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Dilepton Probes of Hot QCD Matter

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Dileptons are penetrating electromagnetic probes of strongly interacting matter and provide direct access to thermal radiation emitted throughout the evolution of relativistic nuclear collisions. We investigate dilepton production from SIS to LHC energies within the off-shell Parton–Hadron–String Dynamics (PHSD) transport approach, which consistently describes the dynamical evolution and interactions of partonic and hadronic degrees of freedom.

The partonic sector of PHSD is based on the Dynamical QuasiParticle Model (DQPM), whose temperature- and baryon-density-dependent quasiparticle properties are constrained by lattice-QCD thermodynamics. At low and intermediate collision energies, we additionally explore dilepton radiation for different realizations of the QCD equation of state, including a crossover and a scenario with a critical end point and first-order phase transition.

PHSD calculations of dilepton invariant-mass spectra in p+p, p+A, light-ion, and heavy-ion collisions are compared with available HADES, STAR, and ALICE measurements and provide an overall good description of the data. We present the excitation function of thermal QGP dilepton radiation and study its competition with correlated heavy-flavor decays. In central Au+Au collisions, the QGP contribution exceeds correlated charm dileptons below $\sqrt{s_{NN}} \simeq 25\text{--}30\text{--GeV}$, whereas toward RHIC and LHC energies heavy-flavor decays become increasingly important in the intermediate-mass region.

We further investigate transverse-mass spectra and inverse-slope parameters T_{eff} , including recent O+O collisions, and discuss the origin of the large effective slopes observed by STAR. Toward LHC energies, we find an increasing contribution of partonic radiation also in small systems, including proton–proton collisions. Our results demonstrate that dileptons provide a sensitive probe of thermal QGP radiation and its space–time evolution over a broad range of collision energies.

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