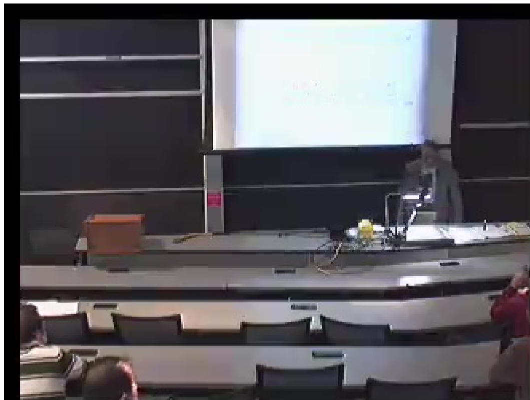
Title: Why there is no information loss

Date: Dec 04, 2008 11:00 AM

URL: http://pirsa.org/08120016

Abstract: Using 2-dimensional CGHS black holes, I will argue that information is not lost in the Hawking evaporation because the quantum space-time is significantly larger than the classical one. I will begin with a discussion of the conceptual underpinnings of problem and then introduce a general, non-perturbative framework to describe quantum CGHS black holes. I will show that the Hawking effect emerges from it in the first approximation. Finally, I will introduce a mean field approximation to argue that, when the back reaction is included, future null infinity is `long enough\' to capture full information contained in pure states at past null infinity and that the S-matrix is unitary. There are no macroscopic remnants.



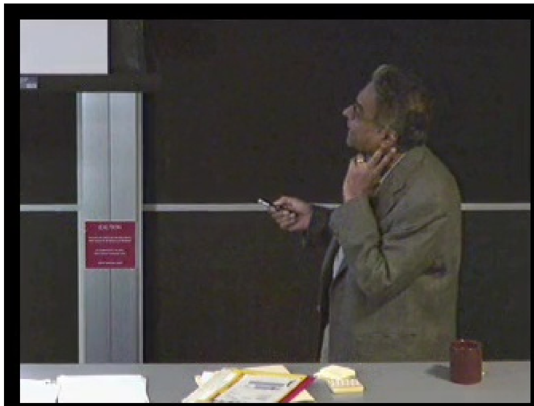
Why there is no information loss

Because the quantum space-time is sufficiently larger than the classical.

Goal: A space-time resolution of the information-loss issue. A general paradigm and realization in CGHS BHs

Organization:

1. Introduction & Conceptual

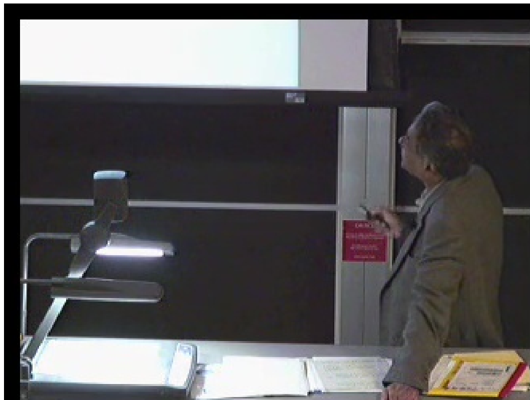


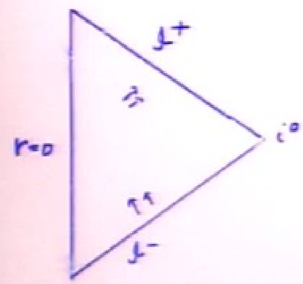
Goal: A space-time resolution of the information-loss issue. A general paradigm and realization in CGHS BHs

Organization:

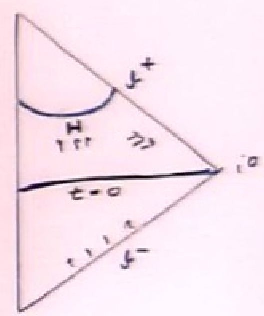
1. Introduction & Conceptual Setting
2. CGHS BHs : Information Recovery
3. Summary & Outlook

Joint work with Victor Tavares & Madhavan Varadarajan (PRL '08); Motivation from AA & Bojowald (CQG '05)



