Examining Dynamics in AdS Spacetime in Einstein-Gauss-Bonnet Gravity

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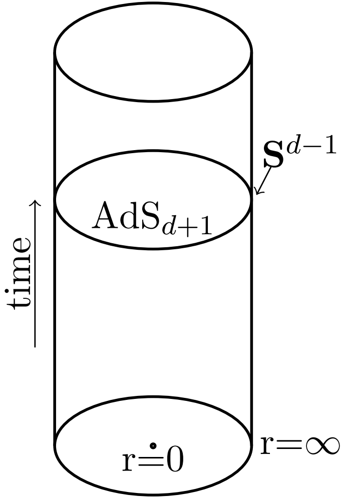
Motivation

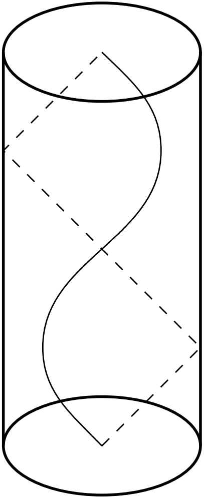
- AdS-CFT correspondence
- To examine gravitational collapse in higher dimensional AdS spacetime
- Wish to extend to Einstein-Gauss-Bonnet
- Is AdS spacetime stable against the formation of black holes?

Motivation

- To repeat previous work done by Buchel et al., Bizoń et al., and Garfinkle but in different coordinates
- Motivated by results of the Gauss-Bonnet work done by Deppe et al.
- To be able to simulate many bounces off of infinity before finally collapsing to form a black hole

Background: Conformal Diagrams





Horizon radius vs amplitude for initial data

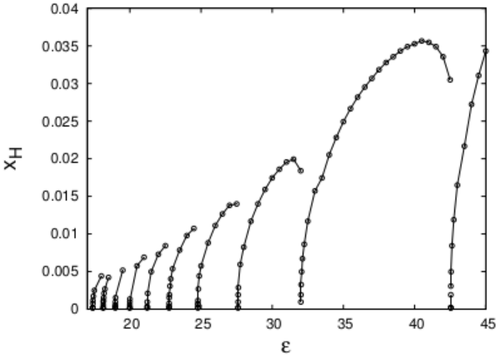


Figure: Bizón, Rostworowski, arXiv:1104.3702

Metric:

$$ds^2 = -N^2dt^2 + \Lambda^2(dx + N_r dt)^2 + R^2 d\Omega^{(n-2)}$$

Gauge fixing conditions:

$$R = f(x) = \frac{Lx}{L-x} \tag{1}$$

$$\Lambda^{-2} = \frac{1}{f_{,x}^2}\left(1 - \frac{2\lambda f^2(x)}{(n-1)(n-2)}\right) \tag{2}$$

Equations of motion:

$$\psi_{,t} = \frac{\delta H}{\delta P_\psi} = N\left[\frac{\tilde{P}_\psi}{\Lambda} + \left(\frac{N_r}{N}\right)\psi_{,x}\right]$$

$$\tilde{P}_{(\psi),t} = \frac{1}{f(x)^{n-2}}\frac{\delta H}{\delta\psi} = \frac{1}{f(x)^{n-2}}\left[\frac{N}{\Lambda}f(x)^{n-2}\psi_{,x} + \left(\frac{N_r}{N}\right)\tilde{P}_\psi\right]_{,x}$$

Constraint Equation:

$$M_{,x} = f(x)^{n-2}\frac{f(x)_{,x}}{\Lambda}\left[\frac{1}{\Lambda}\left(\frac{\tilde{P}_\psi^2 + \psi_{,x}^2}{2}\right) + \left(\frac{N_r}{N}\right)\tilde{P}_\psi\psi_{,x}\right]$$

Consistency Condition:

$$\frac{N_{,x}}{N} = -\left[\frac{\Lambda}{f(x)_{,x}}\right]_{,x}\frac{f(x)_{,x}}{\Lambda} + \frac{f(x)^{n-2}\tilde{P}_\psi\psi_{,x}}{M_{,\left(\frac{N_r}{N}\right)}}\frac{f(x)_{,x}}{\Lambda}$$

Boundary Conditions - At the Origin: Ignoring Self Interaction

Ignoring self-interaction (i.e. $N_r \to 0$ and $N \to 1$) we obtain the spherically symmetric wave equation

$$\partial_t^2 \psi = (n-2)\frac{\partial_x f(x)}{f(x)}\partial_x \psi + \partial_x^2 \psi$$

Assume $\psi(x,t) = e^{i\omega t}\varphi(x)$:

$$0 = \omega^2 \varphi + (n-2)\frac{L}{x(L-x)}\partial_x \varphi + \partial_x^2 \varphi$$

Which gives the asymptotic solution:

$$\varphi(x) = \varphi_{(0)} + \varphi_{(2)}(x)^2 + \varphi_{(4)}(x)^4 + \varphi_{(6)}(x)^6 + \cdots$$

- Much more subtle than at $R = 0$
- At infinity the metric must tend to the AdS metric define $z = L - x$ so that as $x \to L, z \to 0$ and $x \to 0, z \to L$
- We have chosen for our first gauge choice, $f(x) = \frac{Lx}{L-x}$

Will need to solve Bessel's differential equation about $x = L$

$$\begin{aligned}\Phi(t, x \approx L) &= (L - x)^{n-2} \left[\Phi_{(0)} + \Phi_{(2)}(L - x)^2 + \Phi_{(4)}(L - x)^4 + \cdots\right] \\ \Pi_\psi(t, x \approx L) &= (L - x)^{n-1} \left[(\Pi_\psi)_0 + (\Pi_\psi)_2(L - x)^2 + \right. \\ &\qquad \left. (\Pi_\psi)_4(L - x)^4 + \cdots\right]\end{aligned}$$

Current State and Future Goals

- Last summer: put our equations into the code to test them $\rightarrow$ issues
- Removed the gravitational self-interaction (i.e. set $N_r = 0$) $\rightarrow$ still issues
- Now have properly finite differenced equations and fully functional code

Thanks

- The CAP organizers
- Dr. Gabor Kunstatter and Dr. Andrew Frey
- Nils Deppe
- University of Winnipeg
- You for listening!