The Gravitational Wave Spectrum of a RS 1-Brane in a Black Hole Bulk

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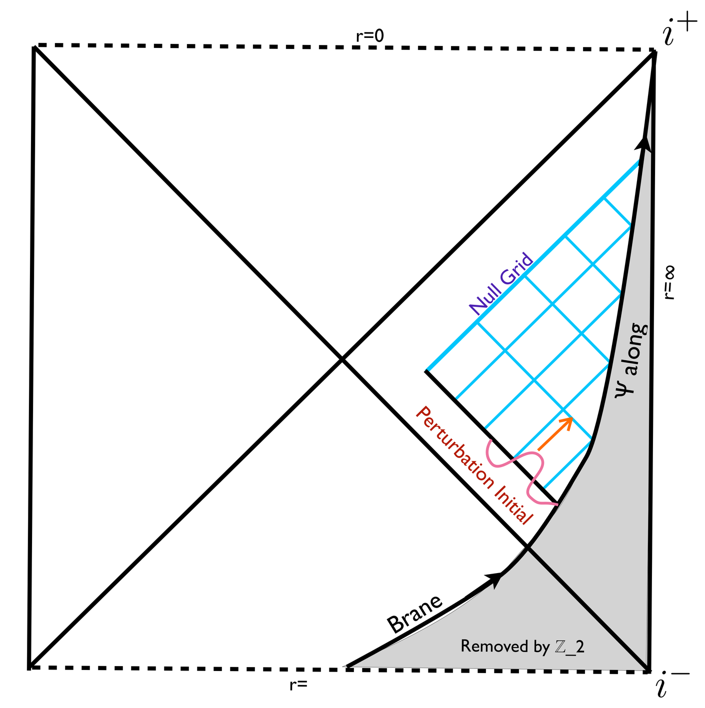


Perturbing the Randall-Sundrum 1-Brane

Introduction

-A RS 1-Brane surrounding a bulk Anti-deSitter-Schwarzchild Black hole can look like a Friedmann-Roberston-Walker spacetime with a modified Friedmann equation.

-The modified Friedmann equations:

$$H^2 = \frac{2\rho_\star a_\star^4}{a^4} + \frac{M}{a^4} + \frac{\rho_\star^2 a_\star^8}{a^8} \qquad \rho = \rho_\star(\frac{a}{a_\star})^{-3(w+1)}$$

- Gravitational waves in the bulk will propagating according to the following wave equation:

