Title: Asymptotically AdS Gravitational Collapse

Date: Jun 08, 2012 10:30 AM

URL: http://pirsa.org/12060018

Abstract: TBA

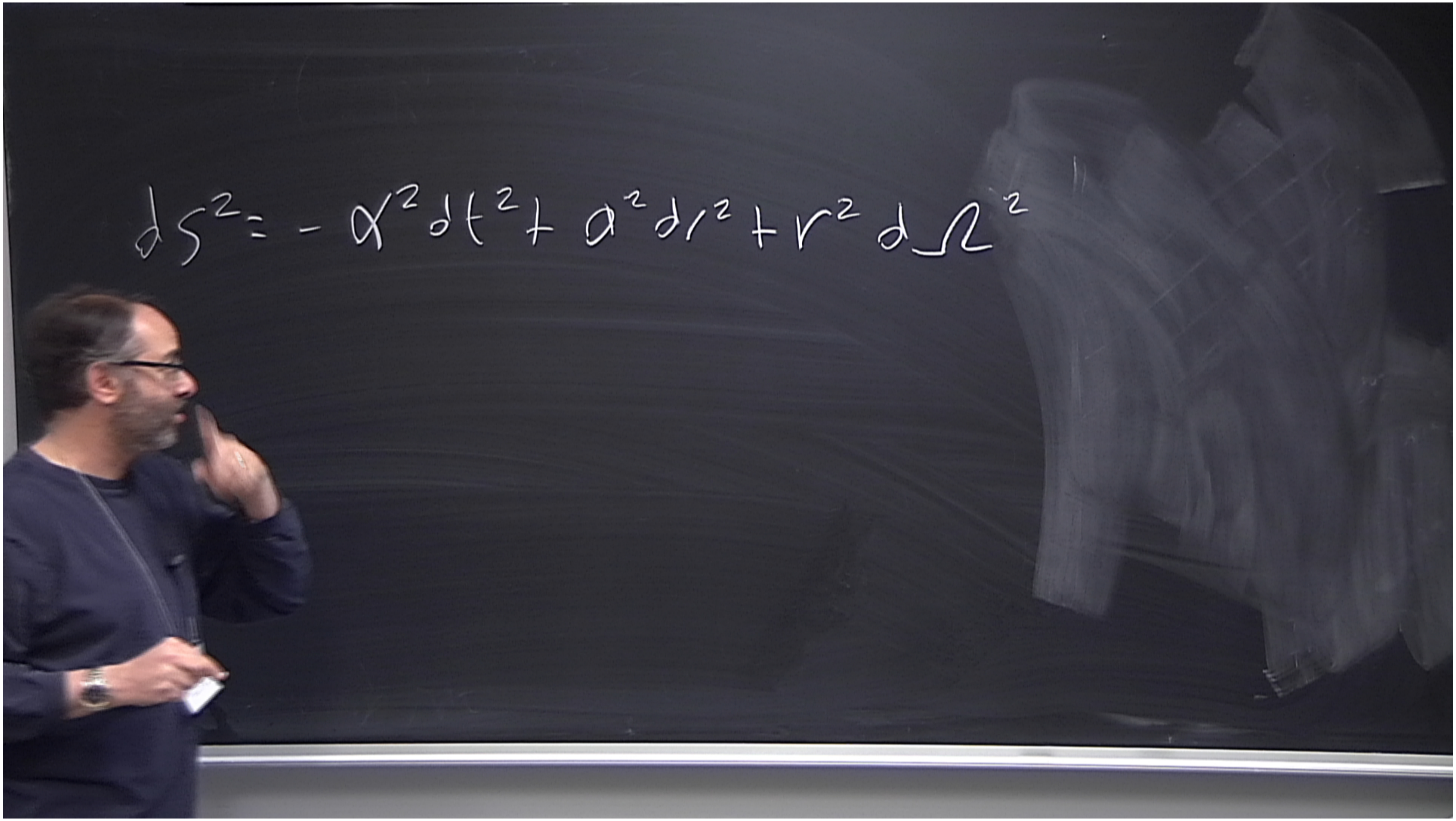
Asymptotically AdS gravitational collapse

