Title: Strings/Quantum Gravity 3

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Abstract:

THE MODEL

$$G_{ab} = 8\pi T_{ab}$$

$$T_{ab} = \partial_a \varphi \, \partial_b \varphi - \frac{1}{2} (\partial \varphi)^2 g_{ab}$$

$$g_{ab}(r,t) \qquad \varphi(r,t)$$

$$ds^2 = -f^2(r,t)\, dt^2 + g^2(r,t)\, dr^2 + r^2 d\Omega^2$$

$\varphi = 0 \rightarrow$ flat space or Schwarzschild

$\varphi(r,t)$ IS THE SOURCE OF LOCAL DEGREES OF FREEDOM.

* COMPLICATED 2D FIELD THEORY
* NO KNOWN ANALYTIC COLLAPSE SOLUTIONS THAT ARE ASYMPTOTICALLY FLAT.
* ANALYTIC COLLAPSE MODELS (Opp.-Snyder, Vaidya, CGHS & variations] HAVE ONLY MATTER INFLOWS — SCALAR FIELD MODEL IS MUCH RICHER...

* THERE ARE 2 CLASSES OF INITIAL DATA (ASYMPTOT. — T)

"WEAK" DATA $\longrightarrow$ NO BH FORMATION IN LONG TIME LIMIT

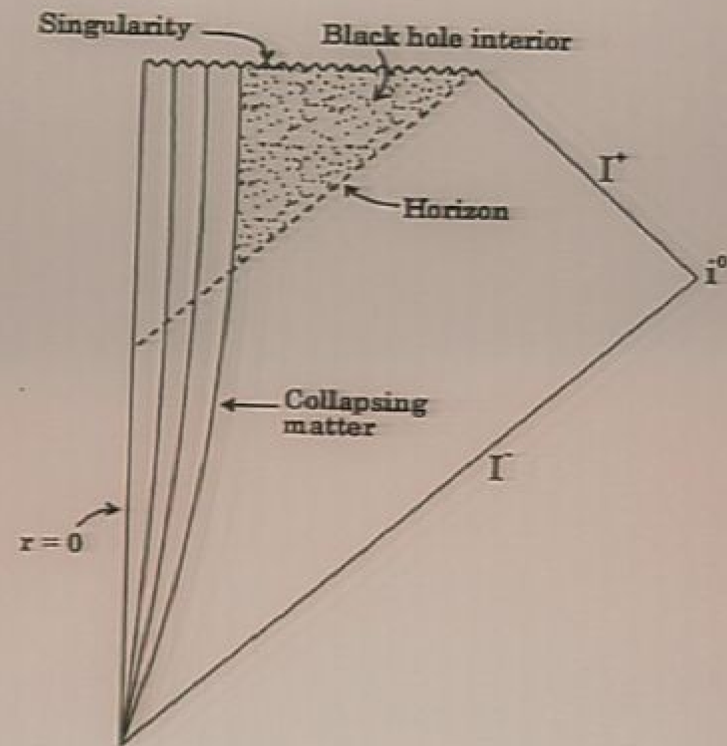
"STRONG" DATA $\longrightarrow$ BH FORMATION ---

— RESULT OF HARD ANALYSIS (CHRISTODOULO ~1975)

