Photon production from a non-equilibrium quark-gluon plasma

Lusak Bhattacharya¹, Radoslaw Ryblewski², and Michael Strickland¹
¹Department of Physics, Kent State University, Kent, OH 44242 United States
²The H. Niedzielski Institute of Nuclear Physics, Polish Academy of Sciences, PL-31342 Kraków, Poland

Introduction

In the study of the QGP-Glauber-Plasma, an important question is the time scale for the thermalization and re-equilibration of the matter created in relativistic heavy ion collisions. Theoretical calculations in both the weak-coupling and strong-coupling limits find that the QGP created immediately after the initial nuclear impact ($\tau = 0.2$ fm/c) is highly anisotropic in local rest frame (LRF) momenta.

- Photon production from a non-equilibrium quark-gluon plasma
- Photon rate
- Anisotropic QGP
- Methodology
- Interesting Results
- Conclusions
- Acknowledgements and References

In the study of the QGP-Glauber-Plasma, we are able to better describe early-time photon circumstances of their production to the detector. For this, we include the two leading-order processes: Compton scattering and quark-antiquark annihilation. We assume a min-bias collision with $p_{T} \leq 10$ GeV and we begin the aHydro evolution at $\tau_0 = 0.03$ fm. The soft and hard contributions to the isotropic ($f_{\eta} = 0$) photon rate and the total rate obtained by summing these contributions.

Interesting Results

We now present our interesting results for the photon spectrum and elliptic flow of QGP-generated photons. We focus here on Pb-Pb collisions with nucleon-nucleon center of mass energies of $\sqrt{s_{NN}} = 2.76$ TeV.

- Increasing the shear viscosity of the QGP results in an increase in peak photon rate and the total rate obtained by summing these contributions.
- Photon elliptic flow coefficient $v_2$ is independent of the choice of the separation scale within numerical uncertainties.

Conclusions

- Our final result indicate that, if one holds the final particle multiplicity fixed, for fixed $q_{T}/a$, varying the initial momentum-space anisotropy $\xi_0$ results in significant variations of the high transverse-momentum photons.

Acknowledgements and References

Lusak Bhattacharya was supported by a M. Hildred Blewett Fellowship from the American Physical Society. M. Strickland was supported by the U.S. Department of Energy under Award No. DE-AE0494ER41274. R. Ryblewski was supported by the National Science Centre Grant No. DEC-2012/07/D/ST2/02125.

References


Methodology

In this work, we studied the impact of space-time dependent anisotropies on the photon differential spectrum and elliptic flow coefficient associated with photons emerging from the QGP as a function of high transverse momenta.

- We assume that the one-particle distribution function is of eikonal form [2].
- The aHydro framework reduces to second-order viscous hydrodynamics in the limit of small anisotropies, but reproduces the dynamics of the QGP space-olalally when there are large nonuniformity anisotropies [4,5].
- For the rate, we included the two-leading-order processes: Compton scattering and quark-antiquark annihilation.
- We integrated the rate over the space-time volume of the QGP using $(3+1)$D anisotropic hydrodynamics.

We assume a min-bias collision with $p_{T} \leq 10$ GeV and we begin the aHydro evolution at $\tau_0 = 0.03$ fm. At $\tau_0$, we assume that the produced matter has no transverse flow, i.e., $v_2(\tau_0, x, y) \equiv v_2(\tau_0, y, x) \equiv 0$, while the initial longitudinal flow is of Bjorken form $v_2(0, x, y) \equiv \xi_0$. We assume that the initial anisotropy field is homogeneous, $v_2(\tau_0, x, y) \equiv \xi_0$.

We now present our interesting results for the photon spectrum and elliptic flow of QGP-generated photons. We focus here on Pb-Pb collisions with nucleon-nucleon center of mass energies of $\sqrt{s_{NN}} = 2.76$ TeV.