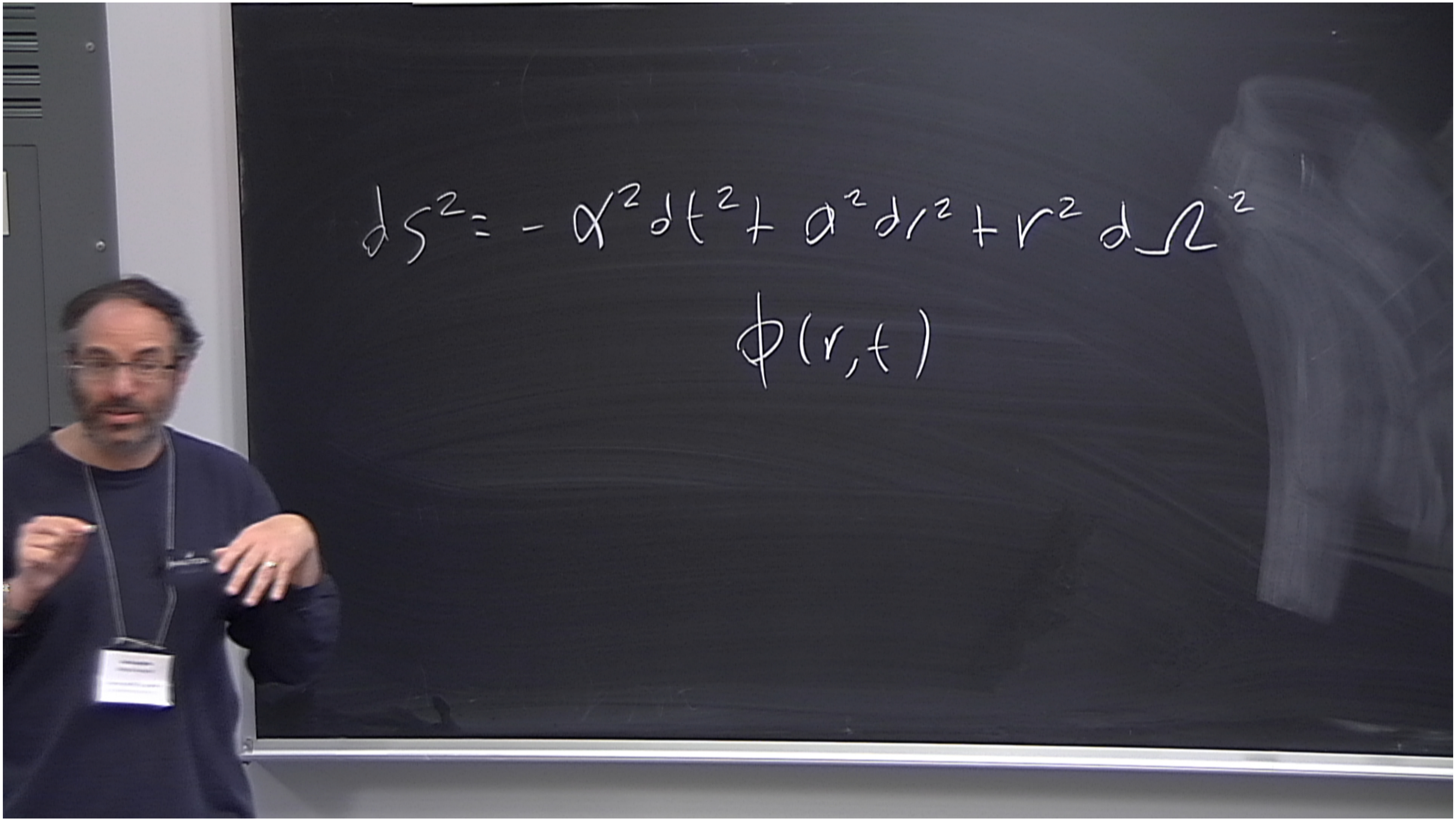
PI

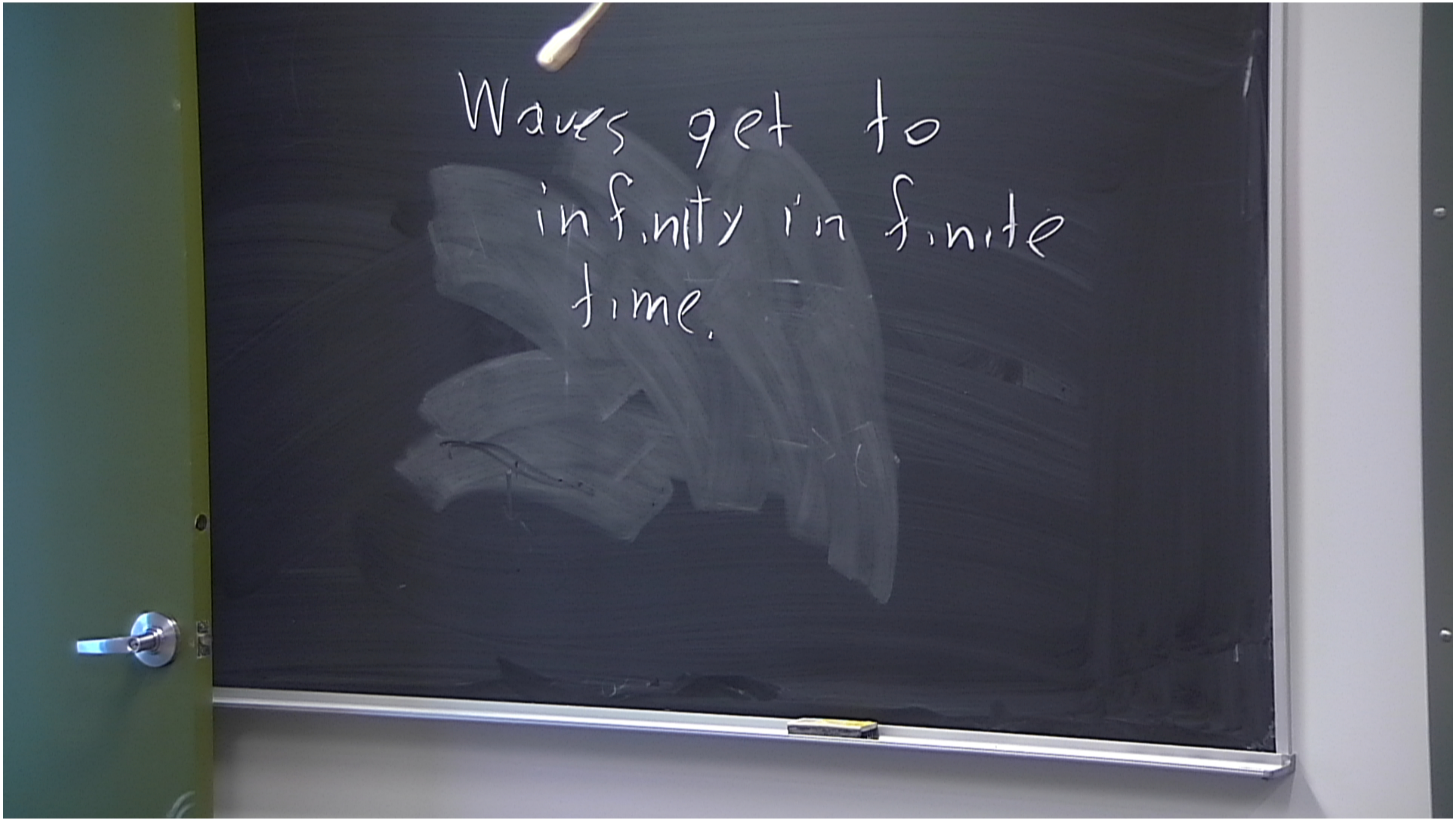
Waterloo, Ontario, June 8, 2012

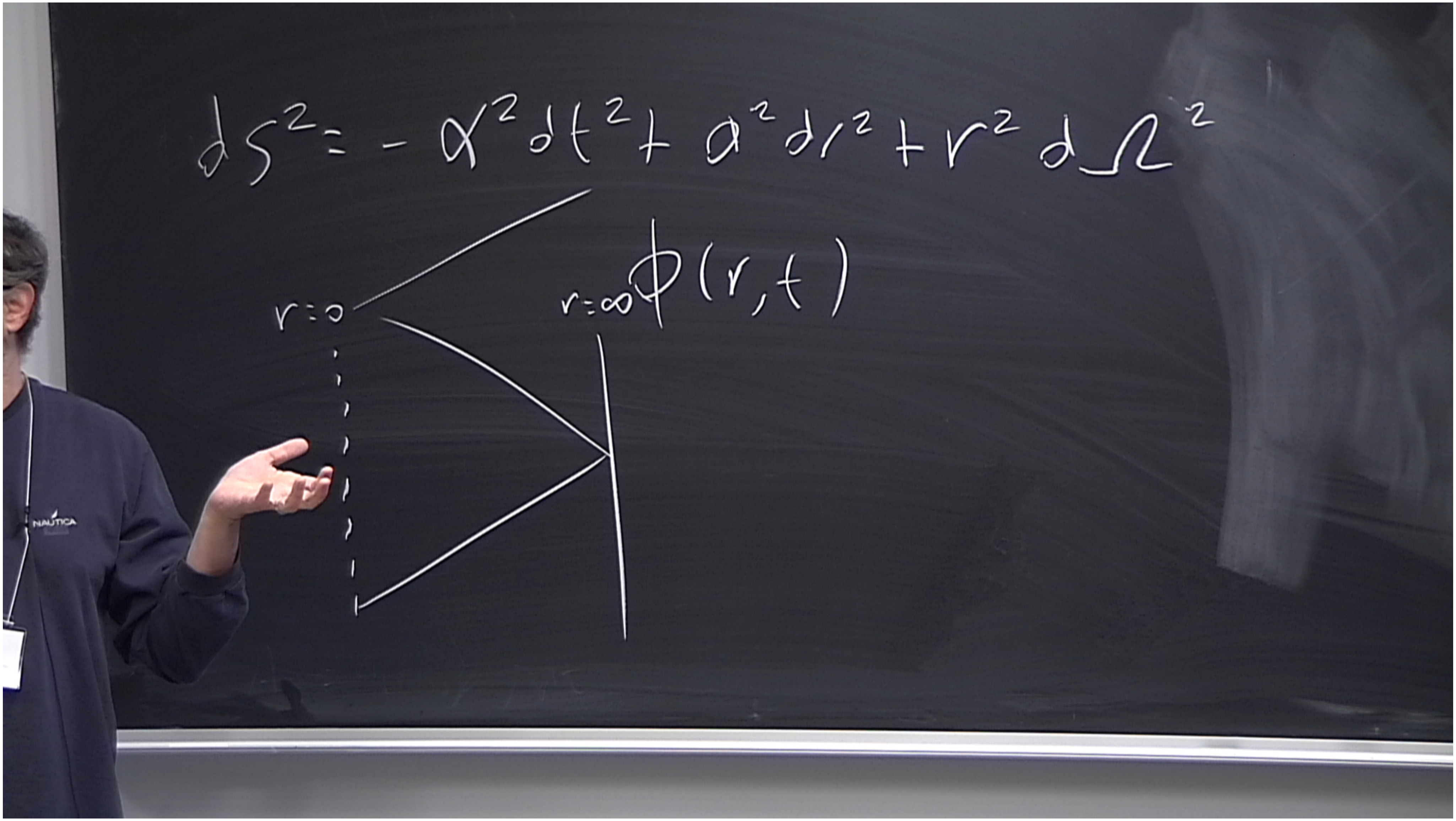
AdS gravitational collapse

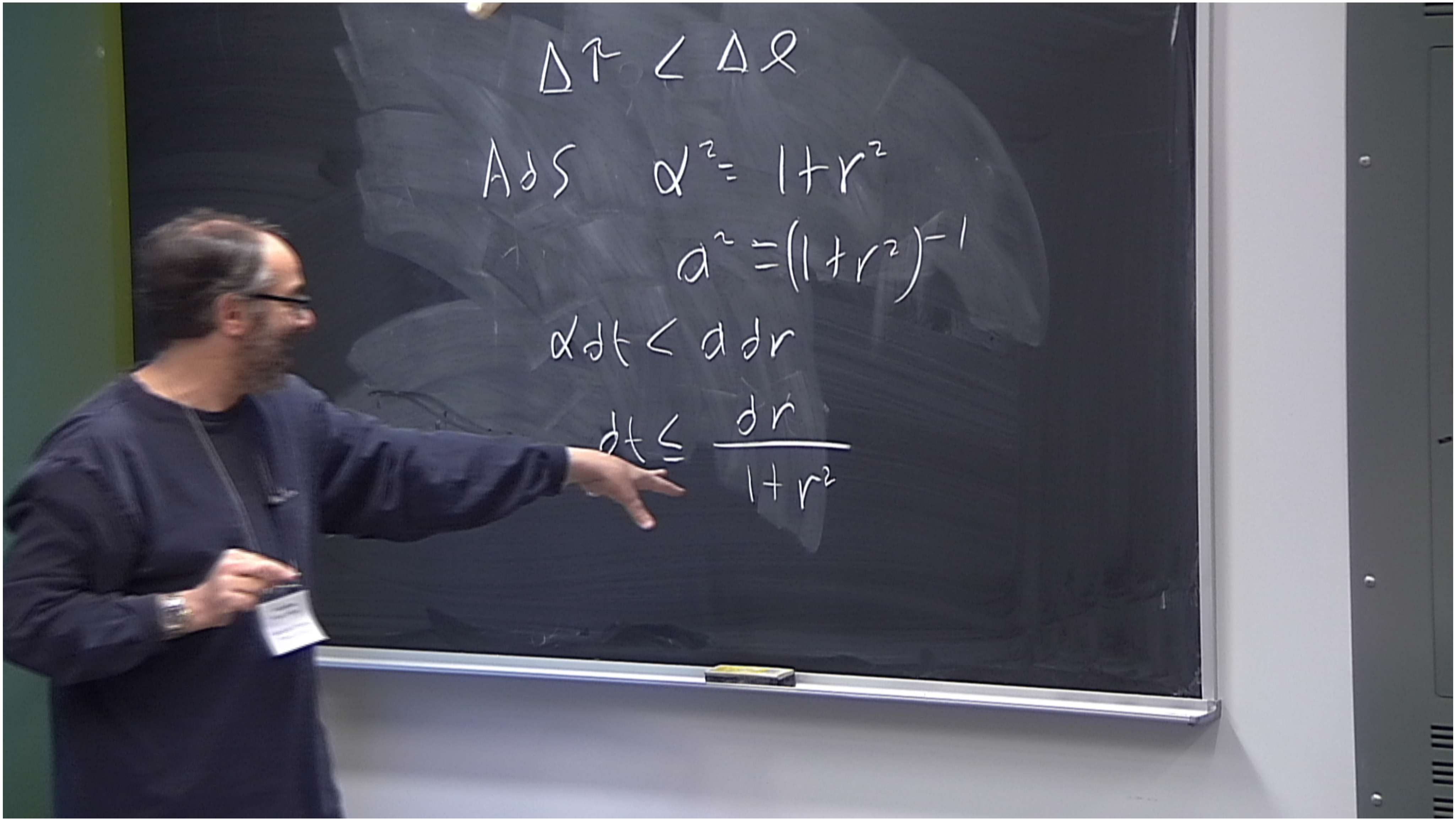
- DG and L. Pando Zayas, PRD **84**, 066006 (2011)
