Equilibrium-Non-equilibrium from AdS/CFT

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April 24, 2013

Lecture 1: My Name

First we need to clarify one thing:

My full name is: Przemyslaw Lukasz Tomasz Witaszczyk

Outside Poland I am sometimes called:

- Chemeque (french)
- Chemeck (english)
- Pziemk (swedish)
- Siemek (esperanto..)
- Xie Mek (chinese)
- And variants I am unable to reproduce..
- You can call me: Siemek (like my 5 years old brother used to do..)

- My main research interest is AdS/CFT correspondence. Here it is:

- Mathematical meaning:

$$Z_{SUGRA}[\phi_{(0)}] = \int_{\Phi \sim \phi_{(0)}} D\Phi e^{-S[\Phi]} = \left\langle e^{-\int_{\partial AAdS} \phi_{(0)} \hat{O}} \right\rangle_{QFT}$$

- Equality of partition functions of a specific string theory on a specific background and some specific quantum field theory.

More precisely

- I work with Romulad Janik (JU) and Michal Heller (UVA) on the non-equlibrium dynamics of conformal field theory.
- In particular we are interested in the early thermalization puzzle and the transition to equlibrium.
- Recent results can be found in:
  - arXiv:1302.0697 "On the character of hydrodynamic gradient expansion in gauge theory plasma" (NEW)
  - arXiv:1203.0755 "A numerical relativity approach to the initial value problem in asymptotically Anti-de Sitter spacetime for plasma thermalization - an ADM formulation" (PRD)
  - arXiv:1103.3452 "The characteristics of thermalization of boost-invariant plasma from holography" (PRL)

The setup: motvated by QGP

- System under consideration is: strongly coupled, time dependent, expanding 4-dimensional boost-invariant conformal 'plasma', with rotational symmetry along the 'beam' axis and transverse translational symmetry (Bjorken model and beyond).
- It is characterized by stress-energy tensor in proper time-spacetime rapidity coordinates:

$$T_{\mu\nu} = Diag(\epsilon(\tau), p_L(\tau), p_T(\tau), p_T(\tau))$$

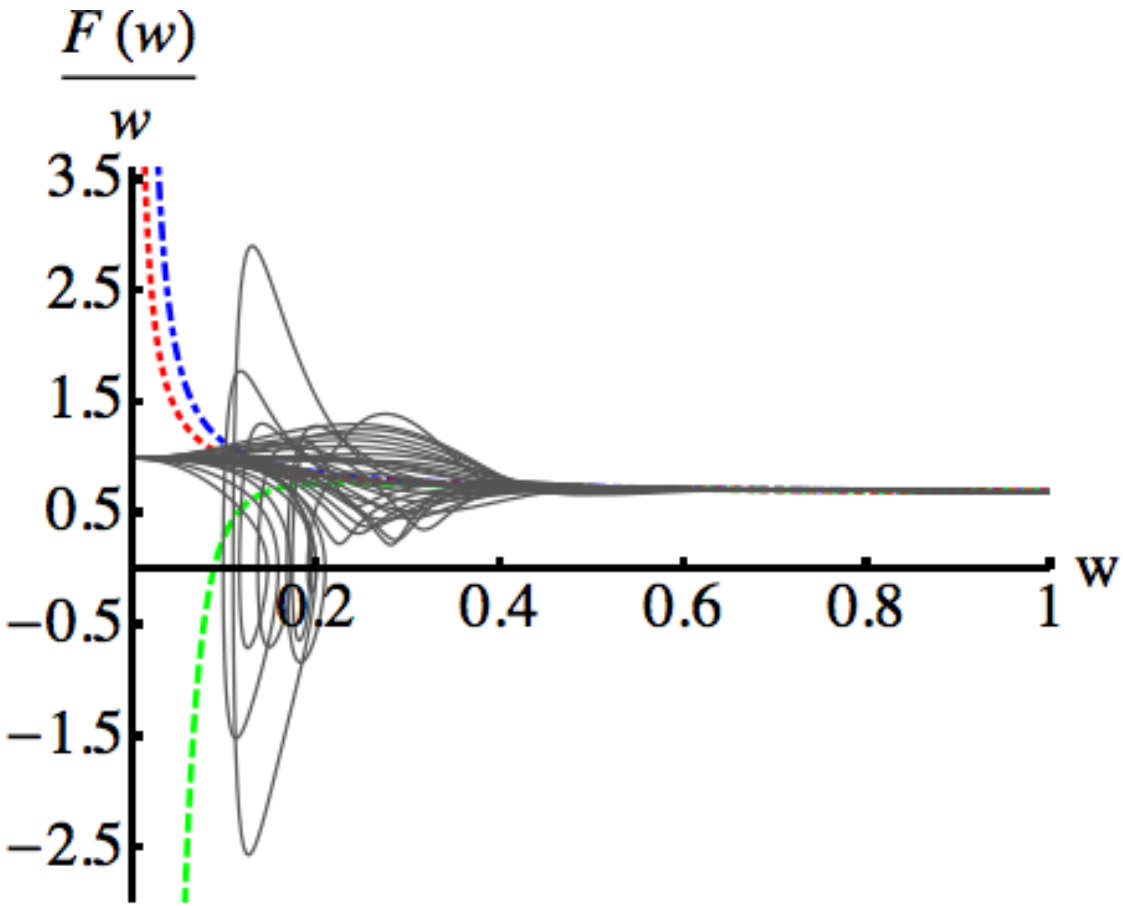
- Equation of hydrodynamics follows:

