TRANSPORT PROPERTIES OF

\[ \mathcal{N} = 4 \] SYM AT FINITE COUPLING

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P.B., Alex Buchel - JHEP 06 01: 103, 2006 - [hep-th/0510041]
Aim of the Work

- Study of the hydrodynamics for SYM theory with leading correction in the inverse 't Hooft coupling
  - Shear diffusion constant
  - Speed of sound
  - Bulk viscosity
- Consistent picture of the $\alpha'$-corrected sugra hydrodynamics
Supergravity Approximation

- Gauge/string correspondence provides an effective description of strongly coupled gauge theories in terms of supergravity black brane background

- Large-$N$ $\mathcal{N} = 4$ $SU(N)$ SYM at large 't Hooft coupling $\sim$ IIB-sugra in near-extremal black 3-brane background

- Hydrodynamics approximation: $\omega \to 0$, $q \to 0$, $\frac{\omega}{q} = \text{const}$
  
  ▶️ Shear viscosity $\eta$ (Policastro, Son, Starinets - [hep-th/0104066], [hep-th/0205052]):
  
  $$\eta = \frac{\pi}{8} N^2 T^3$$

  ▶️ Speed of sound $c_s$ and bulk viscosity $\zeta$ (Policastro, Son, Starinets - [hep-th/0210220]):
  
  $$c_s = \frac{1}{\sqrt{3}} \quad \zeta = 0$$
Leading $\alpha'$-corrections (1)

10-dim type-IIB action with leading $\alpha'$-corrections:

$$I = I_{sugra} + \frac{1}{16\pi G_{10}} \int d^{10}x \sqrt{-g} e^{-\frac{3}{2}\phi} W$$

with

$$\gamma = \frac{1}{8}\zeta(3)(\alpha')^3, \quad W \sim C^4$$

Important features:

- The entropy density differs from B.H. formula
- $T_H$, $S$, $E$, $F$ are $\alpha'$-corrected
- $R(S^5)$ not constant
Leading $\alpha'$-corrections (2)

- Analisis of pertubations in the background geometry

- Shear channel (Buchel, Liu, Starinets - [hep-th/0406264]):

\[
\frac{\eta}{s} = \frac{1}{4\pi} \left( 1 + 135\gamma + \mathcal{O}(\gamma^2) \right)
\]

- Sound channel:

\[
\omega = c_s q - i \frac{2}{3} \frac{q^2 \eta}{T s} \left( 1 + \frac{3}{4} \zeta \right) \rightarrow \omega = c_s q - i \frac{\Gamma_s}{2\pi T} q^2 + \mathcal{O}(q^3)
\]

\[
c_s = \frac{1}{\sqrt{3}} + \mathcal{O}(\gamma^2) \quad \Gamma_s = \frac{1}{3} + 40\gamma + \mathcal{O}(\gamma^2)
\]

- Bulk viscosity:

\[
\zeta = \mathcal{O}(\gamma^2)
\]