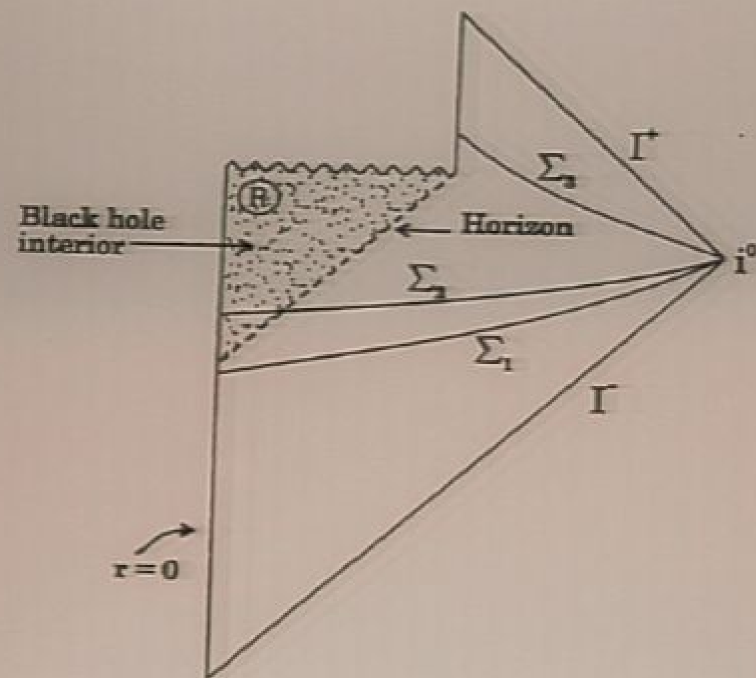
* DETAILS OF TRANSITION WEAK $\rightarrow$ STRONG DONE BY NUMERICAL EVOLUTION

(CHOPTUIK ~1993)

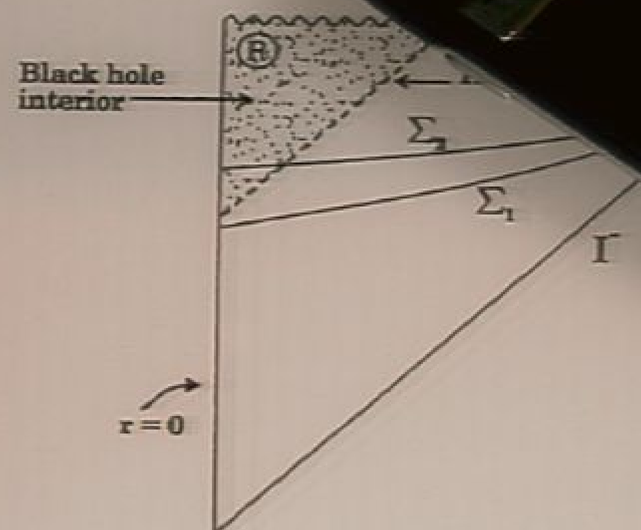
WITH $\pm\Lambda$ (VH, KUNSTATER, OLIVIER, ... ~2001)



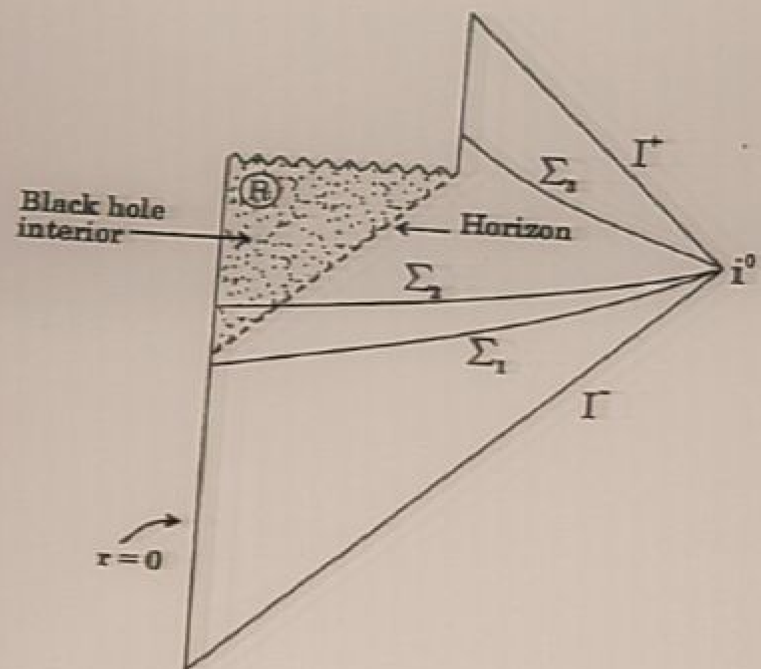
CONFIRMED PICTURE FOR
CLASSICAL BH FORMATION



