Shear viscosity η to electric conductivity σ_{el} ratio for the quark-gluon plasma

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arxiv:1407.2559

53rd International Winter Meeting on Nuclear Physics,

Bormio 25-30 Jan 2015

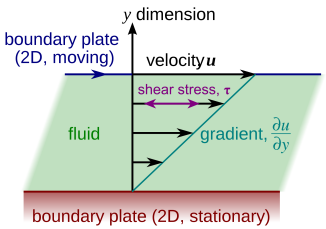
Transport Coefficients

Transport coefficients like η, ζ, σ_{el}, χ, D, characterize the non-equilibrium behavior of a system due to an external perturbation.

Motivations in QGP

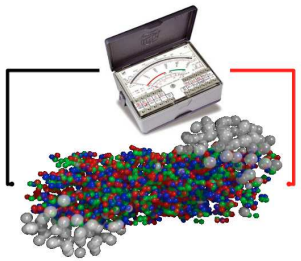
Shear viscosity

$$\frac{F}{A_{yz}} = -\eta \frac{\partial u_x}{\partial y}$$

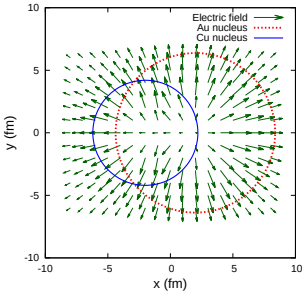


- Collective behavior v_2
- Perfect fluid $\eta/s = 1/4\pi$
- Lattice QCD

Electric conductivity



$$\vec{J} = \sigma_{el}\vec{E}$$



- Strong electric fields
- Collective behavior v_1
- Photon rate $\propto \sigma_{el}$
- Lattice QCD

$$\eta/s = \underbrace{\frac{1}{15Ts}\left\langle \frac{p^4}{E^2} \right\rangle}_{\text{Thermodynamics}} \overbrace{\left(\tau_q \rho_q^{\text{tot}} + \tau_g \rho_g\right)}^{\text{Dynamics}}$$

$$\sigma_{el}/T = \underbrace{\frac{e_\star^2}{3T^2}\left\langle \frac{p^2}{E^2} \right\rangle}_{\text{Thermodynamics}} \overbrace{\tau_q}^{\text{Dynamics}} \rho_q$$

Relaxation Times

- $\tau_q^{-1} \sim \rho_q \sigma^{qq} + \rho_{\bar{q}} \sigma^{q\bar{q}} + \rho_g \sigma^{qg} \Rightarrow$ info about quark-(anti-)quark and quark-gluon scatterings
- $\tau_g^{-1} \sim \rho_q \sigma^{qg} + \rho_g \sigma^{gg} \Rightarrow$ info about quark-gluon and gluon-gluon scatterings

Taking the ratio

$$\frac{\eta/s}{\sigma_{el}/T} \sim \overbrace{\text{Thermodynamics}}^{\text{fixed by IQCD}} \times \underbrace{\left(1 + \frac{\tau_g}{\tau_q}\frac{\rho_g}{\rho_q^{\text{tot}}}\right)}_{\propto \text{ quark to gluon scattering rates}}$$

- How to fix the Thermodynamics?
- What is the behavior of the ratio as a function of the temperature?
- Can we really extract information about the relative role of quarks and gluons?
- Does the ratio depend on the running coupling?