

Title: On Strong Cosmic Censorship

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Abstract:

On
Strong Cosmic Censorship

Great Singularity Debate of 1960s:

- Most known sol'ns of Einstein's Eqs have $|curvature| \Rightarrow \infty$

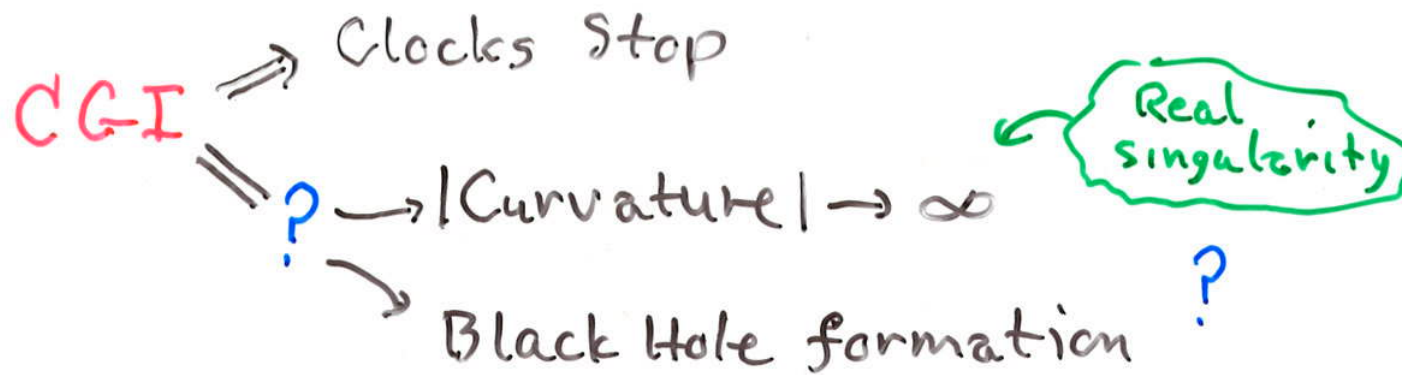
¿ Is this • Artefact of Symmetry of these sol'ns
or
• Feature of Generic Sol'ns ?

Physical Relevance:

¿ Should one expect the Cosmos to have Big Bang and/or Big Crunch?

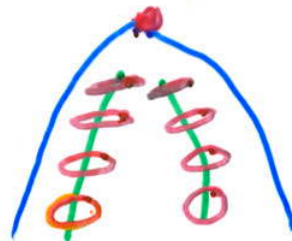
¿ Should one expect isolated concentration of stuff to collapse gravitationally to ... ?

Unresolved Issue:



What We See in Known Sol's

Kasner

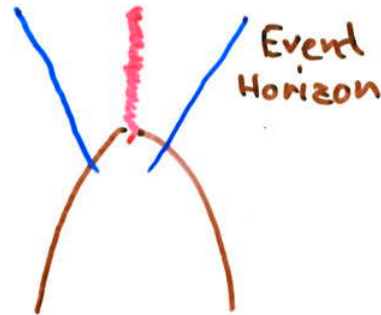


CGI

&

$|Curvature| \rightarrow \infty$

T-O-V Schwarzschild



CGI

&

$|curvature| \rightarrow \infty$

&

Black Hole

$a > M$ Kerr

CGI

&

$|curvature| \rightarrow \infty$

&

No Black Hole

→
Naked
Singularity

Penrose conjectures:

late 1960s

Strong Cosmic Censorship Conj:

(intuitive version)

Globally hyperbolic spm sol'ns of Einstein's Eqs
generically cannot be extended past a Cauchy horizon

So:

CGI generically marked by $|curv| \rightarrow \infty$

Weak Cosmic Censorship Conj:

(intuitive version)

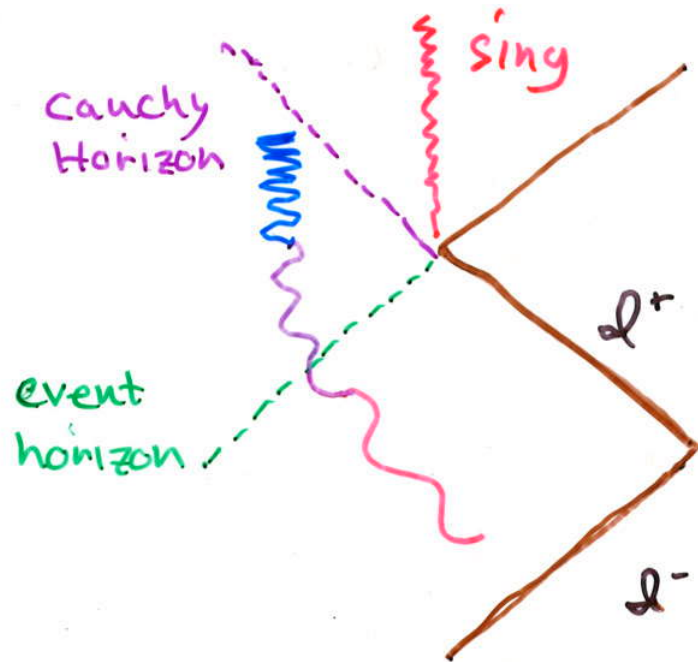
In generic AF spm sol'ns of Einstein's Eqs
Curvature is bounded outside any event horizons

So:

Singularities generically occur

Penrose's Motivation for SCC & WCC

SCC: Blue Shift Instability of Cauchy Horizons



WCC: Dislike of Naked Singularities?

