Pseudo-critical enhancement of thermal photons in relativistyic heavy-ion collisions?

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The radiation of photons from the fireballs created in high-energy collisions of heavy nuclei has long been suggested as an observable to extract the temperatures of the strongly interacting medium in its early (hottest) evolution phases. It thus came as a surprise when the PHENIX collaboration reported a large elliptic flow of "direct photons" in Au-Au($\sqrt{s}$=200GeV) collisions, indicating a rather late emission of these photons, together with an ``effective temperature" (or inverse slope parameter) of about T_{eff} = 220±30 MeV [1]. In our previous work [2] we have shown that these observations can be reconciled with an emission of thermal photons with large contributions from the hadronic phase, where the elliptic flow of the expanding fireball is large and the local emission temperature of $T < 180$ MeV is Doppler blue-shifted to produce the experimentally observed value for T_{eff}.

In the present work [3] we have scrutinized the above findings by implementing an updated equation of state (using lattice-QCD data) and cross-checking our expanding fireball model against a hydrodynamic evolution of the medium. Both evolution models have been tuned to reproduce the bulk-hadron spectra and their elliptic flow at both RHIC and LHC energies.

In Fig. 1 (left) we compare the temperature emission profile of thermal photons at given transverse momentum of q_T = 2 GeV for both evolution models, clearly indicating that in both cases a maximum of the emission occurs around the pseudo-critical temperature of T_{pc} ~ 170 MeV. However, the hydrodynamic model radiates significantly less photons from the hadronic phase, which can be understood by its continuous freeze-out throughout the lifetime of the fireball, leading to a gradual decrease of the "active" matter elements, see right panel of Fig. 1.

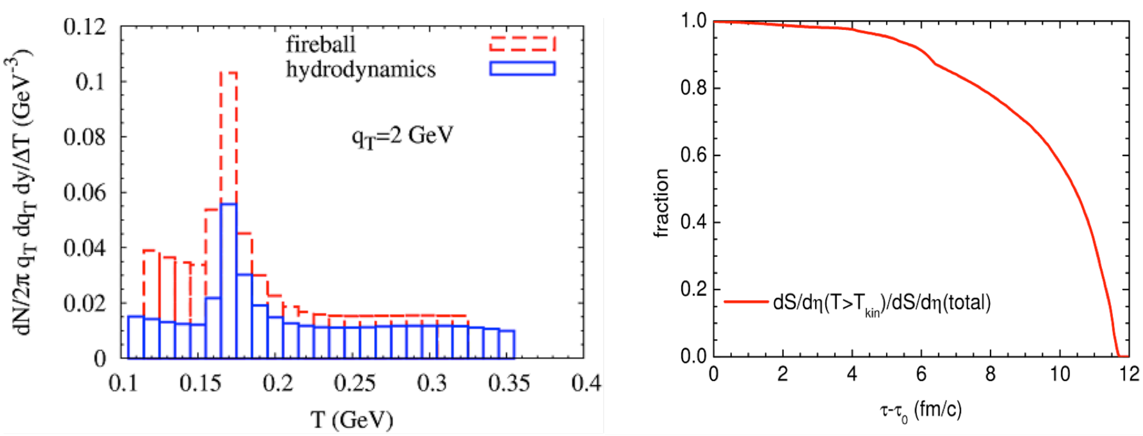

FIG. 1. Left: Emission profile of thermal photons as a function of temperature. Right: fraction of the entropy at temperatures above the kinetic freeze-out temperature to the total entropy in the hydrodynamic evolution model as a function of proper time in the rest frame of the fluid cells.

A comparison of the final photon spectra and elliptic flow from both evolution models is displayed in Fig. 2 for central Au-Au collisions at RHIC. Overall, there is a fair agreement in the photon observables between the two evolution models. Upon closer inspection one finds that the larger hadronic emission contribution from the fireball expansion leads to slightly higher spectral yields and elliptic flow. Since both evolution models tend to under-predict the experimental data at low q_T, an increased thermal photon emission rate seems to be required to help resolve the discrepancies. Investigations of hitherto unaccounted for photon sources in the hadronic phase are ongoing [4].

