Photon and dilepton production in heavy-ion collisions

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Electromagnetic probes – real and virtual photons – carry undisturbed information from every stage of the heavy-ion collision, providing the opportunity to access the dynamics of the collision, the properties of the hot and dense QCD matter, the hadronization process, and even the degrees of freedom in the initial partonic state, discriminating between a gluon-dominated system and a quark matter with abundant charge carriers.

Using the PHSD transport approach, we investigate the role of hadronic and partonic sources for the photon spectra and the flow coefficients $v_2$ and $v_3$ as well as the possibility to extract the QGP signal from the experimental observables.

Sources of real photons

1) hadronic:

- Decays of mesons (e.g., $\pi^0, \rho, \omega, \phi, \eta, \eta'$)
- Meson-meson and meson-baryon bremsstrahlung

2) partonic:

- Initial hard partonic interactions (e.g., QCD photon production)
- In-medium gluon production (PHSD)
- Partonic sources for the photon spectra and the flow coefficients $v_2$ and $v_3$ (PHSD)

Results: photons

Direct photon spectra at SPS, RHIC and LHC energies have strong contributions from the hadronic interaction channels (bremsstrahlung) as well as from the QGP.

$Q^2$ radiation occurs at early times, when flow is not yet developed.

At RHIC energy we found that hadronic channels scale as $N_{c}^{2}$, partonic channels scale as $N_{c}^{-1}$.

The centrality dependence of the photon spectra at LHC is of great interest (see the predictions).

The large elliptic flow of direct photons from PHSD is due to the emission in the late stages of the heavy-ion collisions with dominant hadronic radiation processes. Future precise measurements of the direct photon triangular flow are expected to clarify these findings.

Results: dileptons

Dilepton spectra at low masses ($M=0.4-0.8$ GeV) in heavy-ion collisions at SPS and RHIC energies clearly show an excess over the cocktail of vacuum sources due to the broadening of the $p$-meson.

The spectra in the high-mass region ($M=1$ GeV) are dominated by the QGP radiation and the combined leptons from the semi-leptonic decays of partly correlated heavy mesons.

Results: what are the initial degrees of freedom?

Predicted differences in the photon and dilepton spectra depending on the initial chemical composition of the produced QGP: gluon- or quark-dominated. Disentangling the two scenarios experimentally requires subtracting charm and bottom decays from the dilepton yield.

References:

- O. Linnyk et al., arXiv:1411.5309
- PHENIX Collaboration (A. Adams et al.), arXiv:0609.0657