Theoretical Review of Dileptons from Heavy Ion Collisions

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Invariant-mass spectra of lepton pairs are considered a direct probe of in-medium modifications of the electromagnetic current correlation function in hot and dense partonic and hadronic matter created in heavy-ion collisions. In this talk I review our current theoretical understanding of the dilepton signal with particular emphasis on its connection to the QCD phase diagram and chiral symmetry. In the low-mass region ($M \lesssim 1$ GeV) the dilepton yield is dominated by in-medium decays of the light vector mesons (ρ, ω, and ϕ), allowing to confront effective hadronic models with experimental data. The excess of dilepton radiation in this mass region, observed at the BEVALAC, GSI, SPS, and RHIC, indicate significant medium modifications of the vector mesons. Regarding the microscopic mechanism underlying the restoration of chiral symmetry models either predict a dropping of the vector-meson masses (Brown-Rho scaling, Vector Manifestation of chiral symmetry within hidden-local symmetry models) or a large broadening of their spectral functions with little mass shifts (hadronic many body theory, dominated by in-medium interactions with baryons). In the intermediate-mass region (1 GeV $\lesssim M \lesssim$ 3 GeV) the current correlator becomes continuum like, described by multi-meson processes in the hadronic and $q\bar{q}$ annihilation in the partonic phase. A remarkable finding of hadronic many-body models is a kind of "quark-hadron duality", i.e., close to the expected chiral-phase transition at a critical temperature, $T_c \simeq$ 160-180 GeV, dilepton spectra within the perturbative partonic and hadronic many-body models coincide. I conclude with a brief review of model comparisons with recent data from the SPS (NA60 and CERES/NA45 collaborations), RHIC (PHENIX collaboration), and Jefferson Laboratory (CLAS collaboration).