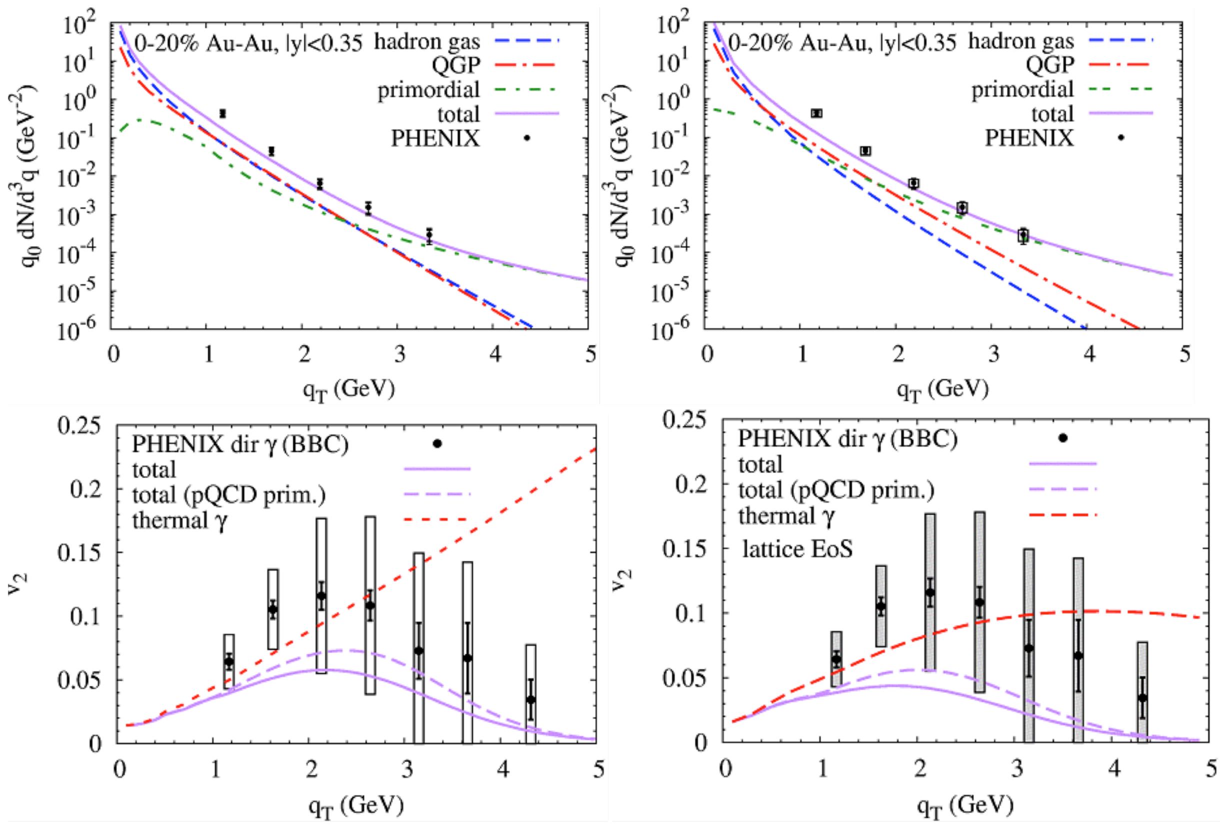

FIG. 2. Comparison of our calculations [3] for direct-photon spectra (upper panels) and their elliptic flow (lower panels) to PHENIX [1] data in 0-20% Au-Au collisions at √s=200AGeV, using either an isotropically expanding fireball model (left column) or ideal hydrodynamics (right column).

[1] A. Adare *et al.*, Phys. Rev. Lett. **103**, 132301 (2010); *ibid.* **109**, 122302 (2012).
[2] H. van Hees, C. Gale, and R. Rapp, Phys. Rev. C **84**, 054906 (2011).
[3] H. van Hees, M. He, and R. Rapp, Nucl Phys. **A933**, 256 (2015); ibid. **A931**, 696 (2014).
[4] N. Holt, P. Hohler, and R. Rapp, in preparation (2015).