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Illuminating the early stages of relativistic heavy-ion collisions: the pre-hydro phase as seen through photons and hadrons

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We model relativistic heavy-ion collisions with a hydrid dynamical approach which consists of an IP-Glasma initial state followed by a phase modeled by an effective QCD kinetic theory [1]. This then leads into viscous hydrodynamics and finally transport theory (MUSIC + UrQMD) [2]. The system's complete energy-momentum tensor – including the shear and bulk viscous components – is followed through these different stages. The effect of the pre-hydro phase on the spectra and flow coefficients of photons and hadrons is highlighted. We study how that non-equilibrium phase influences the hadron and photon flow coefficients in Pb+Pb, Xe+Xe, and O+O collisions at 5 TeV. Because the space-time volume scales differently from the number of binary collisions from O+O to Xe+Xe and Pb+Pb collisions, a systematic system size comparison of photon production can further shed light on the relative contributions from thermal and prompt sources and provide further insight into early time QGP dynamics. We also explore the effect of early chemical equilibrium on the photon observables.

[1] A. Kurkela, A. Mazeliauskas, J.F. Paquet, S. Schlichting, and D. Teaney, "Matching the Nonequilibrium Initial Stage of Heavy Ion Collisions to Hydrodynamics with QCD Kinetic Theory," Phys. Rev. Lett. 122, no. 12, 122302 (2019); "Effective kinetic description of event-by-event pre-equilibrium dynamics in high-energy heavy-ion collisions," Phys. Rev. C 99, no. 3, 034910 (2019)

[2] S. McDonald, C. Shen, F. Fillion-Gourdeau, S. Jeon and C. Gale, "Hydrodynamic predictions for Pb+Pb collisions at 5.02 TeV", Phys. Rev. C 95, no. 6, 064913 (2017)

Collaboration (if applicable)

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Track

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