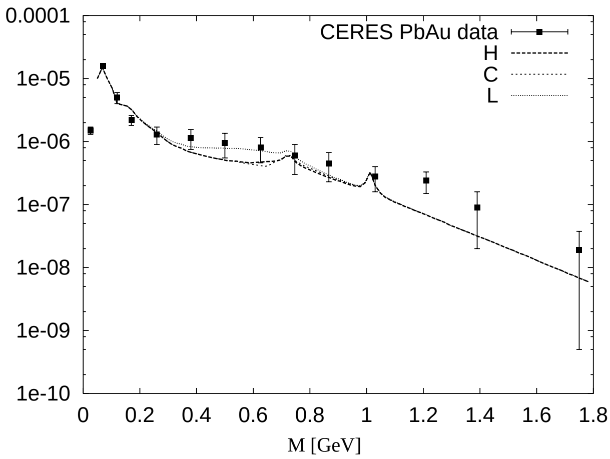
A model for dilepton production from an expanding fireball

R.A. Schneider, T.Renk and W. Weise, TU München

The search for the quark-gluon plasma (QGP) at CERN and RHIC requires a detailed understanding of the properties of hot QCD. It has become clear over the last years that a perturbative approach to thermal QCD is insufficient to calculate properties of the QGP because of the occurrence of infrared divergences and gauge dependencies of physical quantities. Even the Hard Thermal Loop resummation is likely to be applicable only for very large temperatures far outside the scope of present and future experiments. Clearly, nonperturbative input, e.g. from lattice simulations of QCD is needed to improve the situation.

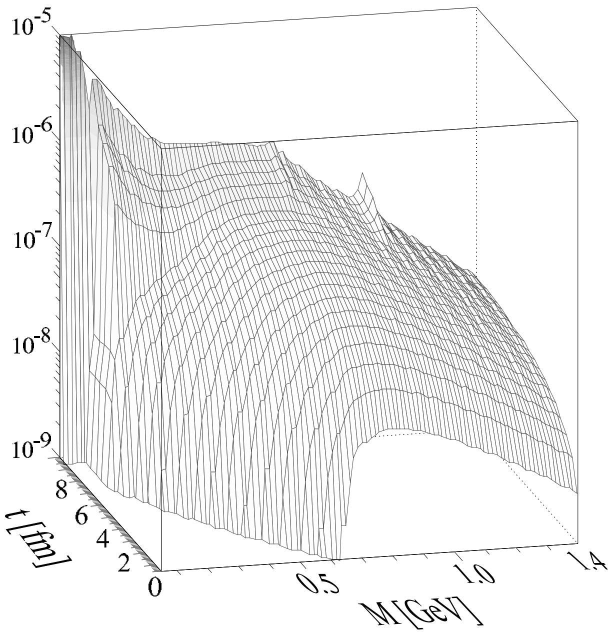
Lattice results indicate that the equation of state (EOS) of a QGP can be fit with a relatively simple quasiparticle model, where quarks and gluons acquire thermal masses. For these quasiparticle masses, the ansatz $m_{th} \sim g(T)T$ is used, where the coupling $g(T)$ is fit to the lattice data. One finds effective quark masses of $\sim$ 300 MeV.

Figure 1: Different quasiparticle scenarios [2] in comparison to the CERES Pb-Au data



We employ this model for the calculation of the dilepton production in a fireball produced by a heavy ion collision and compare to data taken by the CERES collaboration at the SPS. The relevant degrees of freedom in the model above the phase transition temperature T_C are now quarks and antiquarks as thermal quasiparticles which couple to the photon with the standard quark charge, whereas all QCD corrections are already incorporated in the quasiparticle masses. Several scenarios are discussed for the quasiparticle masses close to T_C. In some models, these thermal masses appear to become heavy near T_C. On the other hand, chiral restoration at T_C would imply that the quark masses drop close to the transition. We therefore investigate three cases as to their influence on the spectra of the produced dileptons: a 'heavy' mass scenario (H), a 'light' one (L) which simulates the dropping of effective quark masses near T_C and a 'constant' one (C) in which the quasiparticle mass is kept at $\sim$ 300 MeV at all temperatures.

Figure 2: Time evolution of the dilepton production yield under CERES conditions in the 'light' quasiparticle scenario, as function of the e^+e^- invariant mass M.



We use a model specified in [1] for the expansion of the fireball. For the hadronic phase below T_C, we use an improved Vector Meson Dominance model with ρ, ϕ and ω as the dominant degrees of freedom, combined with pionic excitations carrying the same quantum numbers. We assume factorization of finite baryon density effects and thermal effects and calculate the spectral function using perturbative methods.

The result describes the CERES data nicely (Fig. 1). The simple model for the fireball allows detailed insight into the expansion including its time evolution, this is shown for the 'light' scenario in Fig. 2. The low-mass region between 0.3 - 0.7 GeV is quite insensitive to the detailed parametrization of the thermal quark masses.

In conclusion, we have shown that a quasiparticle model of the QGP phase and, at $T < T_C$, a hadronic theory with finite density and temperature effects lead to a successful description of the CERES data, whereas a purely hadronic description fails in the low invariant mass region as well as in the high mass region.

References

[1] R.A. Schneider, and W. Weise, Eur. Phys. J. **A9** (2000) 357

[2] R.A. Schneider, T. Renk and W. Weise; in preparation

Work supported in part by BMBF and GSI.