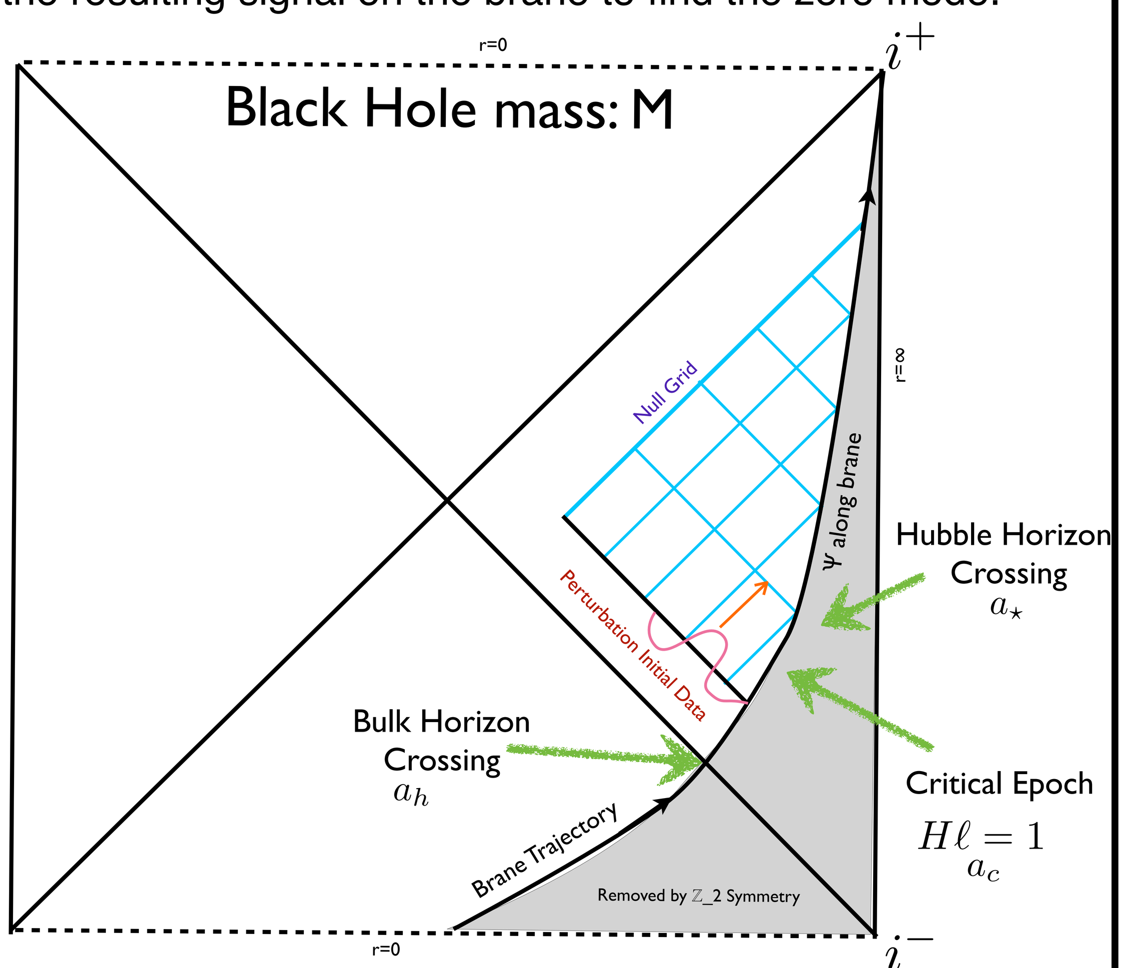
$$\delta h_{ab} = r^2(\frac{r_\star}{r})^{-3/2}\psi(t,z)\Delta_{ab}$$

$$[\partial_t^2 - \partial_z^2 + V(z)]\psi = 0 \qquad V(z) = (\frac{1}{r_h^2} - \frac{r_h^2}{r^4})[r_h^2\rho_\star(\rho_\star + 2) + \frac{1}{r_h^2} + \frac{15r^2}{4r_h^2} + \frac{9r_h^2}{4r^2}]$$

- With boundary condition (on the brane):

$$(n^a\partial_a\psi + \frac{3}{2r}\sqrt{f(r)(1+\dot{z}_b^2)\psi})|_b = 0$$

- Our code evolves Initial perturbations, defined on a null surface in the bulk, as it impinges on the brane; and we fit the resulting signal on the brane to find the zero mode.



Free Parameters: frequency of noncritical mode, ratio between Weyl and ordinary density, Mass.

$$\frac{\nu}{\nu_c} = (\frac{\rho_c}{\rho_\star})^{1/3(w+1)}\sqrt{\rho_\star(2+\rho_\star) - \frac{\kappa}{a_\star^2} + \frac{M}{a_\star^4}} \qquad \epsilon_w = \frac{M}{2\rho_\star a_\star^4} \qquad M = 1$$

$$\nu_c \sim 10^{-5} Hz\,(0.1mm/\ell)^{1/2}$$

References

Roy Maartens, “Brane-World Gravity”, *Living Rev. Relativity 7, (2004), 7.*

Sanjeev S. Seahra “Gravitational Waves and Cosmological Braneworlds: a Characteristic Evolution Scheme”, *Phys. Rev. D74:044010,2006*

Clarkson, C and Seahra S. “Braneworld Resonances” *Class. Quantum Grav. 22 (2005) 3653-3587*

