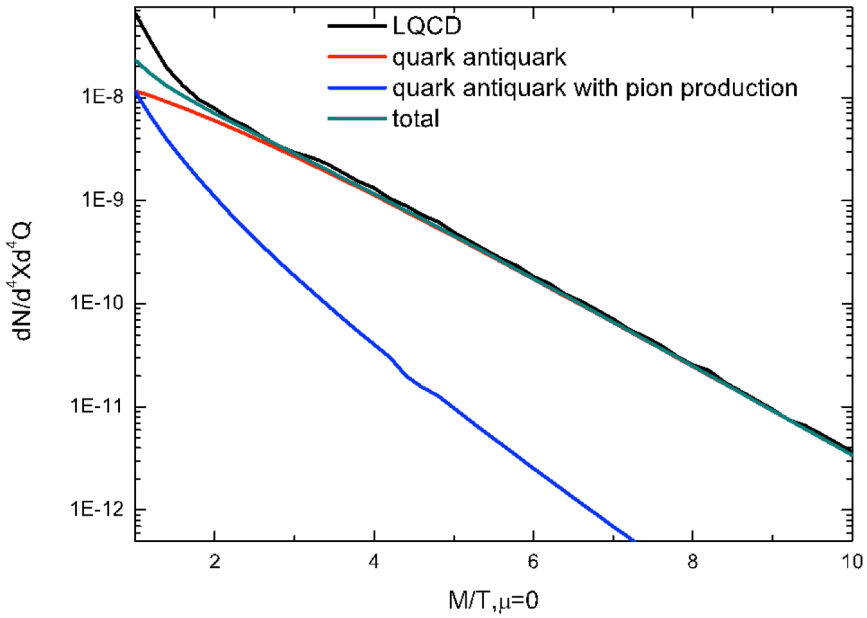

FIG. 2. Production rates of dileptons of zero momentum in a QGP of temperature T = 240 MeV and zero quark baryon chemical potential. Results from lattice QCD caculations are from Ref.[3].

The hot dense matter described by the PNJL model below the Mott temperature, especially around the transition temperature, consists of both quarks and pions as in the quarkyonic matter discussed in Ref. [4]. Since the dilepton production rates calculated with and without the contribution from pions can differ considerably, it can be used as a signature for the quarkyonic matter produced in a heavy ion collision.

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