

Heavy-Quark Diffusion in the Quark-Gluon Plasma

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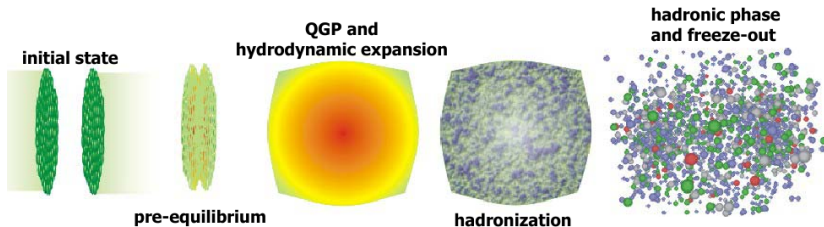
M. Mannarelli, V. Greco and R. Rapp



- 1 Heavy-Ion Collisions in a Nutshell
- 2 Heavy Quarks as probes of the Quark-Gluon Plasma
- 3 Summary and Outlook

Heavy-Ion collisions in a Nutshell

- Theory of strong interactions: Quantum Chromo Dynamics, QCD
- At high enough densities/temperatures: hadrons dissolve into a Quark-Gluon Plasma (QGP)
- hope to create QGP in Heavy-Ion Collisions at RHIC (and LHC)
- RHIC: collide gold nuclei with energy of 200 GeV per nucleon:

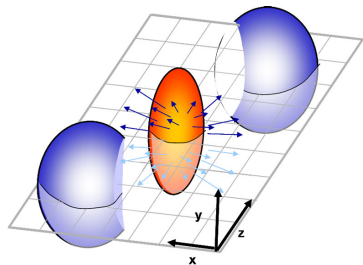


Evidence for QGP from heavy-ion observables

- particle p_T spectra show **hydrodynamical behavior**
- **collective flow** of matter in local **thermal equilibrium**
- nuclear modification factor \Rightarrow degree of **thermalization**

$$R_{AA}(p_T) = \frac{dN_{AA}/dp_T}{N_{\text{coll}}dN_{pp}/dp_T}$$

- no QGP $\Rightarrow R_{AA} = 1$; observed: $R_{AA} < 1$ (suppression) at high p_T
- in **non-central collisions**: **anisotropic collective flow**



- initially reaction zone of elliptic shape
- pressure gradients: $\langle |p_x| \rangle > \langle |p_y| \rangle$
- measure of **flow anisotropy**:

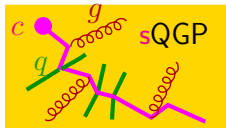
$$v_2 = \left\langle \frac{p_x^2 - p_y^2}{p_x^2 + p_y^2} \right\rangle = \langle \cos(2\phi_p) \rangle$$

Heavy Quarks in Heavy-Ion collisions

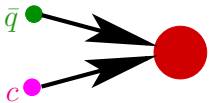


c, b quark

hard production of HQs
described by PDF's + pQCD (PYTHIA)

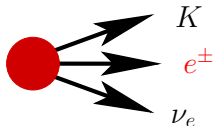


HQ rescattering in QGP: Langevin simulation
drag and diffusion coefficients from
non-perturbative many-body T matrix (sQGP)



Hadronization to D, B mesons via
quark coalescence + fragmentation

V. Greco, C. M. Ko, R. Rapp, PL B **595**, 202 (2004)



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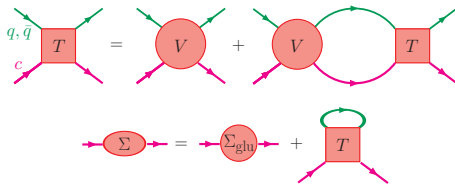
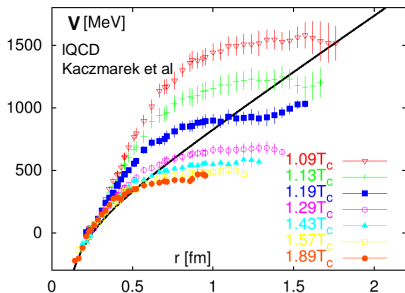
e^\pm