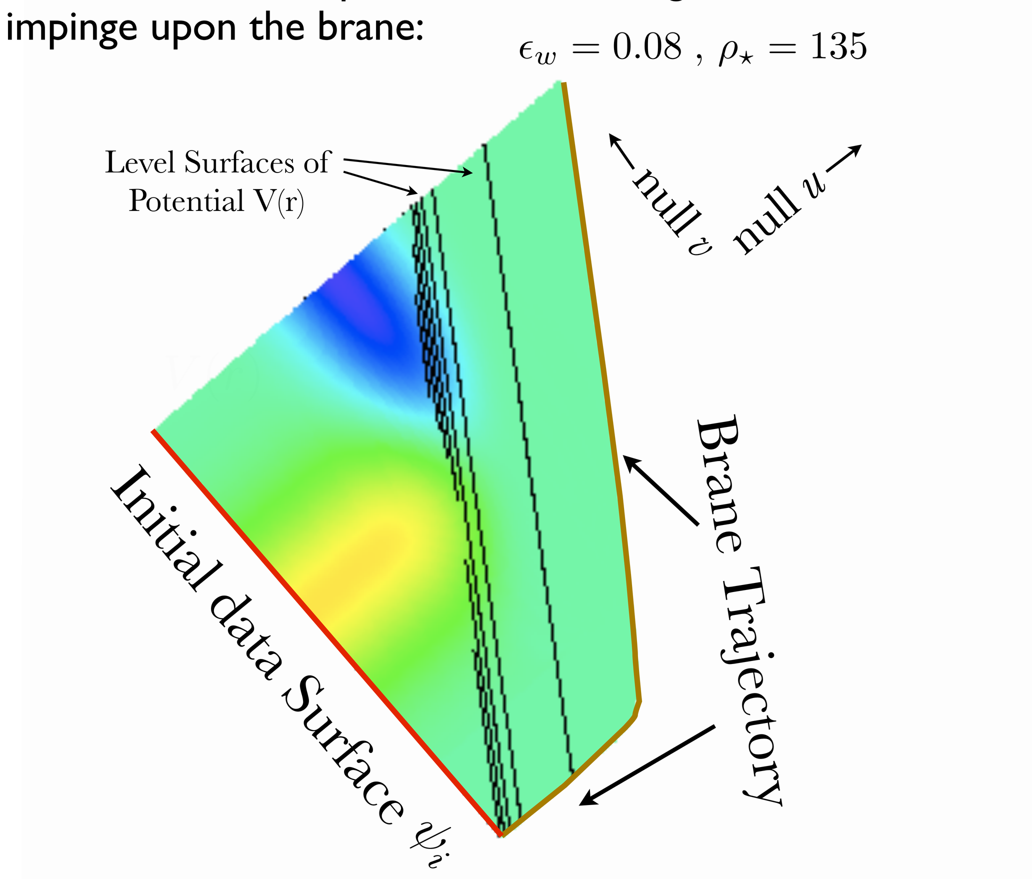
Kodama, H. and Ishibashi, A. “A Master Equation for Gravitational Perturbations of Maximally Symmetric Black Holes in Higher Dimensions” , *Prog.Theor.Phys. 110 (2003) 701-722*

