A central goal of the relativistic heavy-ion collision program is the creation and identification of new forms of highly excited nuclear matter, in particular a deconfined and chirally symmetric Quark-Gluon Plasma (QGP). Recent data from the Relativistic Heavy-Ion Collider (RHIC) indicate that the produced matter exhibits strong collective behavior which is incompatible with expectations based on a weakly interacting QGP: standard perturbative QCD (pQCD) cross sections for quarks and gluons do not allow for rapid thermalization [1] as required in hydrodynamic models to reproduce the observed magnitude of the elliptic flow. The question thus arises what the nature of the produced medium at temperatures $T \approx 1-2 T_c$ is ($T_c \approx 170$ MeV: critical temperature). Of particular importance is the identification of the relevant interactions that can provide sufficiently large scattering rates while maintaining consistency with the QGP equation of state (EoS), as determined in lattice QCD (lQCD). Recent (quenched) lQCD calculations found intriguing evidence that mesonic correlation functions, after transformation into Minkowski space, exhibit resonance (or bound-state) like structures for temperatures up to $\sim 2T_c$ [2]. As is well known, resonance scattering is typically characterized by isotropic angular distributions and thus more efficient in randomizing momentum distributions than forward-dominated pQCD cross sections. Indeed, a recent calculation [3] based on the assumption of resonant “D”-meson states in the QGP has shown that thermal relaxation times for charm quarks are reduced by a factor of $\sim 3$ as compared to using perturbative rescattering cross sections.

In the present work [4] we have set up a Brueckner-type many-body scheme, utilizing (heavy) quark-antiquark (q-qbar) interaction potentials as extracted from lQCD (supplemented by relativistic effects), to study the properties of light (anti-) quarks in a Quark-Gluon Plasma at moderate temperatures, $T \sim 1-2 T_c$. The q-qbar $T$-matrix (including color-singlet and -octet channels) has been evaluated self-consistently with corresponding quark self-energies and spectral functions. Quark interactions with gluons are introduced through a “gluon-induced” quark mass $m$ which is a parameter in our model.

![Figure 1](image_url)

**Figure 1.** Real (full lines) and (absolute value of the) imaginary part (dashed lines) of the light-quark (on-shell) $T$-matrix in the color-singlet channel at temperatures $T=1.2T_c$, $1.5T_c$ and $1.75T_c$ (left, middle and right panel, respectively) vs. q-qbar CM energy $E$, with a "gluon-induced" quark-mass term $m=0.1$ GeV.

Our main results are the following: (i) the attractive color-singlet potential generates light mesonic states in the q-qbar $T$-matrix which persist as resonances up to temperatures $\sim 1.75 T_c$; (ii) the
repulsive octet potential induces quasiparticle masses of up to 150 MeV; (iii) the resonance structures in the \( T \)-matrix entail quark-quasiparticle widths of \( \sim 200 \) MeV, corresponding to scattering rates of \( \sim 1 \text{fm}^{-1} \)c possibly reflecting liquid-like properties of the system.

The real and imaginary part of the on-shell \( T \)-matrix in the color-singlet channel for quasiparticles with a gluon-induced mass-term of \( m=0.1 \text{GeV} \) are shown in Fig.1 for temperatures \( T=1.2-1.75 \text{T}_c \). At \( T=1.2 \text{T}_c \) the color-singlet \( T \)-matrix exhibits a relatively narrow bound state located below the \( \text{q-qbar} \) threshold energy of \( E_{\text{thr}} \sim 0.52 \text{ GeV} \) (corresponding to twice the real part of the total quark self-energy discussed below). When increasing the temperature to \( 1.5 \text{T}_c \) and \( 1.75 \text{T}_c \), the state moves above the threshold \( (E_{\text{thr}} \sim 0.48 \text{ GeV}) \), accompanied by a significant broadening.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{Real (solid lines) and imaginary (dashed lines) parts of the on-shell quark self-energy vs. quark 3-momentum at temperatures \( T=1.2\text{T}_c, 1.5\text{T}_c \) and \( 1.75 \text{T}_c \) (left to right) with \( m=0.1 \text{GeV} \).}
\end{figure}

In Fig. 2 the real and imaginary parts of the self-consistently determined self-energy are displayed. The imaginary parts translate into widths of about 200 MeV at low momenta and for temperatures around \( 1.5 \text{T}_c \), and are mostly due to resonant scattering in the singlet channel. This is further illustrated by the significant increase in \( \text{Im} \Sigma \) when going from 1.2 to 1.5 \( \text{T}_c \) (cf. left and middle panel in Fig. 2), during which the state in the \( T \)-matrix moves from below to above threshold (cf. left and middle panel in Fig. 2), \textit{i.e.}, converts from bound state to resonance. The magnitude of the quark widths is quite comparable to the thermal masses, qualitatively supporting the notion that the QGP could be in a liquid-like regime.