Aspects of Holographic Thermalization

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Motivation

♣ Heavy ion collision:

- Approach regime: relativistic velocities, energies 100 GeV/nucleon.
- Thermalization process: QGP formation.
- Strongly coupled QGP: hydrodynamical description: ideal fluid with small η/s.
- Hadronization process: cooling down system.

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♣ Hot QCD matter produced in nuclear collisions is strongly coupled (RHIC) $\rightarrow$ AdS/CFT: thermalization of SC plasmas (pre-hydrodynamical stage).

Dictionary of Thermalization

♣ Thermal state of gauge theory ≡ BB in AdS

♣ Near equilibrium dynamics of gauge theory ≡ Dynamics of perturbations in AdS_5-BH metric.

♣ Scenarios:

Small perturbations around thermal equilibrium

Gravity side: QNM in BB background. $\omega_I \rightarrow$ thermal relaxation rates of various excitations such as anisotropic perturbations of stress-energy tensor.

Thermalization of an initial field configuration far from equilibrium

- Approach to thermal equilibrium $\rightarrow$ BH formation.
- Approach to hydrodynamical limit $\rightarrow$ thin shell collapse study.
- How thermalization rate varies with spatial scale and dimension?

♣ $< T_{\mu\nu} >$ and its derivatives $\rightarrow$ information on applicability of viscous hydrodynamics, but not scale dependence (sensitive only to metric close to the boundary).

♣ Wilson loops and 2-point correlators $\rightarrow$ extended spatial scales (IR field theory).

Basic Setup

Vaidya Metric: Collapsing Shell

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The metric in Poincaré coordinates

$$ds^2 = \frac{1}{z^2}\left\{-[1 - m(v)z^d]dv^2 - 2\,dz\,dv + d\vec{x}^2\right\}\ , \tag{1}$$

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where

$$m(v) = (M/2)[1 + tanh(v/v_0)] \,. \qquad (2)$$

Geodesic Approach

2-point function (equal time correlator) in a state evolving to thermal equilibrium $\equiv$ bulk geodesic lengths $\mathcal{L}(x,t)$ in collapsing shell: $<\mathcal{O}(t,x)\mathcal{O}(t,x')>\sim e^{-\Delta\mathcal{L}}$.

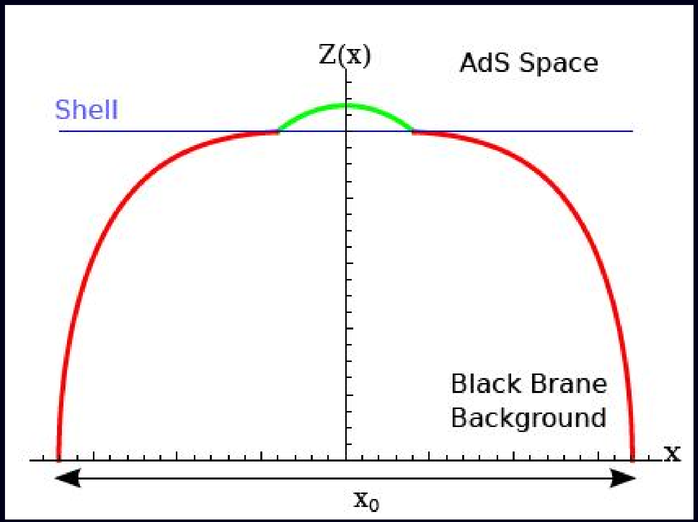

Figure 1: Geodesic refraction by the shell.

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Finding space-like geodesics:

- Solve $v = v(x)$ and $z = z(x)$, symmetric with v or z axis.
- Initial and boundary conditions:

$$v(0) = v_*, \qquad z(0) = z_* \tag{4}$$

$$v(\pm\ell/2) = t_0\,, \qquad z(\pm\ell/2) = z_0 \tag{5}$$

- Length

$$\mathcal{L}(\ell, t_0) = 2\int_0^{\ell/2} dx \frac{z_*}{z^2}\,. \tag{6}$$

- Thermal length

$$\mathcal{L}_{thermal} = 2\int_{z_0}^{z_*} \frac{dz}{z} \frac{1}{\sqrt{(1 - Mz^d)(1 - \frac{z^2}{z_*^2})}} \tag{7}$$