- DG, L. Pando Zayas, and D. Reichmann, arXiv:1110.5823 and JHEP in press
- And work in progress

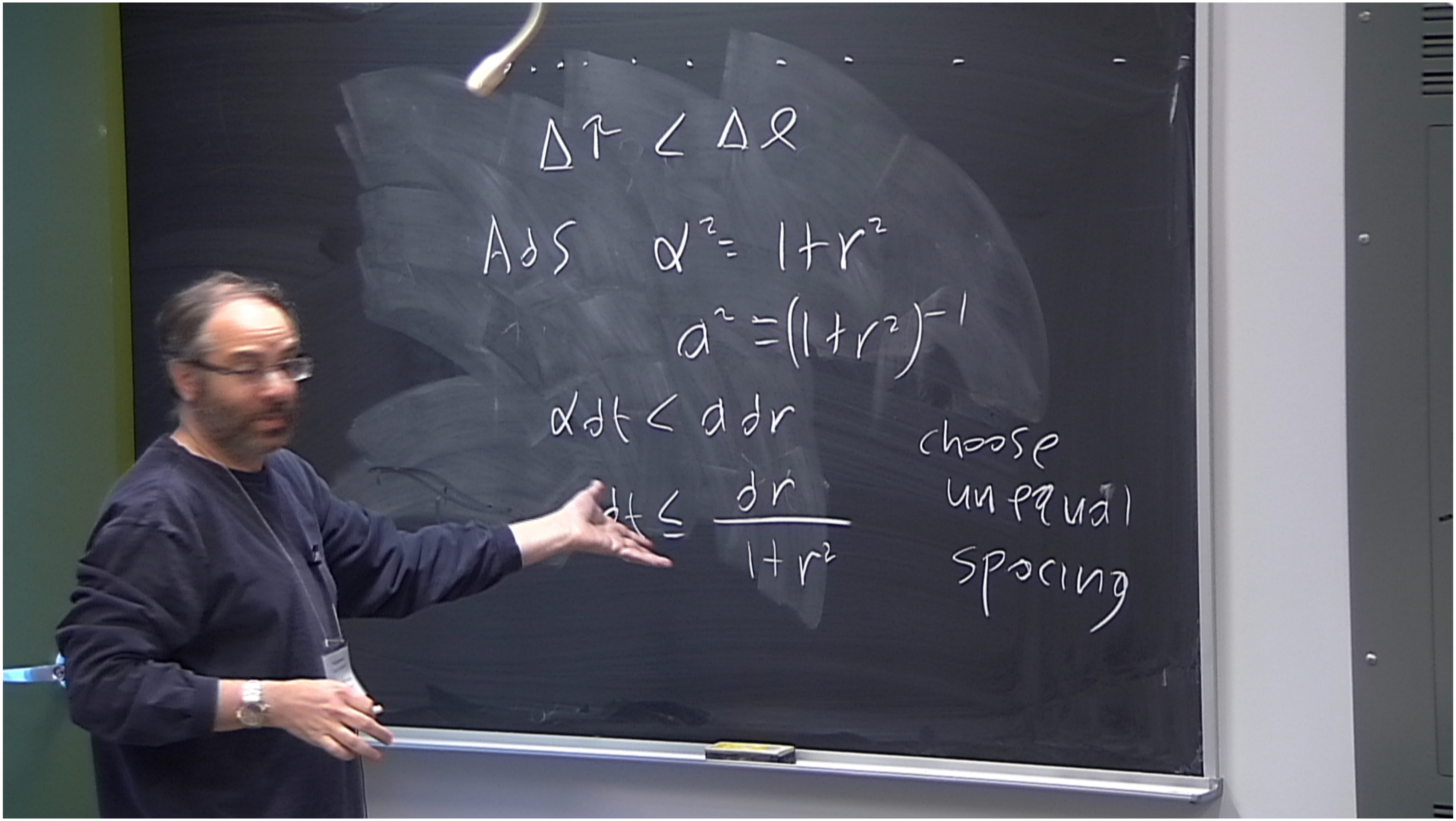

$ds^2 = -\alpha^2 dt^2 + a^2 dr^2 + r^2 d\Omega^2$


$ds^2 = -\alpha^2 dt^2 + a^2 dr^2 + r^2 d\Omega^2$
$\phi(r,t)$


Waves get to
infinity in finite
time.