$$\nabla_\mu T^{\mu\nu} = 0, \;\; T^\mu_\mu = 0.$$

- Goal: know everything about $< T^{\mu\nu}(\tau) >$, with the aid of AdS/CFT, which means: gravity.
- At the present we are in the 'Numerics Age'.

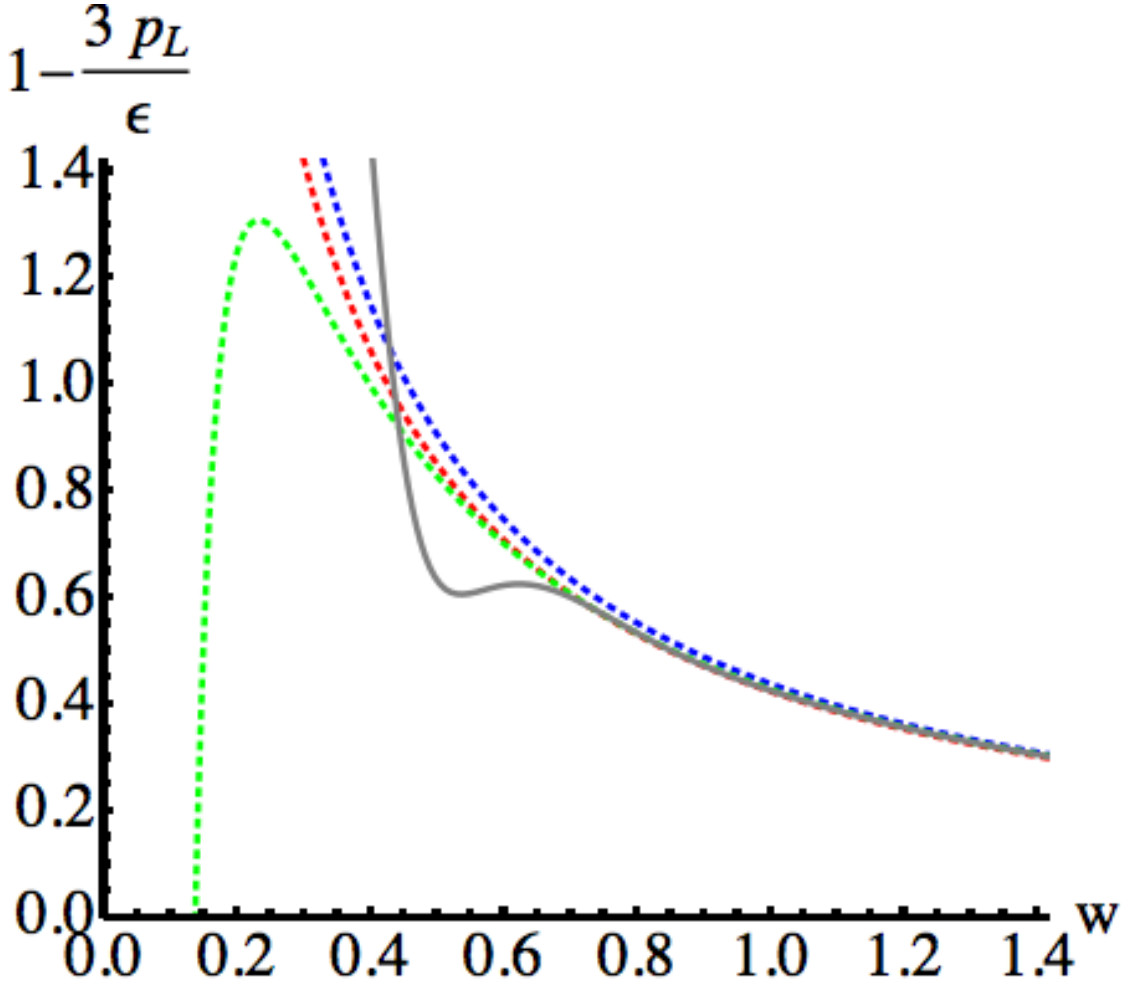
Recent findings

- Effective (numerical) all order hydrodynamics
- Allows for ultimate test of hydro applicability
- Fundamentally (from AdS/CFT) contains all the transport coefficients



Recent findings

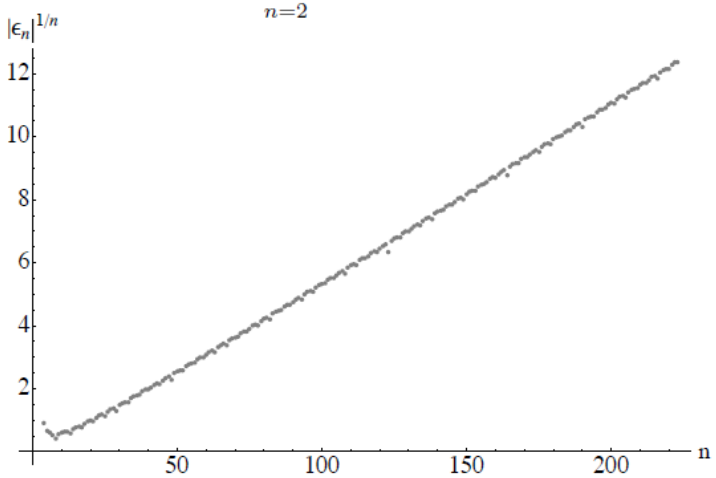
- Thermalization is not Hydrodynamization
