Long-range correlations in the deconfined phase of QCD

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Motivation

Problem

Perturbative resummation scheme (g→1) describe QCD at the electric scale gT. However, important contribution from IR physics are missing; they are essential to understand dynamics, such as transport coefficients, in realistic conditions since at phenomenologically relevant temperatures, T~1-4T\textsubscript{C}, the QCD coupling is sizable g~O(1). These shortcomings can in part be traced back to the origin of the magnetic scale g\textsuperscript{2}T, which cannot be treated perturbatively [1].

Approach

Gribov-Zwanziger framework [2] at finite temperature: fixing residual gauge transformations that remain after Fadeev-Popov. Generation of a new scale related to onset of confinement in the vacuum: the Gribov parameter \( \mu_s \approx \text{const.} \) in the vacuum and g\textsuperscript{2}T at high-T [3]. The theory is renormalizable (Landau gauge) and suited for perturbative calculations. In the GZ theory,

\[
D_{\mu\nu}(P) = \left( g_{\mu\nu} - \frac{P_{\mu}P_{\nu}}{P^2} - \frac{1}{\gamma_G} \right).
\]

Screening mass

- We find a suppressed quark screening mass wrt. the HTL expectation: negative contribution from the presence of the IR scale, see Fig. 1. This can be understood as the suppression of the quark screening due to the presence of IR screened gluons.

Modified analytical structure

- The analytical structure of the quark propagator is modified due to complex conjugate structures from GZ propagator: allows pole contributions for the quark propagator close to the origin (IR).
- Reproduce the conventional quasi-particle poles in the time-like regime (\( \omega>0 \)).

Conclusions & outlook

- Modified IR dynamics of the gluon sector can shed light on novel features of the quark-gluon plasma. These are related to manifestations of the long-range confinement effects surviving at finite temperatures in the plasma.
- The Gribov parameter at high-T scales as the (chromo)magnetic scale g\textsuperscript{2}T
- New, improved quark screening mass (including contributions from the magnetic scale).
- Novel magnetic scaling that allows for the existence of a massless mode in the IR. This comes with a negative spectral weight, indicating that this excitation is not a quasiparticle.
- Genuine non-Abelian effects (QCD ≠ QED)
- In line with expectations from lattice and functional methods, see eg. [5]
- Interesting to study further the impact of IR improved gluons on transport coefficients, thermalization; relation to Cherenkov radiation and plasma instabilities.

References