$ds^2 = -\alpha^2 dt^2 + a^2 dr^2 + r^2 d\Omega^2$
r=0
r=∞
$\phi(r,t)$


Δτ < Δℓ
AdS α² = 1+r²
a² = (1+r²)⁻¹
α dt < a dr
dt ≤ dr / (1+r²)


$\Delta \tau < \Delta \ell$
AdS $\alpha^2 = 1 + r^2$
$a^2 = (1+r^2)^{-1}$
$\alpha\, dt < a\, dr$
$dt \leq \frac{dr}{1+r^2}$
choose
unequal
spacing

What's different about AdS_5

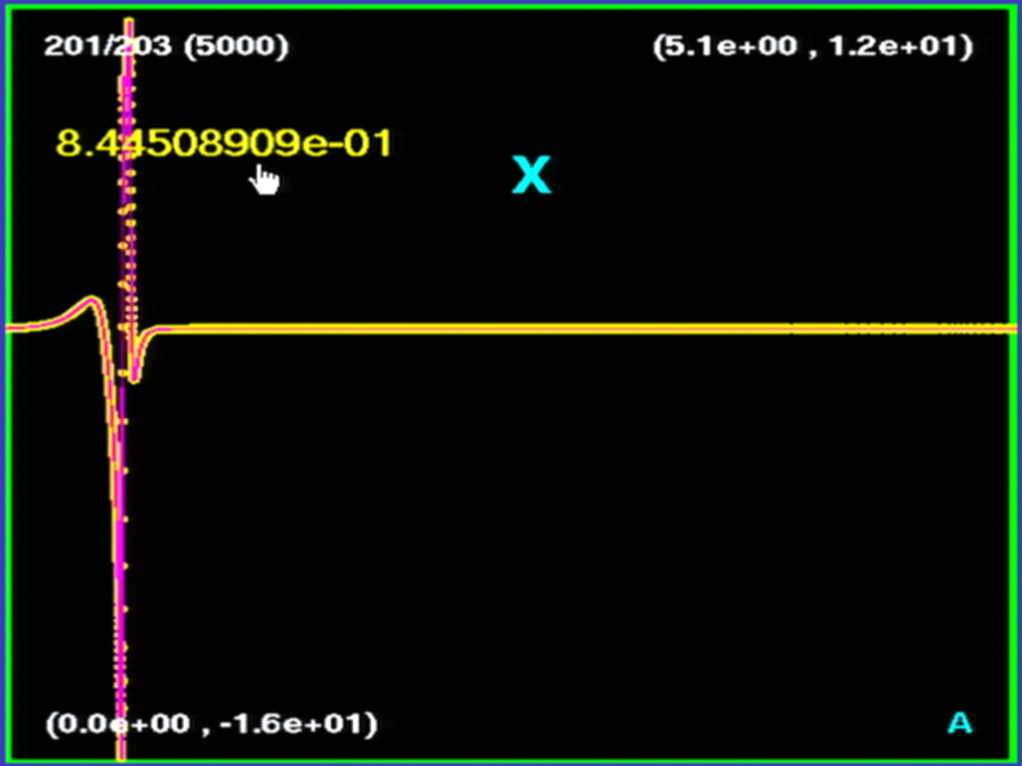
- 5 dimensions
- Signals get to infinity in finite time
- a goes like r^{-2} and α goes like r^2 as r goes to infinity
- Use $d\Omega^2$ of the three sphere instead of the two sphere.
- Put a boundary at $r=r_{max}$ and fix $\phi=0$ there.

$\alpha dt<adr$ but use unequal spacing in r so that the time step doesn't have to be too small

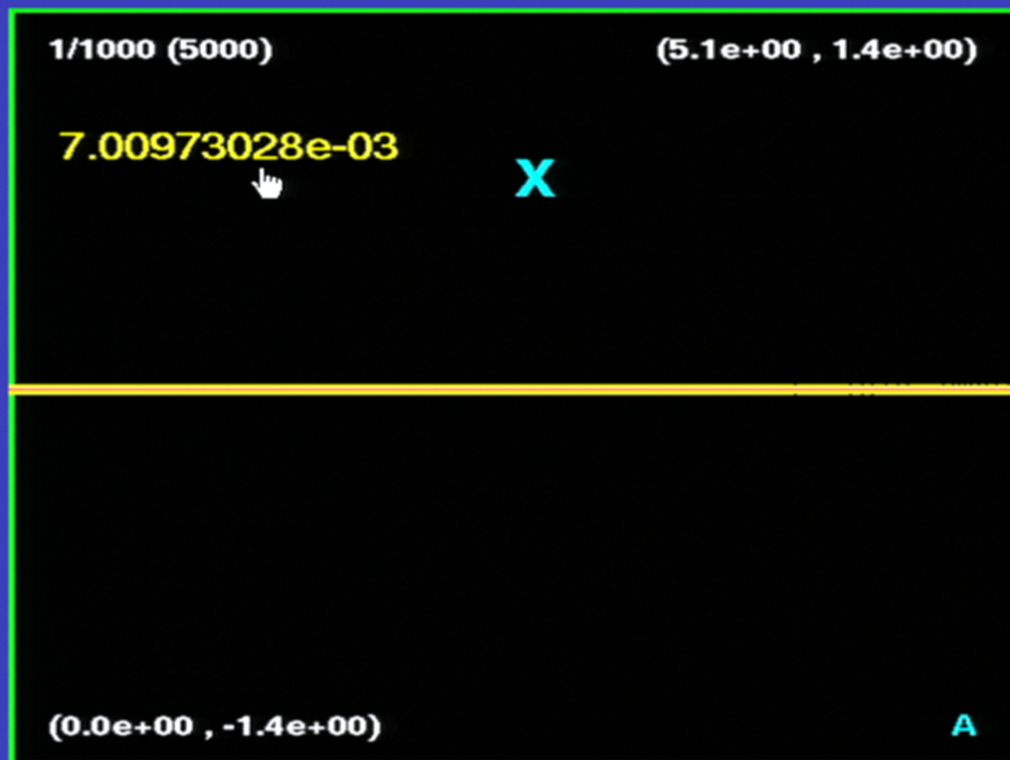
Some results

- Choose an ingoing gaussian wavepacket with amplitude and width as parameters
- Small amplitude wavepackets bounce
- Large amplitude wavepackets promptly form black holes.

