Transport coefficients in lattice $SU(2)$ gluodynamics.

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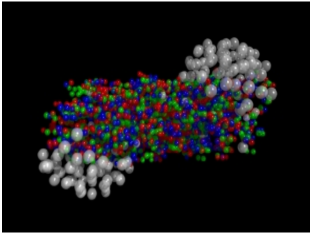
Outline

- Introduction
- Calculation of viscosity
- Results and conclusion

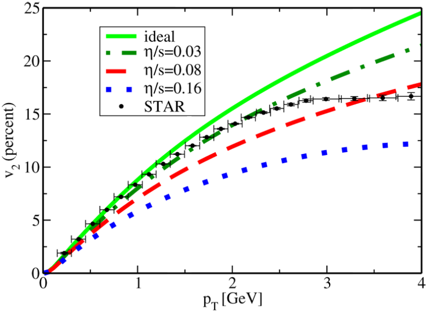
Introduction. Hydrodynamical description.



Hydrodinamical description of the distribution of final particles

- One heavy ion collision produces a huge number of final particles
- Large number of particles $\Rightarrow$ hydrodynamical description can be used
- In hydrodinamics transport coefficients control flow of energy, momentum, electrical charge and other quantities

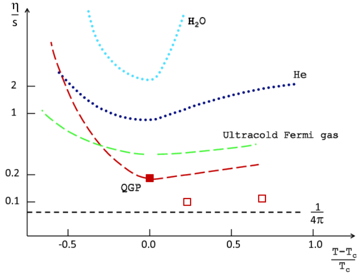
Shear viscosity. Value and bounds.



Teaney D., *Viscous Hydrodynamics and the Quark Gluon Plasma*, arXiv:0905.2433

- Experimentally preferred value: $\frac{\eta}{s} \sim (1 \leftrightarrow 3)\frac{1}{4\pi}$
- Experimental bound: $\frac{\eta}{s} < 5\frac{1}{4\pi}$
- KSS-bound: $\frac{\eta}{s} \geq \frac{1}{4\pi}$ arXiv:hep-th/0405231

Shear viscosity. Value and bounds.



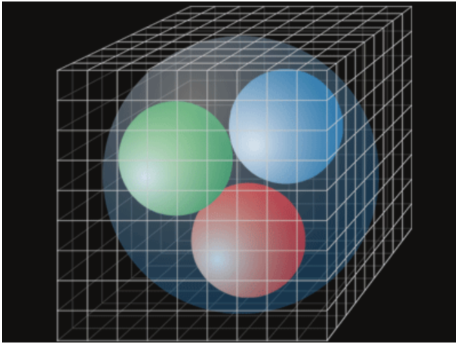
Cremonini S., Gursoy U. and Szepietowski P., *On the Temperature Dependence of the Shear Viscosity and Holography*, arXiv:1206.3581

Comparison of different liquids

QGP the most superfluid liquid

The aim: first principle calculation of transport coefficients

Lattice simulations of QCD.



- **Allows to study strongly interacting systems**
- **Based on the first principles of quantum field theory**
- **Acknowledged approach to study QCD**
- **Very powerful due to the development of computer systems**

Previous lattice calculations ($SU(3)$ gluodynamics).

- F. Karsch, H. W. Wyld. Phys. Rev. D35 (1987)
- A. Nakamura, S. Sakai Phys. Rev. Lett. 94, 072305 (2005)
- H. B. Meyer, Phys. Rev. Lett. 100 (2008) 162001

Viscosity in lattice calculations.

Green-Kubo relation:

$$\eta = \pi \lim_{\omega \to 0} \frac{\rho_{12,12}(\omega, \mathbf{q} = 0)}{\omega}$$

Green function measured on the lattice(Eucledian):

$$C_{12,12}(x_0, \mathbf{p}) = \beta^5 \int d^3\mathbf{x} e^{i\mathbf{p}x} \langle T_{12}(0) T_{12}(x_0, \mathbf{x}) \rangle$$

Spectral function and correlator of stress-energy tensor:

$$C_{12,12}(x_0, \mathbf{p}) = \beta^5 \int_0^\infty \rho_{12,12}(\omega, \mathbf{p}) \frac{\cosh \omega(\frac{1}{2} L_0 - x_0)}{\sinh \frac{\omega L_0}{2}} d\omega$$

Stress-energy tensor for gluodynamics:

$$T_{\mu\nu} = 2 \,\mathrm{tr}(F_{\mu\sigma} F_{\nu\sigma} - \frac{1}{4} \delta_{\mu\nu} F_{\rho\sigma} F_{\rho\sigma})$$

Numerical setup

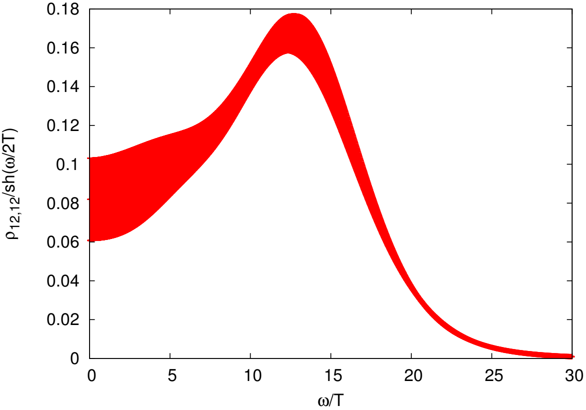
- $SU(2)$-gluodynamics with Wilson action:

$$S = \frac{\beta}{2} \sum_{pl} \mathrm{tr}(1 - U_{pl})$$

- Lattice 8×32^3
- $\beta = 2.643$
- $T/T_c \approx 1.2$
- Clover-shaped discretization for $F_{\mu\nu}$
- Two-level algorithm for measuring stress-energy tensor correlator (significantly improves statistical accuracy of our calculations).

V.V. Braguta, A.Yu. Kotov, JETP lett. 98 (2013) 147

Spectral function $\rho_{12,12}$



Numerical results

$$\frac{\eta}{s} = 0.111 \pm 0.032(stat.)$$

KSS-bound (arXiv:hep-th/0405231):

$$\eta/s \geq \frac{1}{4\pi} \approx 0.08$$

Perturbative result (arXiv:hep-ph/0302165,hep-ph/0408347):

$$\eta/s \sim 2.0$$

Experimental bound and preferred value (arXiv:0905.2433):

$$\eta/s < 5\frac{1}{4\pi} \approx 0.4$$

$$\eta/s \sim (1 \leftrightarrow 3)\frac{1}{4\pi}$$

Conclusions

- Stress-energy tensor correlator was measured on the lattice;
- Spectral function and value of viscosity ($\eta/s = 0.111 \pm 0.032$) were extracted;
- QGP manifests properties of strongly correlated system.