CONJECTURED PICTURE FOR
HAWKING EVAPORATION



CONJECTURED PICTURE FOR HAWKING EVAPORATION

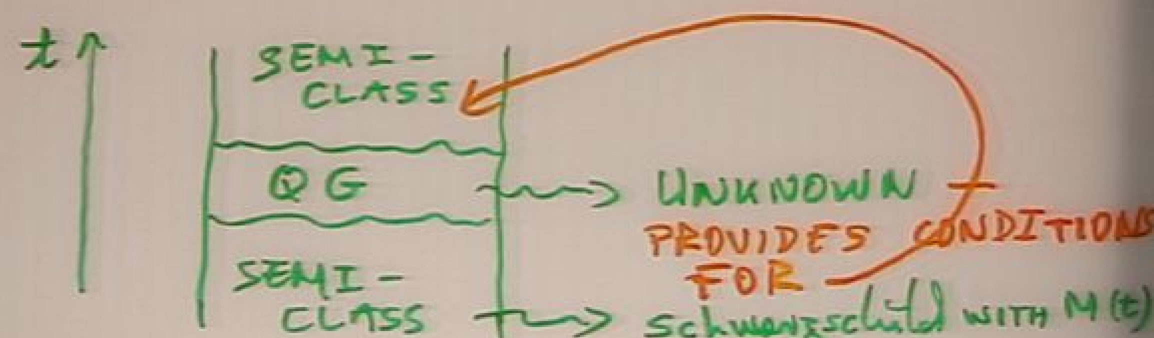


CONJECTURED PICTURE FOR HAWKING EVAPORATION

WHAT IS WRONG WITH THIS PICTURE?

* No computed metric for which this is the conformal diagram.
* Classical singularity is still there
* Event horizon is still there.

EXPECT THAT IN QG THE SINGULARITY SHOULD BE RESOLVED AND HORIZON SHOULD BE FUZZY.



THREE CENTRAL INGREDIENTS
FOR QG COLLAPSE

* SINGULARITY AVOIDANCE
  - BOUNDED CURVATURE OPERATORS
* FUZZY HORIZONS
  - QUANTUM TEST FOR TRAPPED SURFACES
* UNITARY EVOLUTION
  - HAMILTONIAN OPERATOR IN A TIME GAUGE

★ USE A HAMILTONIAN FORMULATION OF THE $g(r,t)$ $\phi(r,t)$ EINSTEIN EQNS.

★ ADM VERSION : $M \sim \Sigma \times R$

CANONICAL VARIABLES $\Big(\underbrace{q_{ab}(r,t)}_{\text{METRIC ON } \Sigma} ; \underbrace{\pi^{ab}(r,t)}_{\sim \text{EXTRINSIC CURVATURE OF } \Sigma \text{ IN } M} \Big)$

$$S = \frac{1}{8\pi G}\int_M \sqrt{-g}\, R\, d^4x + \int_M \sqrt{-g}\, g^{ab}\partial_a\phi\,\partial_b\phi\, d^4x$$

$$= \int_M d^3x\, dt \left\{ \pi^{ab}\dot{q}_{ab} + P_\phi\dot{\phi} - N^a C_a - N\mathcal{H} \right\} + \int_{\partial M} dt\, d^2x\, (\cdots)$$

$C_a(\pi, q; P_\phi, \phi) \simeq 0$ space reparam.

$\mathcal{H}(\,\cdot\cdot \quad \cdot\cdot\,) \simeq 0$ time "

★ $$S^{RED} = \int dr\, dt \left[\dot{R} P_R + \dot{\Lambda} P_\Lambda + \dot{\phi} P_\phi - N^r C_r - N\mathcal{H} \right] + \int dt\, (\cdots)$$

$$ds^2 = \Lambda^2(r,t)\, dr^2 + R^2(r,t)\, d\Omega^2$$

* GAUGE FIXING

FULL → $r = R$, $t = f(q, \pi)$

PARTIAL → $t = f(q, \pi)$

USEFUL TO EVOLVE WITH A KNOWN TIME VARIABLE

* WE WORK WITH ONLY A TIME GAUGE FIXING.