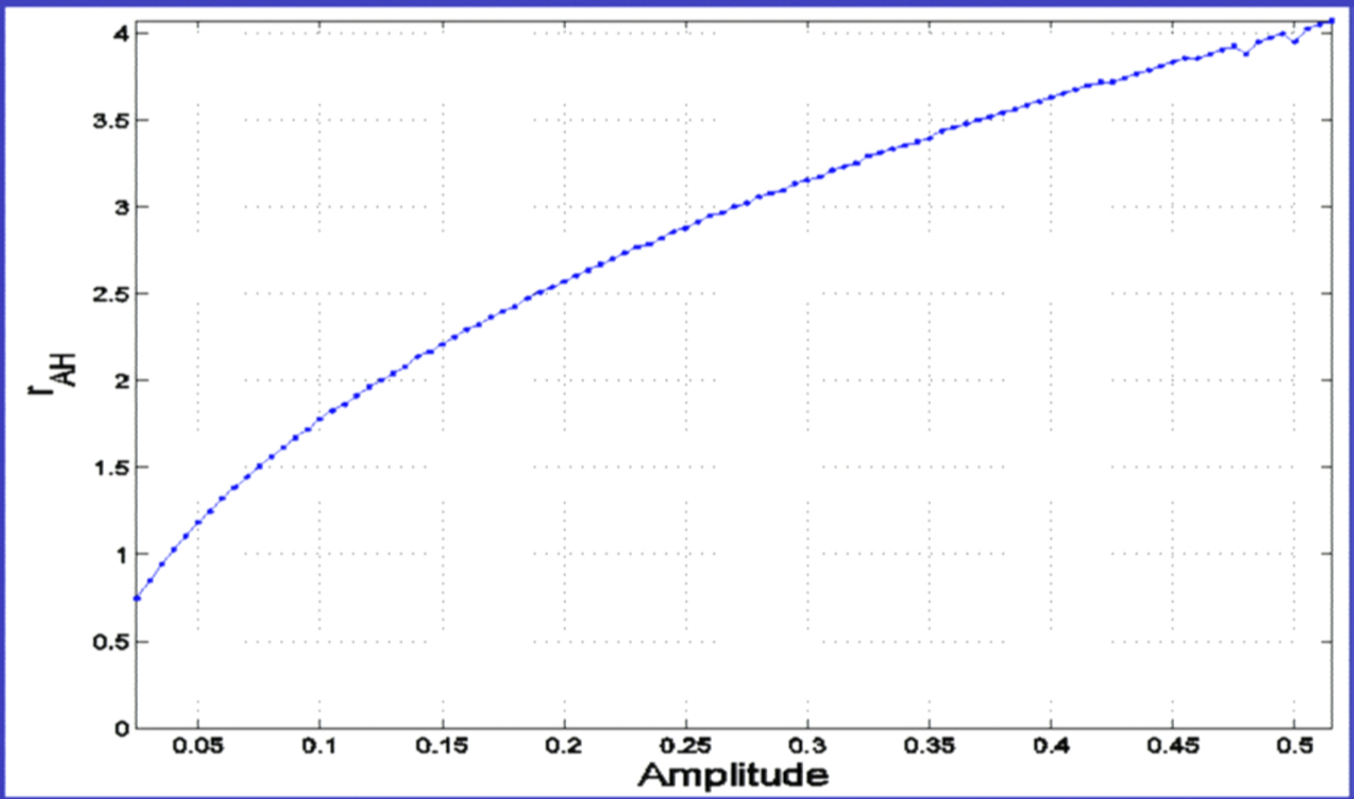
Black hole formation



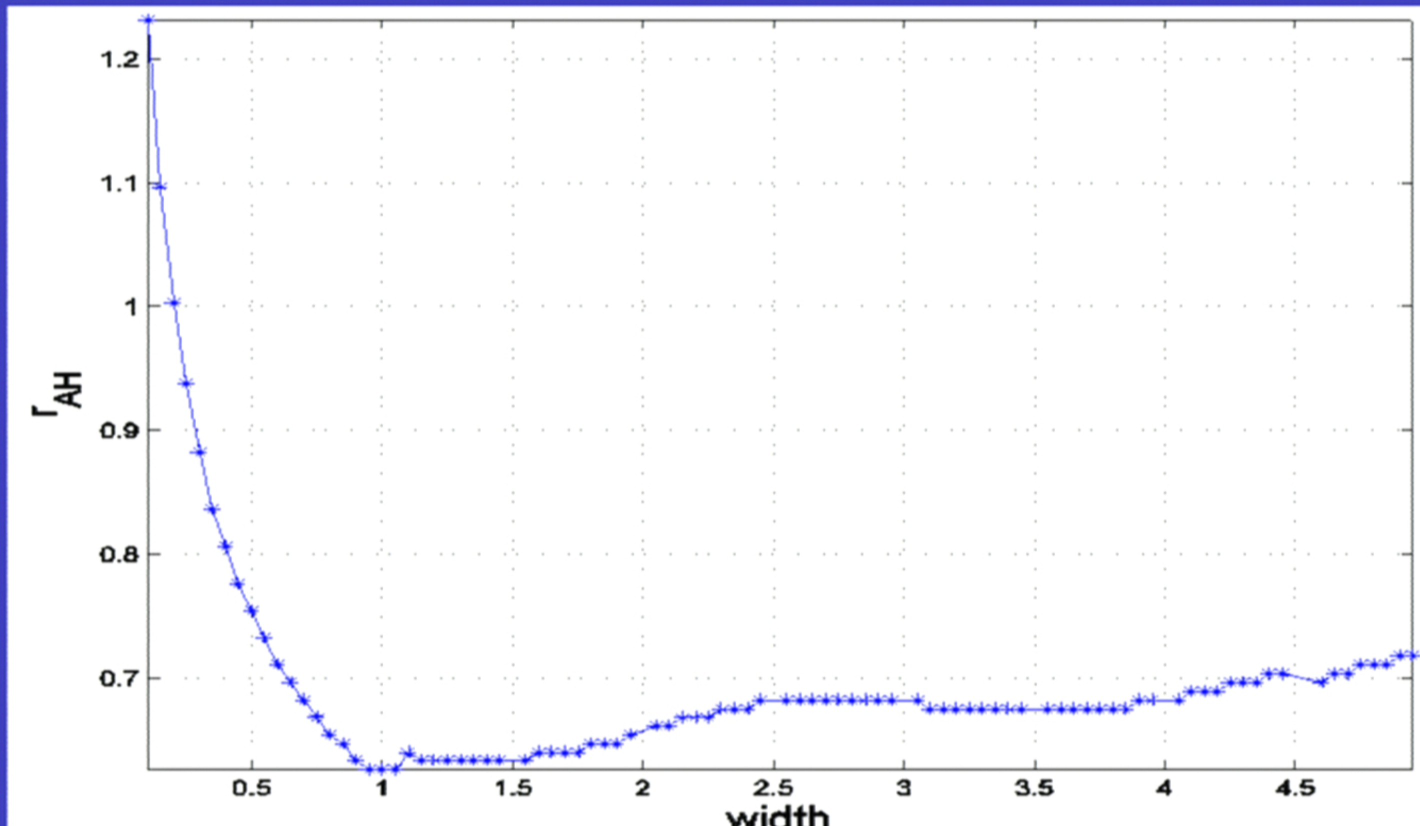
Low amplitude bounce



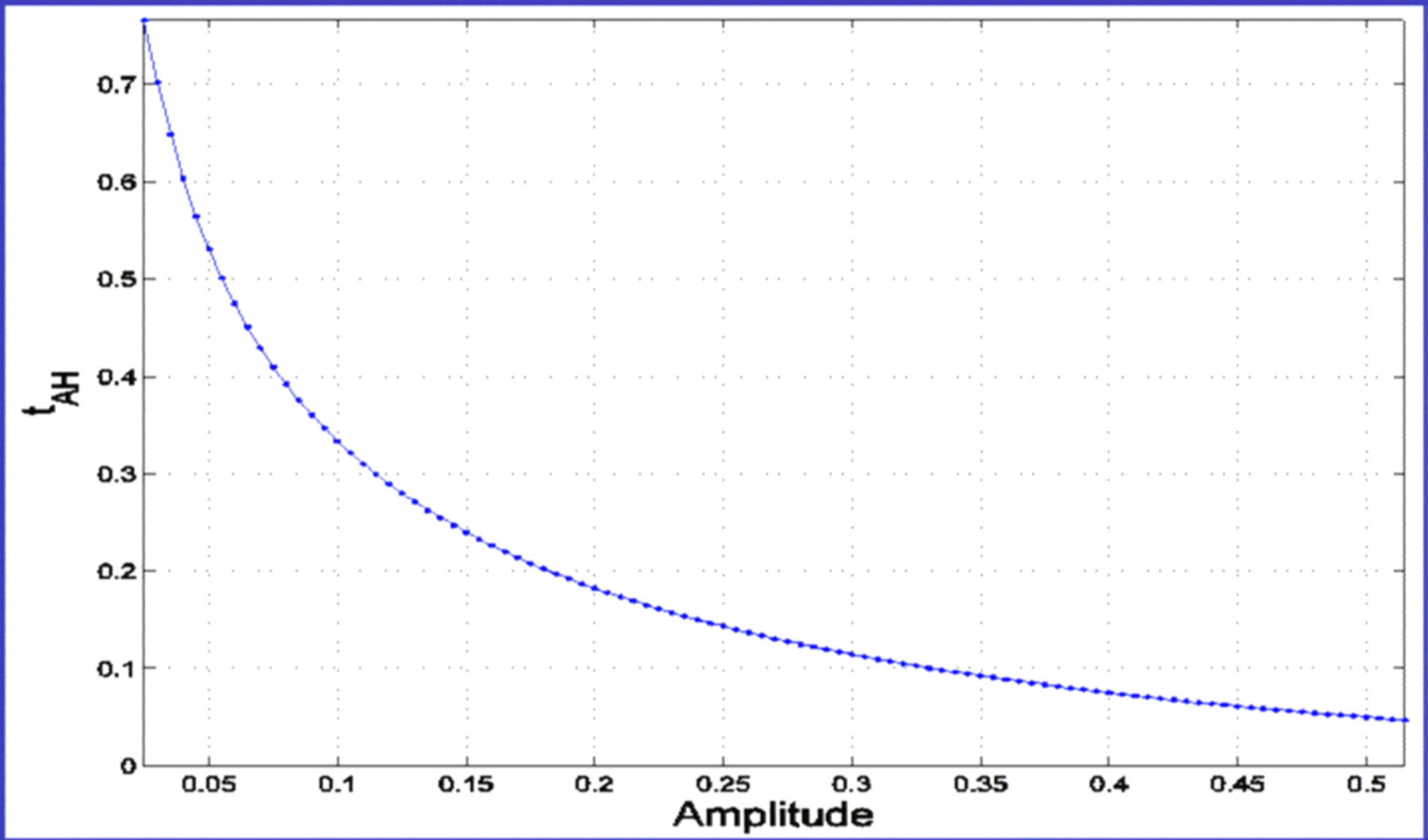
r_h vs amplitude (larger amplitude gives larger mass)



r_h vs width (for small width mass decreases with width)



t_h vs amplitude (mostly geometric optics)



AdS in Poincare coordinates