Gaussian ψ_i

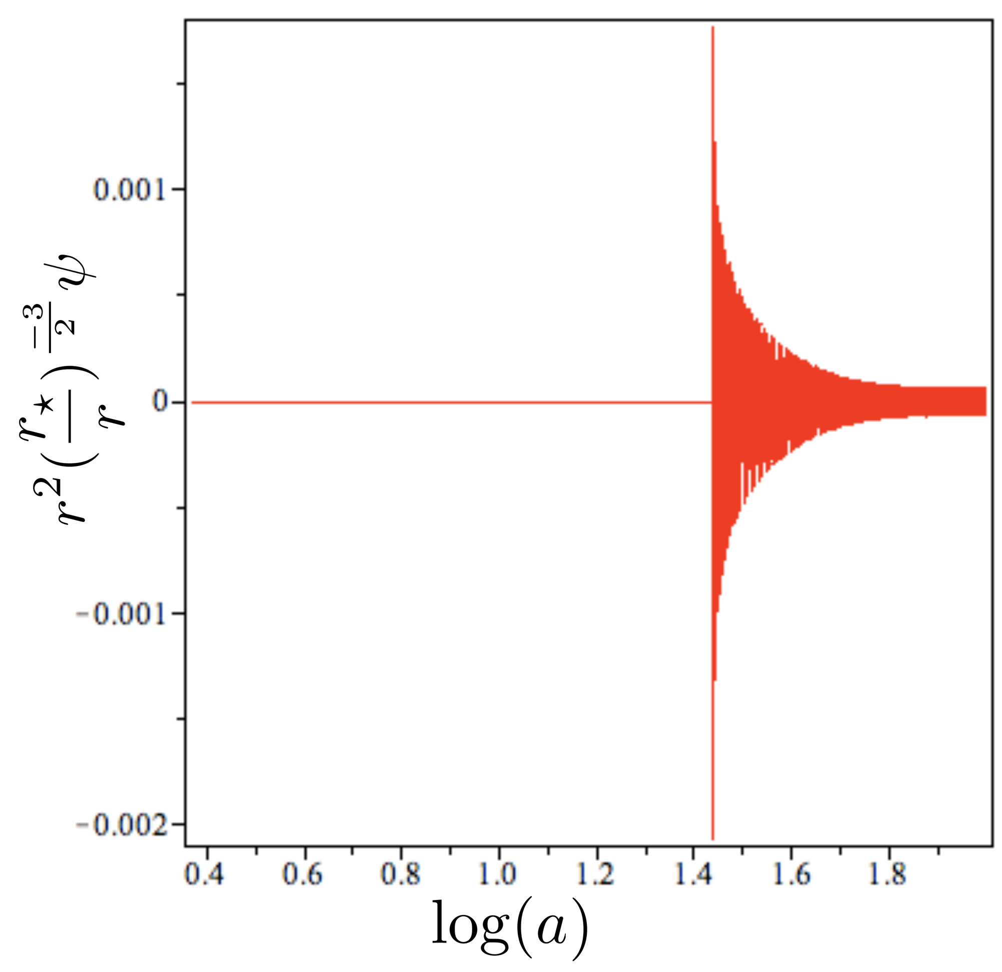
We define the initial data $\psi_i(v)$ to be a truncated Gaussian:

$$\psi_i(v) = e^{-(v-(3+v_o))^2}H(v-1)$$

And we evolve the perturbation through the bulk to impinge upon the brane: $\epsilon_w = 0.08$, $\rho_\star = 135$