- Big anisotropy but viscous hydrodynamics applicable!

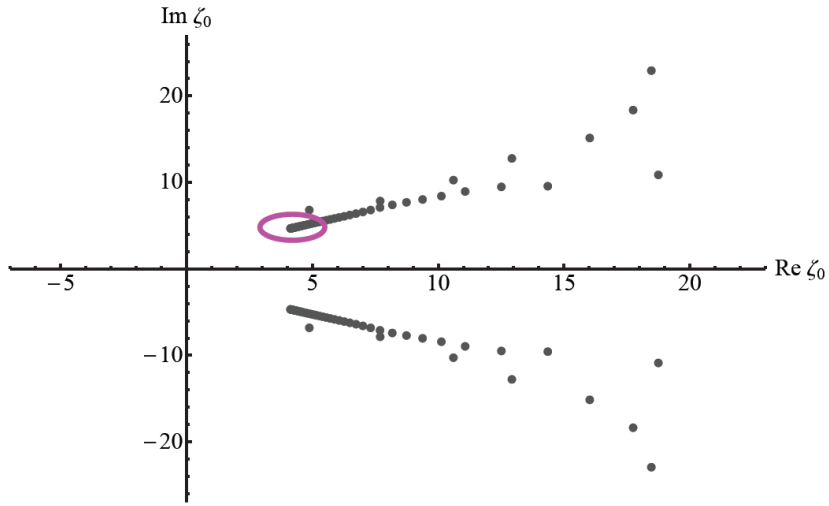


Recent findings

- Hydrodynamic series has zero radius of convergence (at least in Bjorken model)
- We have obtained expansion up to order 240 and the series seems to be asymptotic
- First pole in the Borel plane of hydrodynamic expansion is related to first non-hydrodynamic QNM
- Thus: non-equilibrium=non-perturbative?

$$\epsilon(u) \sim \sum_{n=2}^{\infty} \epsilon_n u^n \quad (u = \tau^{-2/3})$$





The End

May I ask something..