- $ds^2 = -\alpha^2 dt^2 + a^2 dr^2 + r^2\, d\mathbf{X}^2$
- In AdS $\alpha = r/L$ and $a = L/r$
- These coordinates go bad (sort of) at $r=0$

(really like polar coordinates)

Use “puncture method”

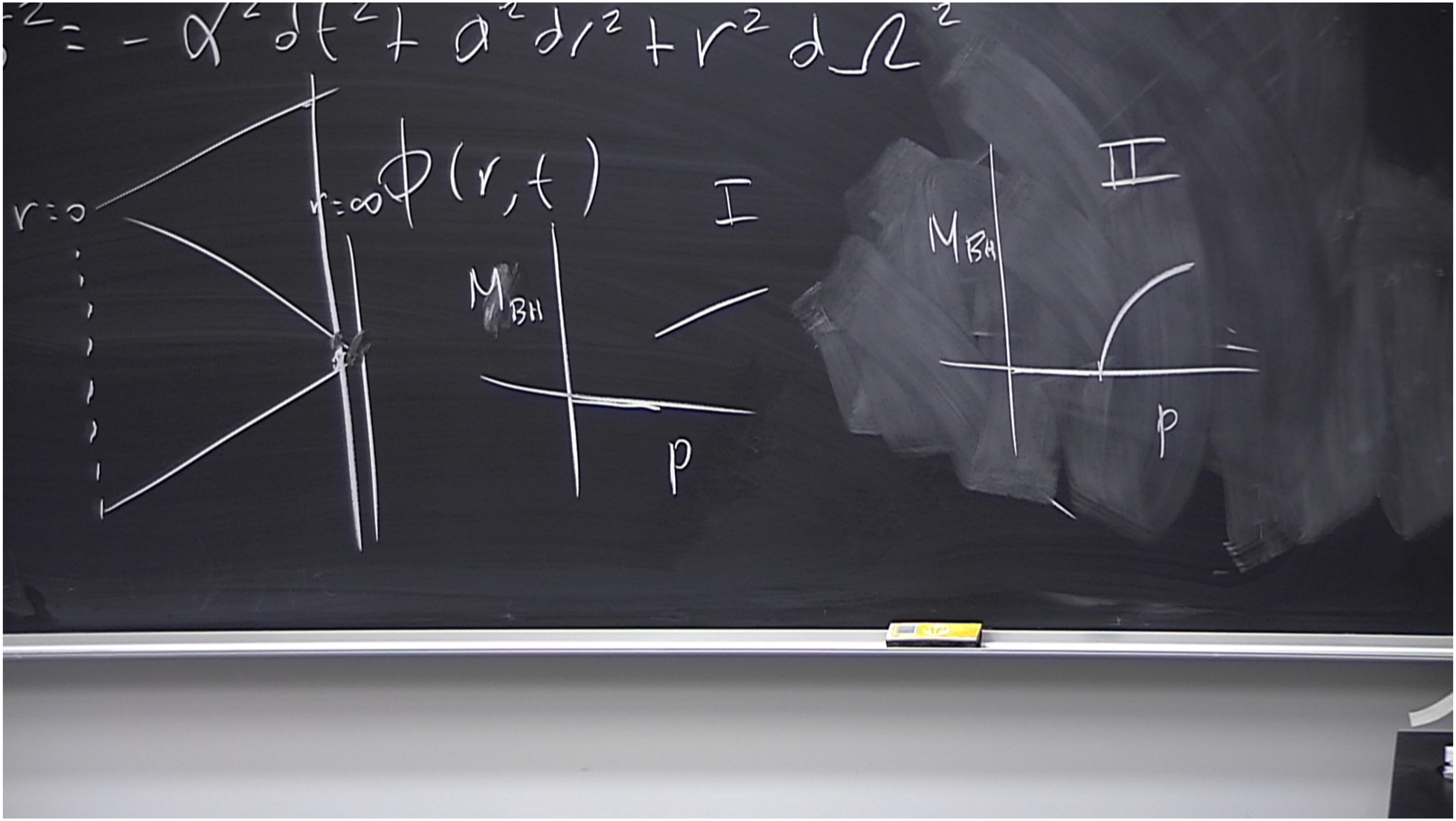
$\alpha = (r/L)\, f \qquad a = (L/r)\, g$

Rewrite equations in terms of f and g

Scalar field does not evolve at $r=0$.