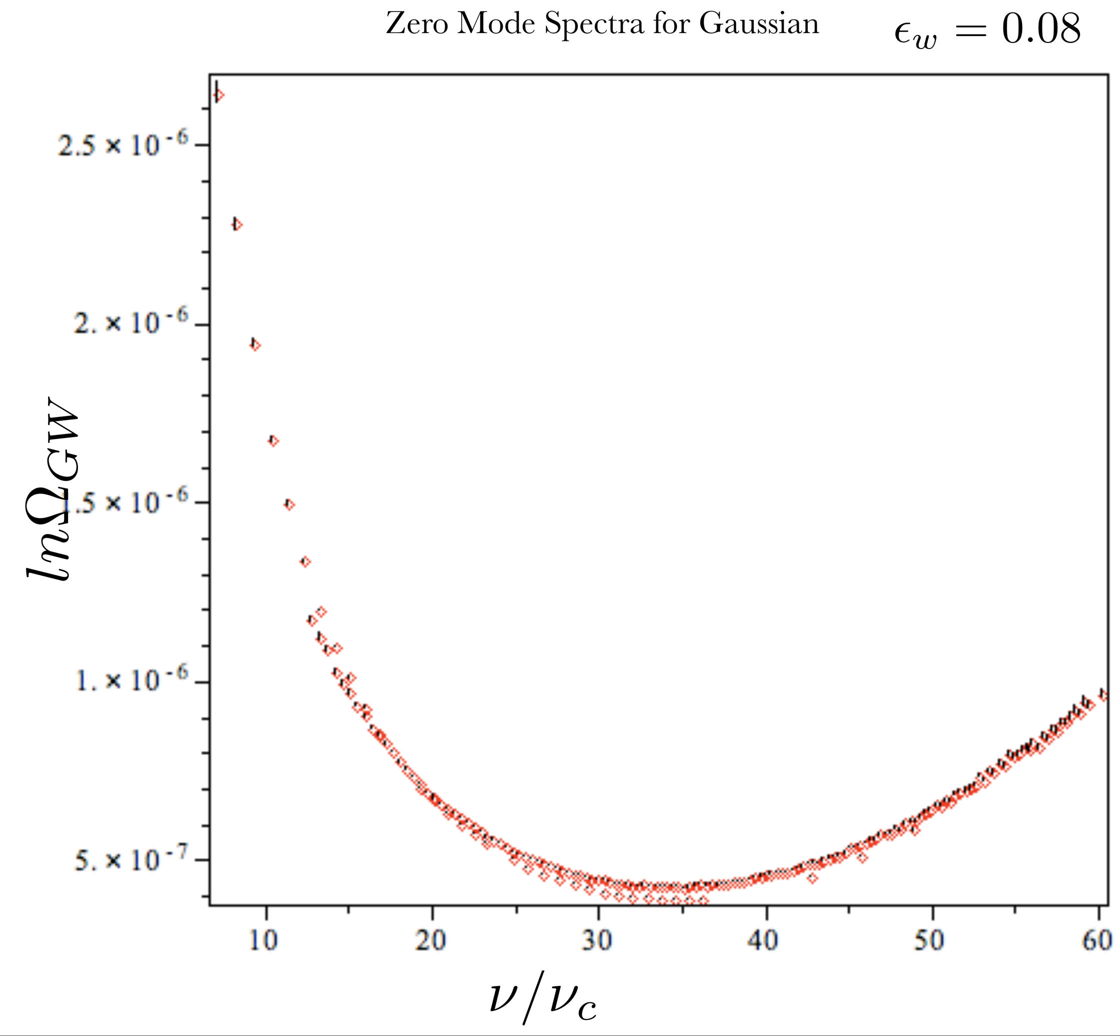


This provides us with the perturbation signal as measured by observers upon the brane: $\rho_\star = 187$, $\epsilon_w = 0.08$



We determine the amplitude of the zero mode by fitting the data points from the tail of the signal. We use this to determine a spectrum:

