Strange and charm quark production in hot QCD

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Quasiparticle Model Setup

QGP = weakly-interacting system of massive, dressed quarks and gluons

\[ s = \sum_{i=g,(l,l,s,\bar{s},c,\bar{c})} \frac{d_i}{\pi^2} \int dp \frac{2p^2}{E_i(T)T} \left( \frac{4\pi^2}{3p^2 + m_i^2[G(T), T]} \right) f_i^0 \Rightarrow G(T) \Rightarrow m_i[G(T), T] \]

Full bullets - in quasiparticle model (QPM), open bullets - original lattice data

Interactions are encoded in dynamically generated masses \( m_i \) through effective coupling \( G(T) \) deduced from lQCD EoS \( (s/T^3) \).

[V.M, M. Bluhm, C. Sasaki, K. Redlich, PRD 100 (2019) and preliminary; lQCD: Wuppertal-Budapest]
Specific Shear Viscosity

Computed in kinetic theory with relaxation time approximation, \( \tau_i \approx (\sum n_i \bar{\sigma}_{12 \rightarrow 34})^{-1} \)

\[
\eta = \frac{1}{15T} \sum_{i=l,\bar{l},s,\bar{s},g} \int \frac{d^3p}{(2\pi)^3} \frac{p^4}{E_i^2} d_i \tau_i f_i^0 (1 \pm f_i^0).
\]

[V.M, M. Bluhm, C. Sasaki, K. Redlich, PRD 100 (2019)]


Full bullets - QPM result. Red curve on LHS = black on RHS.
Time evolution of the QGP

For boost-invariant medium we juxtapose:


\[ T(\tau) = T_0 \left( \frac{\tau_0}{\tau} \right)^{1/3} \]

2. (2+1)D 2\textsuperscript{nd} order viscous hydro with $\eta/s$ from QPM [J. Auvinen et al., Phys.Rev.C 102 (2020)]

\* Same initial conditions for both: $\tau_0 = 0.2 \text{ fm}$, $T_0 = 0.624 \text{ GeV}$
Production rate of strange and charm quarks

Cross-sections depend on effective masses of the quasiparticles

\[
    R_{s}^{\text{gain}} = \frac{1}{2} \bar{\sigma}_{gg \rightarrow s\bar{s}} n_{g}^{2} + \bar{\sigma}_{q\bar{q} \rightarrow s\bar{s}} n_{q}^{2} + \bar{\sigma}_{c\bar{c} \rightarrow s\bar{s}} n_{c}^{2}
\]

\[
    R_{c}^{\text{gain}} = \frac{1}{2} \bar{\sigma}_{gg \rightarrow c\bar{c}} n_{g}^{2} + \bar{\sigma}_{q\bar{q} \rightarrow c\bar{c}} n_{q}^{2} + \bar{\sigma}_{s\bar{s} \rightarrow c\bar{c}} n_{s}^{2}
\]


Production rates for \( N_f = 2 + 1 + 1 \) are suppressed by larger effective \( m_s \) and \( m_c \).
Production rate of strange and charm quarks

\( N_f = 2 + 1 \), comparison to models with different setup

Differences up to few OOM arise due to different particle masses, couplings, EoS...

\( T_0 \simeq 0.6 \text{ GeV} \rightarrow T_c \text{ at } \tau = 11-13 \text{ fm} \)

Preliminary

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