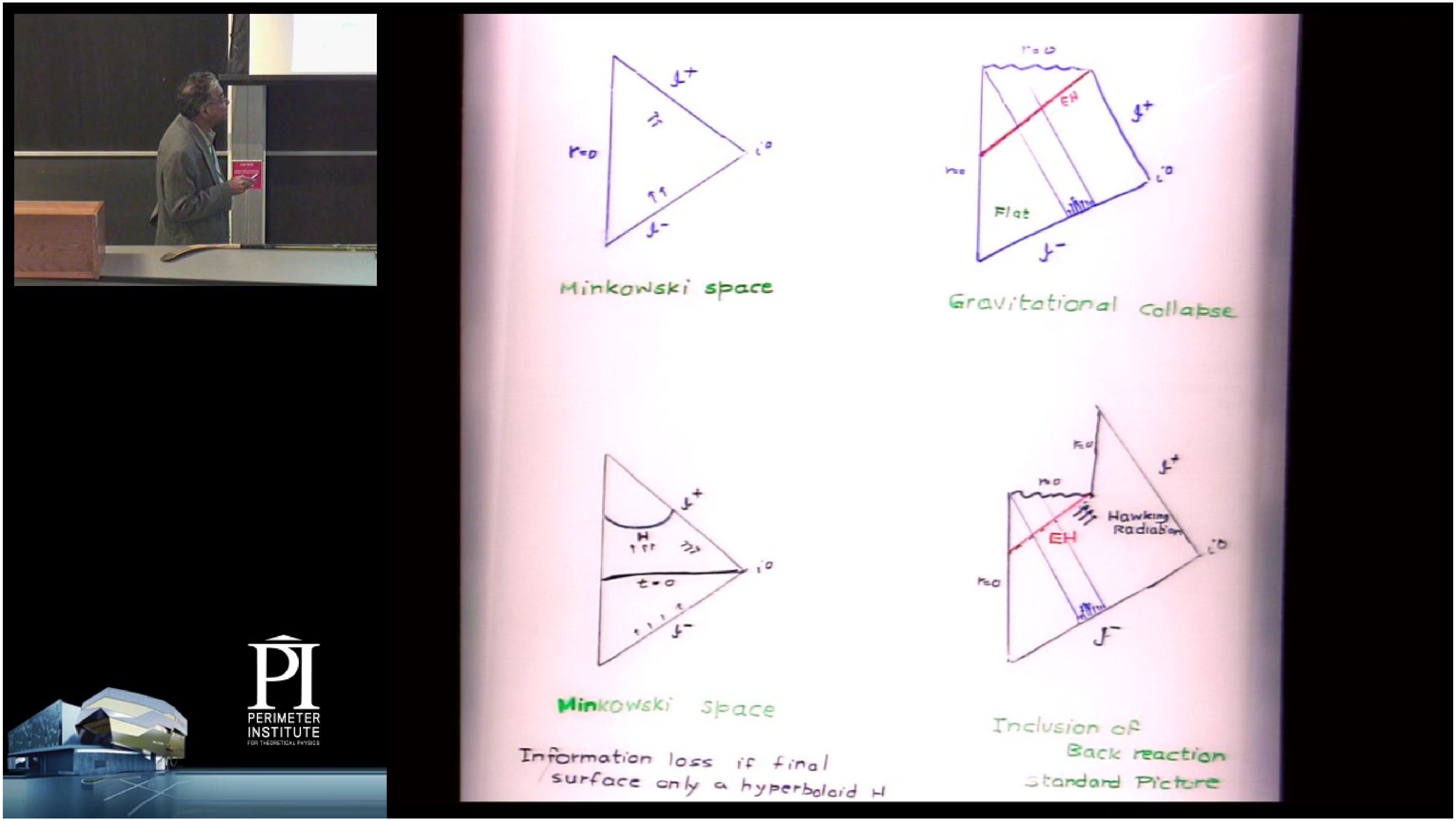


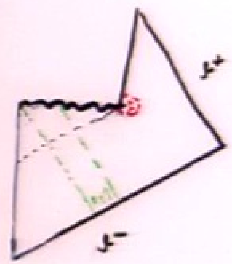
Minkowski space



Minkowski space

Information loss if f


Minkowski space
Gravitational collapse
Flat
EH
Minkowski space
Information loss if final surface only a hyperboloid H
Hawking Radiation
EH
Inclusion of Back reaction
Standard Picture
PERIMETER INSTITUTE



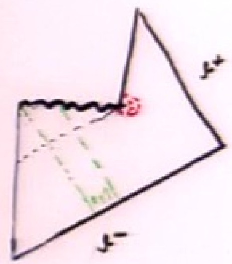
Full quantum gravity ?