Comments

(before answering)

- Math Question, Not Physics Question

- Occurrence of Cauchy horizon or Naked Sing in our Cosmos is Physics Question
- SCC & WCC are about generic subsets of all sol'n's

- Generic is crucial to SCC & WCC

- Finding small collection of solns with Cauchy Horizon or Naked Singularity does not disprove SCC or WCC

¿ Is Strong Cosmic Censorship True?



¿ Is there a SCC-inspired Thm ?

or

¿ Is there a SCC-inspired Coenter Thm?

Short Answer

Neither, yet

Longer Answer

Interesting progress in both directions !

Model - SCC Theorems

- What we mean:

- Choose restricted family of sptms defined by Isometry

- * Locally Homogeneous
3 dim isometry

- * Gowdy
2 dim isometry +

- * T^2 -Symmetric
2 dim isometry

- * $U(1)$ -Symmetric
1 dim isometry

- Formulate SCC-type Thm for that Family

Example: Polarized Gowdy

- Why Model-SCC Thm is Useful

- Practice in Rigorous Formulation of SCC-type Thm

↖ Get rid of
vagueness

- Practice in proving such thms
- March down the Symmetry Ladder:

Table of Model-SCC & AVTD/Mixmaster Results

Family	Isom Dim'n	Model SCC	AVTD	AVTD Evidence	Mixmaster Evidence
- Loc Homog	3	Y	Some		Rest
- Pol'd Gowdy	2^{++}	Y	Y		
- Gowdy	2^+	Y	Y		
- Pol'd T^2 Sym	2			Y	
- T^2 Sym	2		N		Y
- Pol'd $U(1)$ Sym	1^+			Y	
- $U(1)$ Sym	1		N		Y
- General	0		N		

AVTD & Mixmaster Behavior

- What AVTD is

"Asymptotically Velocity-Term Dominated"

Define using Evolution Hamiltonian Density

$$\mathcal{H}(\chi, k) = \mathcal{T}(\chi, k) + \mathcal{V}(\chi, \underline{2\chi}, k)$$

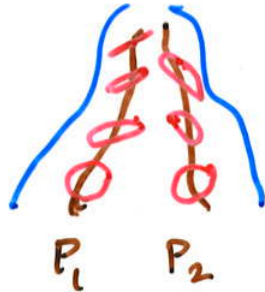
Defn:

- A spm sol'n (M, g) is AVTD if
as $t \rightarrow \text{sing Region}$

$$\frac{|\mathcal{V}|}{|\mathcal{T}|} \rightarrow 0$$

For
some choice
of time

So



Your own private Kasner

- A family of sol'n's is AVTD
if generic sol'n in family is AVTD
- How AVTD is Useful for Proving Model-SCC Thm
 - If a family of sol'n's is AVTD
then
 $| \text{Curvature}(g) | \rightarrow \infty$
iff

- Evidence for AVTD

4 levels:

- Proof that generic sol'n in family is AVTD

* Pol'd Gowdy

Based on Energy Estimates

Chrusciel
Moncrief
I

* Gowdy

Based on Energy Estimates
& careful analysis of spikes

Ringstrom

- Proof that open sets of sol'ns in family are AVTD

* General Sol'ns with Stiff Fluid

Based on Stability Analysis of FLRW

Rodnianski
Spect

- Proof that lots of sol'ns in family are AVTD

Archetypal Staged Analysis of AVTD: Gowdy

- Numerical Simulations
observe AVTD

when no one
believed it would
be there

- Asymptotic IVP Study (Fuchsian)
constructs lots of AVTD sol'n's
 - * Analytic Solns
 - * Smooth Solns

- Global Analysis
shows that AVTD is generic in Gowdy

- ¿ Might Generic Sol'ns be AVTD?

- Early 1960s BKL → Yes
- Numerical Simulations → No!

But, perhaps

Mixmaster

- What Mixmaster Is

AVTD epochs interrupted by Eruptions

- Is Mixmaster useful for Proving Model-SCC Thm?

Don't know:

- Evidence for

- * Model-SCC Thm proven for Bianchi IX

Rings from

- Obstructions

- * No $g \rightarrow \hat{g}$ correspondence

- * No theorems for inhomogeneous sol'ns

- Evidence for Mixmaster

only

Counter-SCC Theorems

- Goal of Counter-SCC Thms

Show that existence of Cauchy Horizon is Stable.

- in all sol'ns: Counter-SCC Thm
- in family of sol'ns: Model Counter-SCC Thm

~~~~~  
No such results known

unless generalize Cauchy Horizon  
to "Weak Null Singularity"



## - Results on Weak-Null Singularities

- Spherically Symmetric Solns of Einstein-Maxwell
  - Open set of solns with weak null sings

So Blue shift effect does not kill  
R-N Cauchy horizon  
⇒ only "weakens" it

Dafermos

- General Sol's of Einstein Eghs
  - Open set of sol's with weak null sings

So Blue shift effect does not kill  
Kerr Cauchy horizon  
⇒ only "weakens" it

Luk

- Gargantua

# Is SCC True?

- Have Model-SCC Thms for

Spatially Homog Solns  
Pol'd Gowdy  
Gowdy

- Strong Indications for Model-SCC for

via AVTD

Pol'd  $T^2$  Sym

Pol'd  $U(1)$  Sym

General Einstein-Stiff Fluid

General Einstein-Vac  $n$  Dims

- Strong Indications for Counter-SCC Thm

via Weak-Null Sings