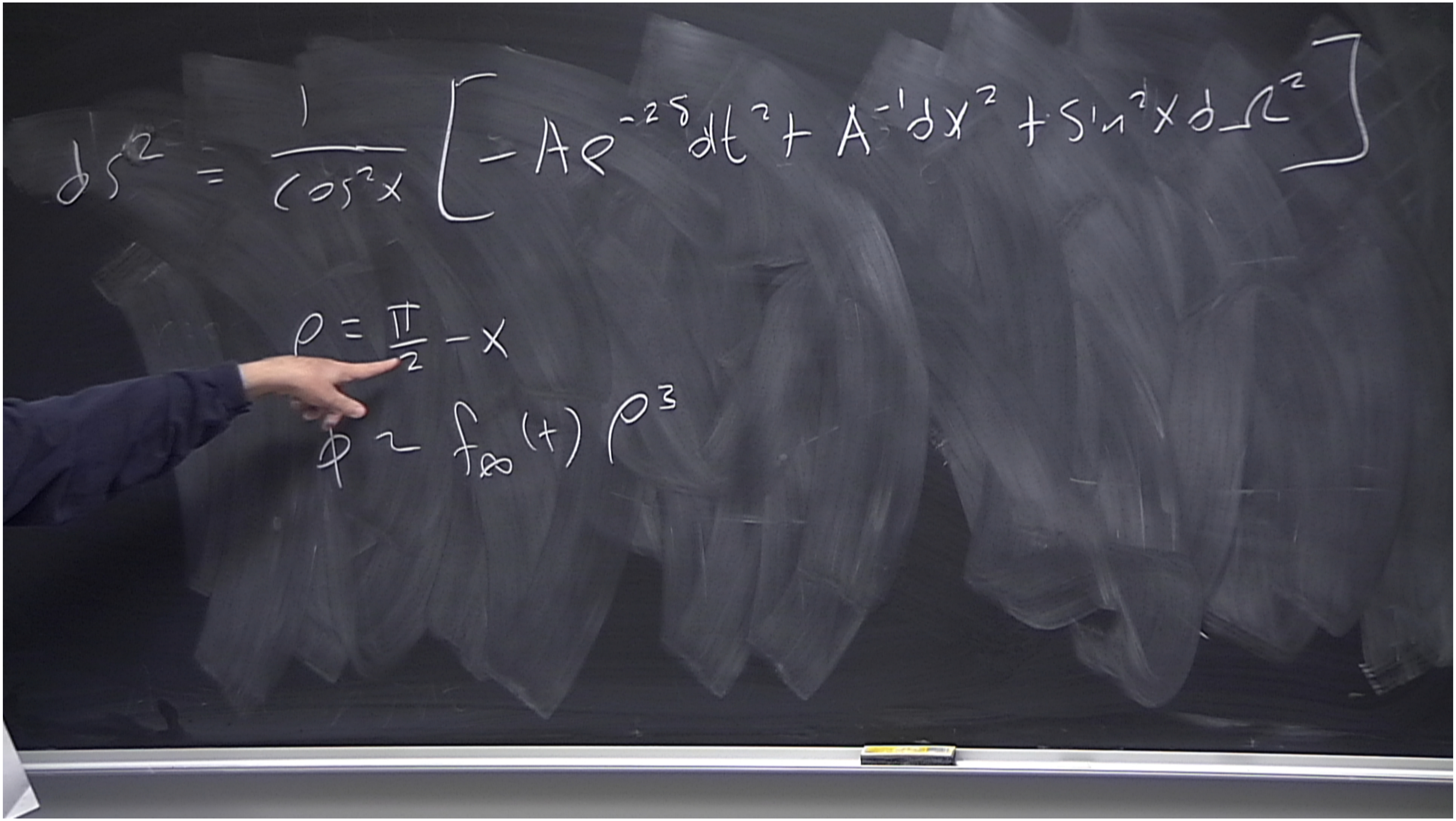
Potential for scalar field

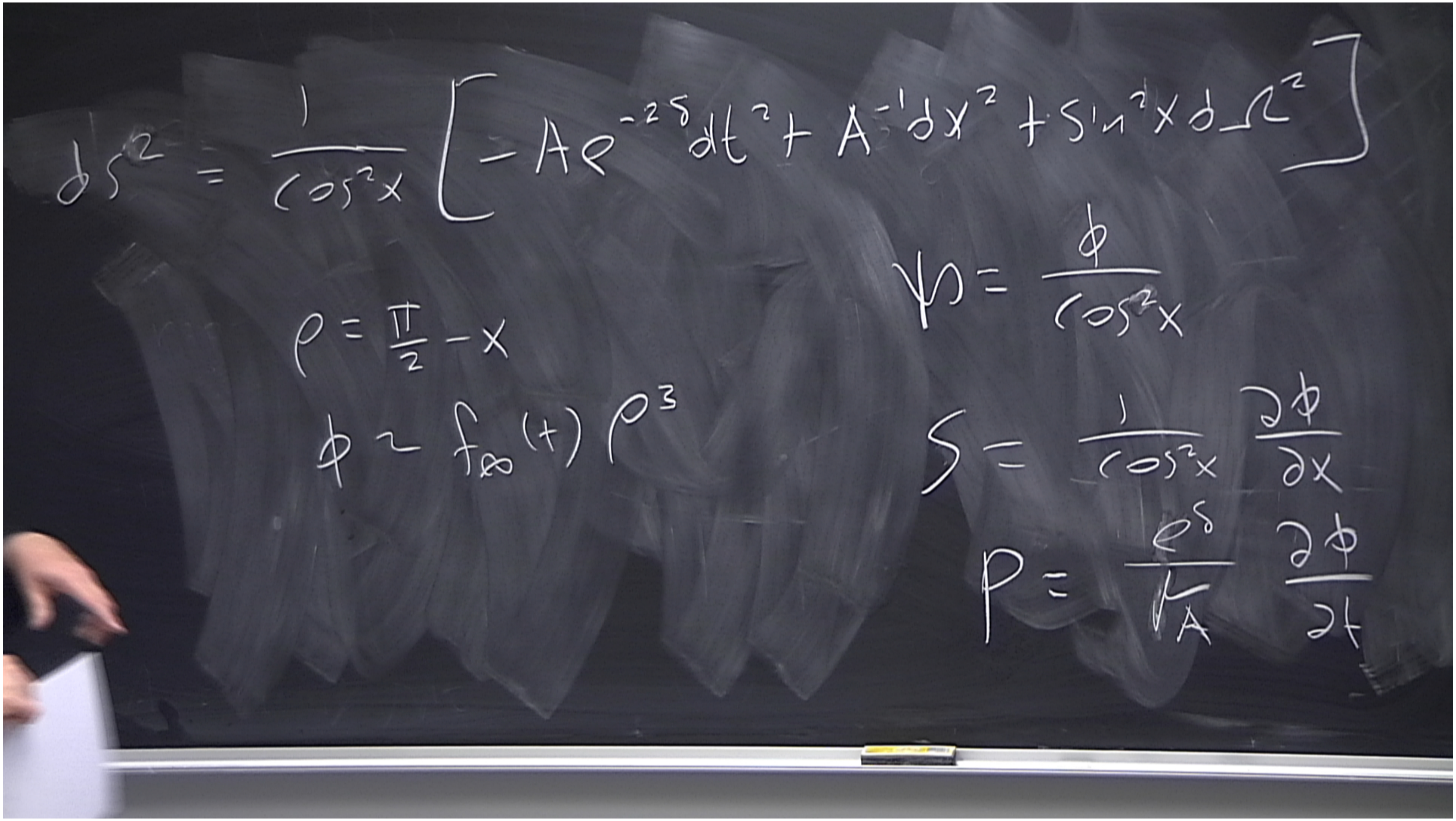
- The cosmological constant can come from a potential for the scalar field.
- Effective m^2 for scalar field can be either positive or negative (but not too negative).
- Is there type I critical gravitational collapse?

