

**Title:** Timelike Surfaces in Gravity

**Speakers:** Themistocles Zikopoulos

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**Abstract:**

It may be the case that a spacetime exhibits no asymptotia where gauge invariant observables can be defined in a natural way. On such occasions the introduction of a timeline boundary may be helpful. We therefore discuss the initial boundary value problem in the context of General Relativity.



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IN  
GRAVITY

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# TIMELIKE SURFACES IN GRAVITY

AKA GRAVITATIONAL OBSERVATORIES

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PI GRAD CONFERENCE, 13 SEPTEMBER 2023



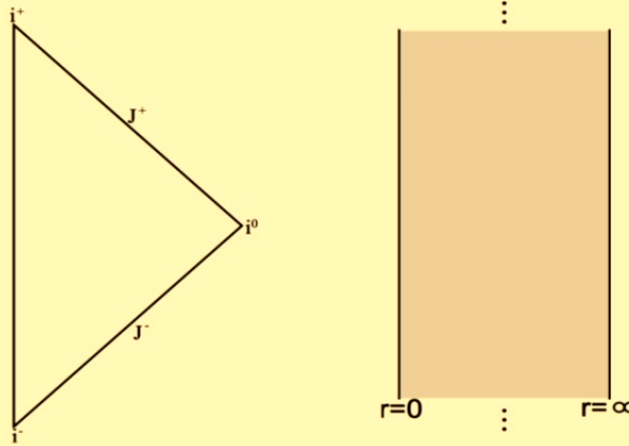


## GRAVITY OBSERVABLES

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Given a spacetime  $(\mathcal{M}, g)$ , how can one define gauge invariant observables?



ex. null infinity or asymptotically AdS timelike boundary



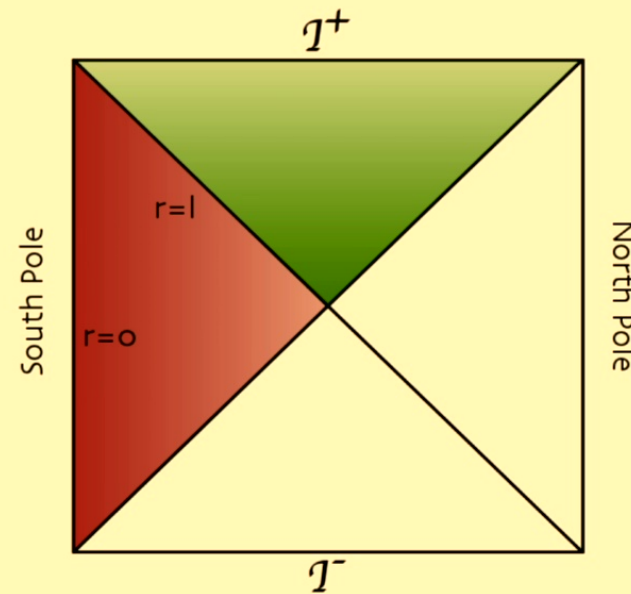


## COSMOLOGICAL SCENARIOS

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What happens, though, when there is no such asymptotia?



i.e. cosmological settings, where the Cauchy slice can also be compact



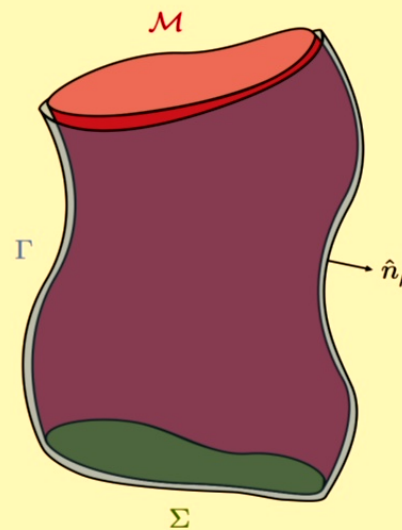


## SETUP

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As an auxiliary step, consider the Initial Boundary Value Problem of GR



Specifying the ordinary IVP data of GR along  $\Sigma : \{\tilde{h}_{mn}, \tilde{K}_{mn}\}$   
[CHOQUET-BRUHAT, GEROCH 69'], which are the appropriate boundary conditions for the IBVP to be well-posed?





## IBVP IN GR

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- Dirichlet boundary conditions:  
 $\Gamma : \{h_{mn}\}$  &  $\Sigma : \{\tilde{h}_{mn}, \tilde{K}_{mn}\}$   
Not well-posed! [ANDERSON 08']





## IBVP IN GR

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- Dirichlet boundary conditions:  
 $\Gamma : \{h_{mn}\} \ \& \ \Sigma : \{\tilde{h}_{mn}, \tilde{K}_{mn}\}$   
Not well-posed! [ANDERSON 08']
  
- Conformal boundary conditions:  
 $\Gamma : \{h_{mn}|_{conf.}, K\} \ \& \ \Sigma : \{\tilde{h}_{mn}, \tilde{K}_{mn}\}$   
Proved to be well-posed in Euclidean, conjectured in Loren-  
tzian! [AN, ANDERSON 21']





## OUTLOOK

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Conformal boundary conditions offer exciting new insights on:

- characterizing (cosmological) spacetimes from the perspective of finite timelike surfaces
- black hole thermodynamics
- dS holography (e.g.  $T\bar{T} + \Lambda_2$  deformations of AdS/CFT)







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THANK YOU!