*
$$S^{RED}_{GF} = \int dr\, dt \left(\dot{R} P_R + \dot{q} P_q - N^r C_r \right) + \int dt \, (\cdots) \, .$$

E CONSTRAINT REMAINS.

GOAL FOR QUANTISATION :

A FRAMEWORK IN WHICH ONE CAN OBTAIN A COMPUTATIONAL PROCEDURE FOR STUDYING GRAV. COLLAPSE IN QG.

INITIAL DATA $\longrightarrow$ INITIAL STATE $|\Psi_0\rangle$

$\theta_\pm \longrightarrow \hat{\theta}_\pm$

CURVATURES $\longrightarrow$ $\widehat{\text{CURVATURE}}$

+ A PROCEDURE FOR STEP BY STEP TIME EVOLUTION OF $|\Psi_0\rangle$.

QUANTISATION

POISSON ALGEBRA OF "BASIC" CLASSICAL VARIABLES

$\longrightarrow$ COMMUTATOR ALGEBRA ON HILBERT SPACE

* $Q_f = \int_0^\infty f\, Q\, dr \qquad U_\lambda(P_\phi) = \exp(i\lambda P_\phi)$

translation.

$$\{Q_f, U_\lambda\} = i\lambda f(r)\, U_\lambda$$

* HILBERT SPACE

$r_1 \qquad\qquad r_N$

$\{r_i\}$ a sample of points from half line $r \in [0,\infty)$

$|a_1 \cdots a_N; b_1 \cdots b_N\rangle$

* a_i : "excitations" of field $R(r)$
b_i : " " " $Q(r)$

* $\hat{Q}_f\,|\ \rangle = \sum_{k=1}^{N} f(r_k)\, a_k\, |\ \rangle$

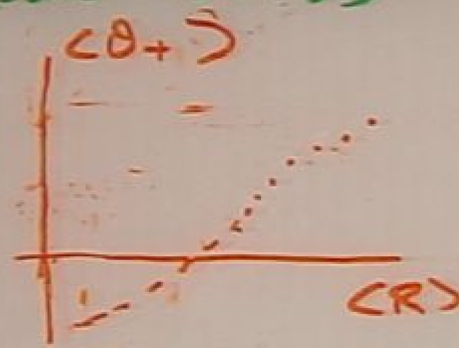
* $\hat{U}_\lambda(r_k)\,|\ \rangle = |a_1 \cdots a_k - \lambda \cdots a_N; b_1 \cdots b_N\rangle$

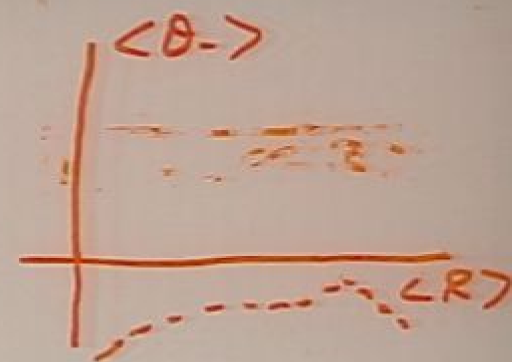
TRAPPING – ST OPERATORS

* $\Theta_\pm (P_\varphi, \varphi, R, P_R) \longrightarrow \hat{\Theta}_\pm$

  HAVE WELL DEFINED ACTION ON BASIS STATES $|a_1 \cdots a_N ; b_1 \cdots b_N\rangle$

* STATES THAT SATISFY QUANTUM TRAPPING CONDITIONS HAVE BEEN CONSTRUCTED





* COHERENT STATES PEAKED ON CLASSICAL SOLN: OF CONSTRAINTS:

$|C)(q_0, \pi_0 ; \varphi_0 P_{\varphi_0})$ $\quad \langle C | \hat{C}_r | C \rangle = 0 + \mathcal{O}(\hbar)$

15-

SUMMARY

A FRAMEWORK FOR EXPLICIT GRAVITATIONAL COLLAPSE CALCULATIONS IN QG.

---- BUT

MUCH WORK STILL TO BE DONE.