Universal parameterization of thermal photons in hadronic matter

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The emission of thermal photon radiation from hadronic matter plays an important role in the understanding of direct-photon observables in high-energy heavy-ion collisions [1]. In particular, the soft spectral slopes and large elliptic flow of photon radiation observed by the PHENIX collaboration in Au-Au($\sqrt{s}$=200GeV) collisions at RHIC [2] suggest important emission sources from the later hadronic phases of the expanding fireball formed in these collisions, based on our previously calculated emission rates from hot and dense hadronic matter including the effects of baryons and anti-baryons [3].

To render the rather involved microscopic rate calculations widely available for phenomenological applications in heavy-ion collisions, we have in the present work [4] developed a universal parameterization of the photon emissivity valid over a broad range of temperatures, T = 100-180 MeV, and baryon chemical potentials, μ_B = 0-400 MeV, and for photon energies from q_0= 0.2-5 GeV. While parameterizations of the emission rates from the $\pi\rho a_1$ system have been provided earlier [3], the effects of higher mesonic resonance and baryon-induced emission (as encoded in the in-medium ρ-meson spectral function of Ref. [5]) have not been readily available through a compact parameterization thus far. Here, we have constructed such a parameterization in the 3 variables (q_0, μ_B, T) using nested fitting techniques, resulting in an overall accuracy of within 20% over more than 10 decades in the emission

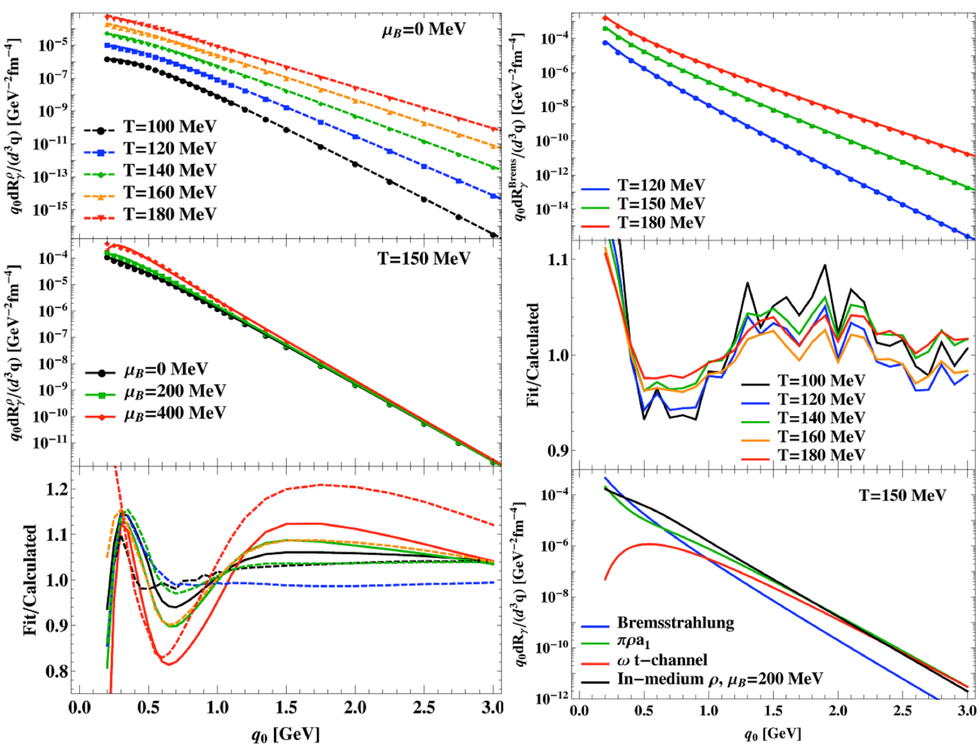

FIG. 1. Parameterizations (lines) of thermal photon emission rates from hot and dense hadronic matter (symbols). Left column: for the in-medium ρ-meson spectral function [5] at the photon point at vanishing (upper panels) and finite (middle panel) baryon chemical potential, with pertinent relative error plot (lower panel). Right column: for $\pi\,\pi \rightarrow \pi\,\pi\,\gamma$ Bremsstrahlung [6] (upper panel) with corresponding relative error plot (middle panel), and an overview plot of different sources (lower panel).

rate, cf. Fig. 1 left. Note that even at vanishing chemcial potential, the (equal) contributions of baryons and anti-baryons do not vanish but add up.

In addition, we have revisited the role of $\pi\pi \rightarrow \pi\pi\gamma$ and $\pi K \rightarrow \pi K\gamma$ Bremsstrahlung, by extending the calculations of Ref. [6] to high energies and providing pertinent parameterizations as well, cf. Fig. 1 right. The lower right panel of Fig. 1 summarizes the various sources of thermal hadronic photon emission, indicating the importance of anti-/baryonic and mesonic-resonance sources while the Bremsstrahlung off light meson scattering comes in at the ~10% level.

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