Zero Mode Spectra for Gaussian $\epsilon_w = 0.08$



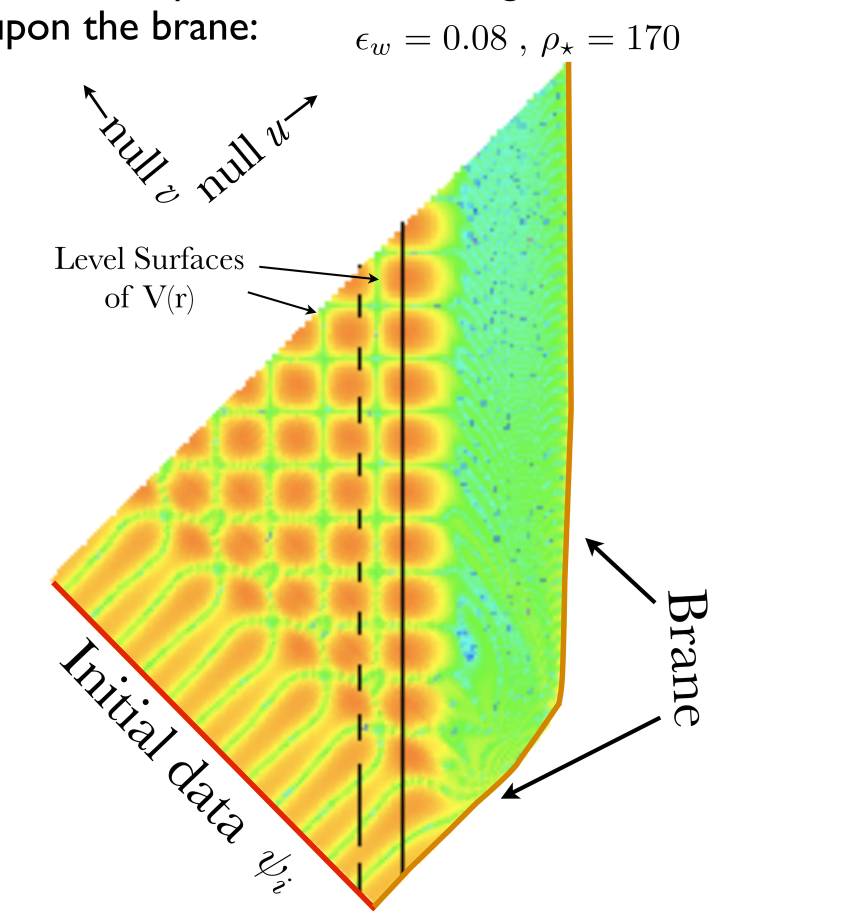
Cosine ψ_i

ψ_i

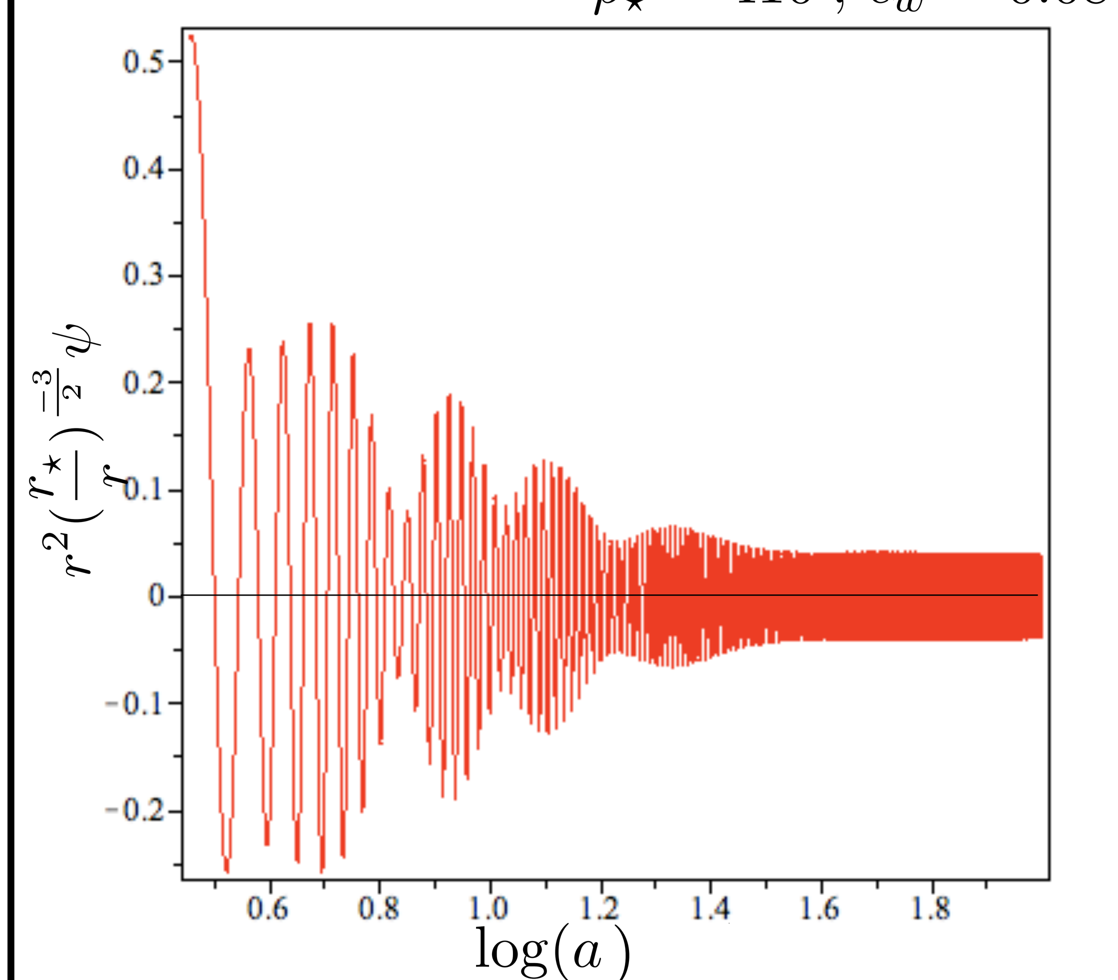
We define the initial data $\psi_i(v)$ to be a Sinusoid:

$$\psi_i(v) = \cos(8v)$$

And we evolve the perturbation through the bulk to impinge upon the brane: $\epsilon_w = 0.08$, $\rho_\star = 170$



This provides us with the perturbation signal as measured by observers upon the brane: $\rho_\star = 410$, $\epsilon_w = 0.08$



We determine the amplitude of the zero mode by fitting the data points from the tail of the signal. We use this to determine a spectrum:

Zero Mode Spectra for Cos(8v) $\epsilon_w = 0.08$