Our Setup

We consider a charged GB black brane in D dimensions

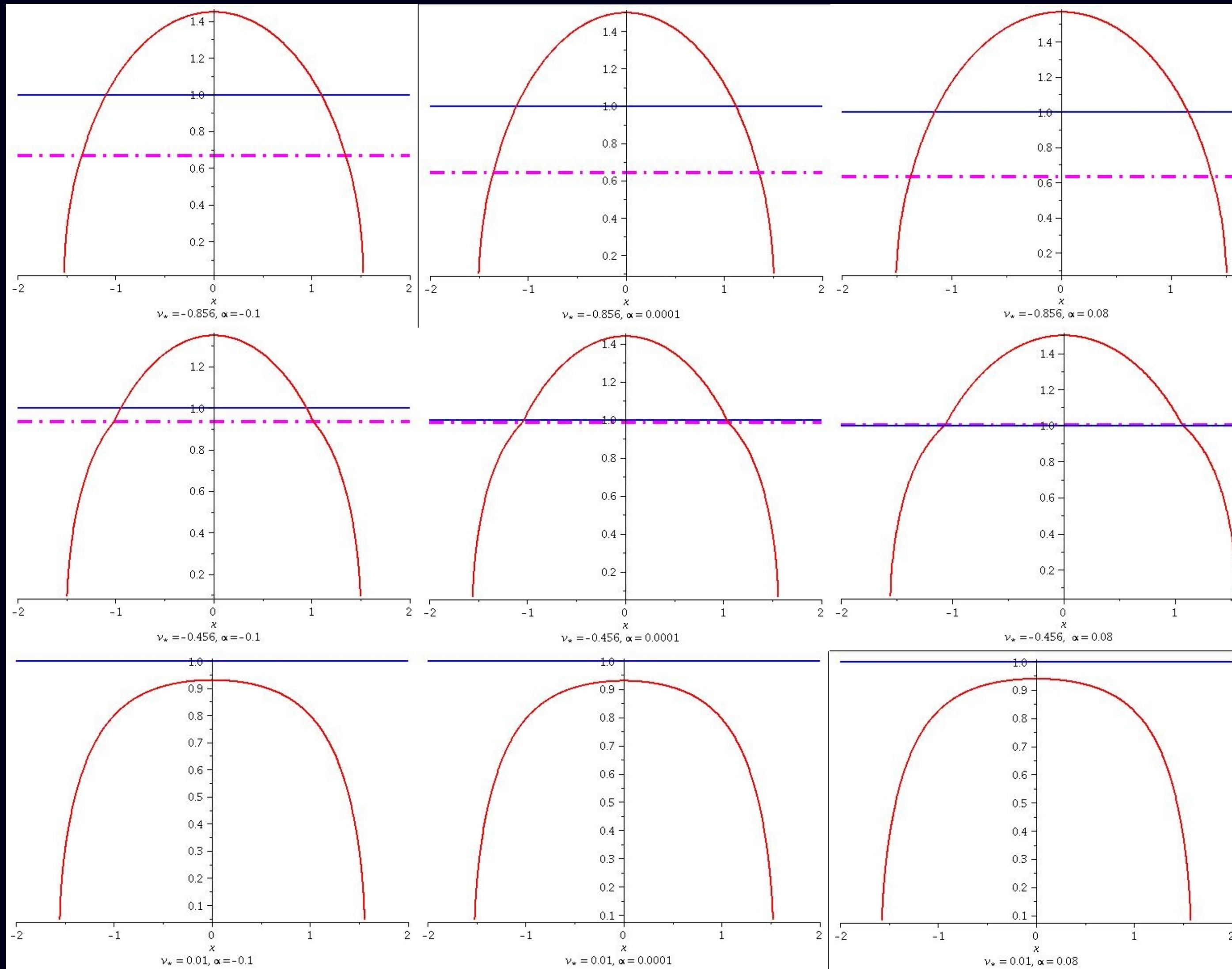
$$ds^2 = \frac{1}{z^2}\left\{-X(z)dv^2 - 2\,dz\,dv + d\vec{x}^2\right\}\ , \tag{8}$$

where

$$X(z) = \frac{1}{2\alpha}\left[1 - \sqrt{1 - 4\alpha(1 - m(v)z^{D-1} + q(v)^2 z^{2(D-2)})}\right]\,. \tag{9}$$

Again

$$m(v) = (M/2)[1 + tanh(v/v_0)]\,, \qquad q(v) = (Q/2)[1 + tanh(v/v_0)]\,. \tag{10}$$


ν* = -0.856, α = -0.1
ν* = -0.856, α = 0.0001
ν* = -0.856, α = 0.08
ν* = -0.456, α = -0.1
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Summary

♣ We considered the collapse of a dust charged shell in GB theory to model the thermalization of a QGP.

♣ Our results show that compared to the AdS case the GB parameter seems to accelerate the thermalization process. However, the inclusion of charge retards this process.

♣ A more careful study is necessary to determine the regime of dominance of each effect.

♣ The use of other metrics can also enrich the present conclusions.