- Standard Scenario :

  Effects important only at the very end of Hawking evaporation ; too small to restore correlations

- Limitations

1. Can't trust the semiclassical diagram near the entire singularity.



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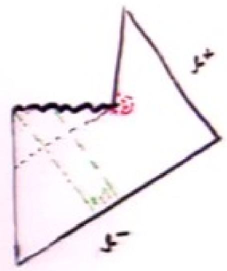

- Standard Scenario :

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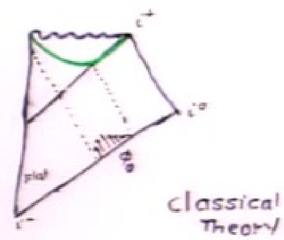
1. Can't trust the semiclassical diagram near the entire singularity.

2. Event horizon too global a concept. (e.g. Hajicék argument)

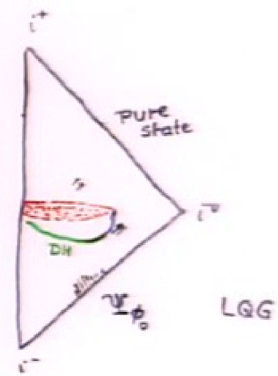
If singularity is resolved, event horizon may disappear completely or 'transcended'. What then is a BH? What evaporates?

Marginally trapped surfaces still exist & Well-defined quasi-local notion of Dynamical Horizons. (AA+ Krishnan, PRL, PRD, Living Reviews)

- Gather these precise results to develop a qualitative heuristic picture within LQG.
- spherical collapse of a scalar field: Large BH



LQG: strong Indications that quantum space-time does not end at singularity. ⇒ No sink of information!



Pure states on $\mathscr{I}^-$ evolve to pure states on $\mathscr{I}^+$ of the larger, quantum space-time.

Deep Planck regime
No classical space-time

2. CGHS (1+1 dim) BHs

(Callen, Giddings, Harvey & Strominger)

- Spherically symmetric GR with massless f

$${}^4g_{ab} = g_{ab} + \underbrace{e^{-2\phi}\,\kappa^{-2}}_{r^2}\, S_{ab} \qquad [\kappa] = L^{-1}$$

$$S^{(4)} = \frac{1}{G}\int d^2x\,\sqrt{|g|}\,\left[e^{-2\phi}\left(R + 2\,\nabla^a\phi\,\nabla_a\phi + 2\,e^{+2\phi}\,\kappa^2\right)\right]$$
$$-\frac{1}{2}\int d^2x\,\sqrt{|g|}\,e^{-2\phi}\,\nabla^a f\,\nabla_a f$$

- Dilaton Gravity: 1+1 dim, g_{ab}, ϕ, f

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- Both cases true degree of freedom: f

  But eqns simpler in CGHS

  in particular: $\Box f = 0 \iff \overset{\circ}{\Box} f = 0$ — refers to η^{ab}

  $g^{ab} = \Omega\,\eta^{ab}$

Dilatonic geometry: Ω and $\Phi := e^{-2\phi}$

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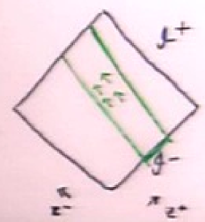
determined in a closed form by (f, η^{ab}).

$\eta_{ab} = -\partial_{(a} z^+ \partial_{b)} z^-$

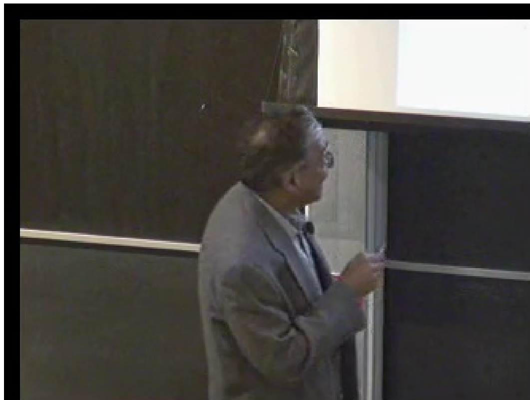
A) 2-d Flat space-time (M_o, η)
ZRM scalar field f



$\Box f = 0 \Rightarrow f = f_L + f_R$

S-matrix well-defined

No information loss in classical or quantum theory



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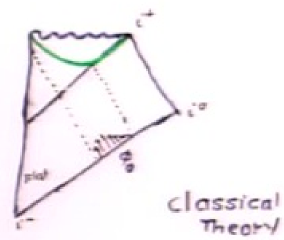

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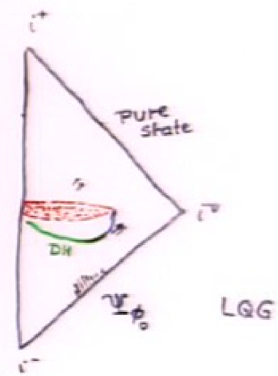

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