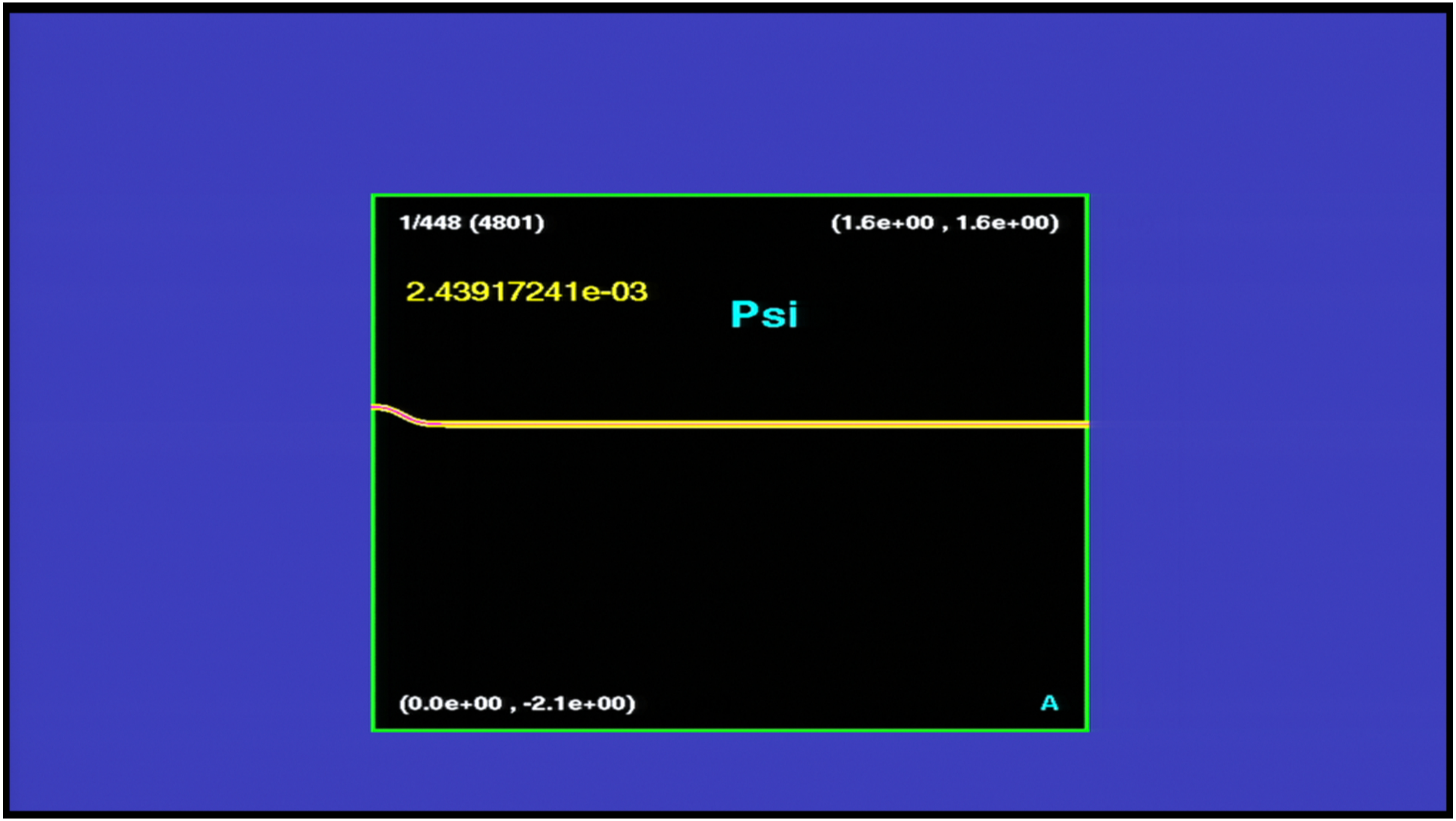

r=0
r=∞
Φ(r,t)
I
M_BH
p
II
M_BH
p

Compactified coordinates

- $r = \tan x$
- Need fields that are regular at the boundary and don't need too many conditions.


$ds^2 = \frac{1}{\cos^2 x}\left[-Ae^{-2\delta}dt^2 + A^{-1}dx^2 + \sin^2 x\, d\Omega^2\right]$
$\rho = \frac{\pi}{2} - x$
$\phi \sim f_\infty(t)\, \rho^3$


$ds^2 = \frac{1}{\cos^2 x}\left[-Ae^{-2\delta}dt^2 + A^{-1}dx^2 + \sin^2 x\, d\Omega^2\right]$
$\rho = \frac{\pi}{2} - x$
$\phi \sim f_\infty(t)\,\rho^3$
$\psi = \frac{\phi}{\cos^2 x}$
$S = \frac{1}{\cos^2 x}\frac{\partial \phi}{\partial x}$
$P = \frac{e^\delta}{\sqrt{A}}\frac{\partial \phi}{\partial t}$


1/448 (4801)
(1.6e+00 , 1.6e+00)
2.43917241e-03
Psi
(0.0e+00 , -2.1e+00)
A

go past

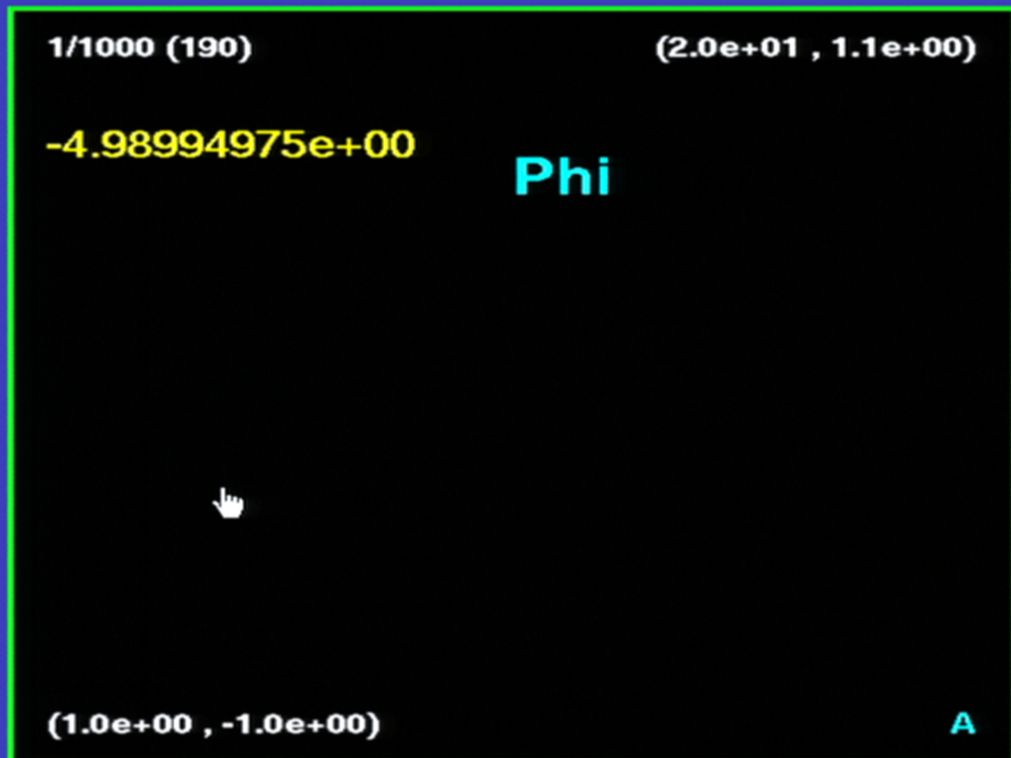
$$e^{-2\delta} dt^2 + A^{-1} dx^2 + \sin^2 x \, d\Omega^2 \Big]$$

bh formation

generalize past

spherical symmetry.

Charged black holes and scalar field



Conclusions

- Numerics is starting to tell us a few things about AdS collapse
- The type of numerical methods needed depend on what questions are being asked.