ν_e

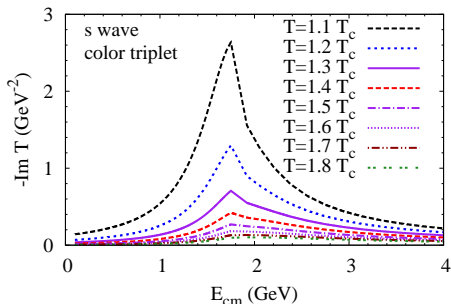
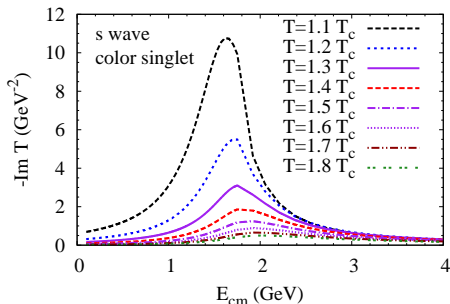
semileptonic decay \Rightarrow
“non-photonic” electron observables

HQ Interactions in the sQGP

- rapid **thermalization** \Rightarrow **strongly** coupled QGP (sQGP)
- static potential between two quarks in the QGP
- calculated in lattice-QCD simulations (model independent!)
- evaluate cq and $c\bar{q}$ scattering amplitudes in **many-body T -matrix approach**



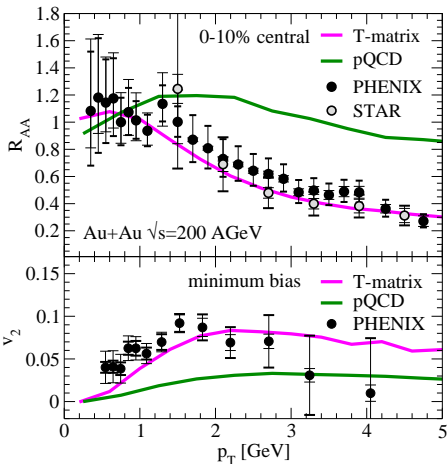
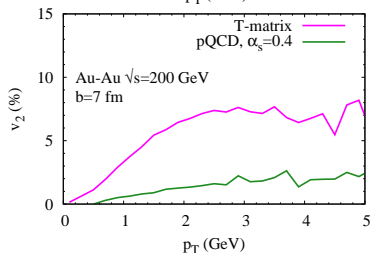
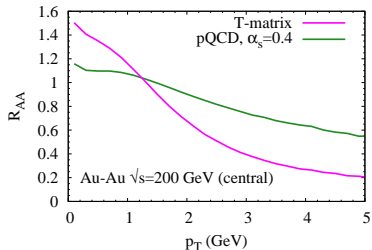
HQ Interactions in the sQGP



- **non-perturbative** interactions
- **resonance formation** at lower temperatures $T \simeq T_c$
- **melting** of resonances at higher T
- provides explanation for **strongly coupled** medium \Rightarrow sQGP

Heavy-Quark Diffusion in the sQGP and RHIC data

- use **T matrix** \Rightarrow transport coefficients \Rightarrow drag and diffusion
- **Brownian Motion** of heavy quarks in relativistic Langevin simulation
- quark **coalescence**+fragmentation $\rightarrow D/B \rightarrow e + X$



Summary and Outlook

- Summary

- Heavy quarks in the sQGP
- non-perturbative interactions necessary to understand data
- resonance formation at $T > T_c$ mechanism for strong coupling
- for details see: arXiv:0706.4443 [hep-ph],
Phys. Rev. C **73**, 034913 (2006)

- Outlook

- include inelastic heavy-quark processes (gluon-radiation processes)
- study other heavy-quark observables like charmonium suppression/regeneration (see next talk by Xingbo Zhao!)