Title: Is singularity resolution trivial?

Speakers: Ding Jia

Collection: Young Researchers Conference

Date: June 22, 2022 - 9:25 AM

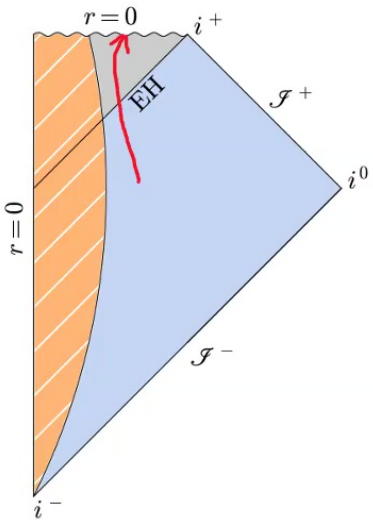
URL: https://pirsa.org/22060055

Abstract: Many non-trivial ideas have been proposed to resolve singularities in quantum gravity. In this talk I argue that singularity resolution can be trivial in gravitational path integrals, because geodesically incomplete singular spacetimes are usually not included in the sum. For theories where this holds, there is no need to develop non-trivial ideas on singularity resolution. Instead, efforts should better be directed to understand tunneling processes and complex-valued spacetimes.

IS SINGULARITY RESOLUTION TRIVIAL?

June 21, 2022, Waterloo
Young Researchers Conference
Ding Jia

PENROSE-HAWKING SINGULARITY THEOREMS FOR CLASSICAL SPACETIME



Establish singularities in the geodesically incomplete sense

-Timelike paths terminate at finite proper time

-g stops existing at singularities

THERE ARE MANY NON-TRIVIAL IDEAS ABOUT SINGULARITY RESOLUTION IN QUANTUM SPACETIME

The Gordian Knot

Choose variable
(e.g., Loop Quantum Cosmology vs. Wheeler-deWitt)

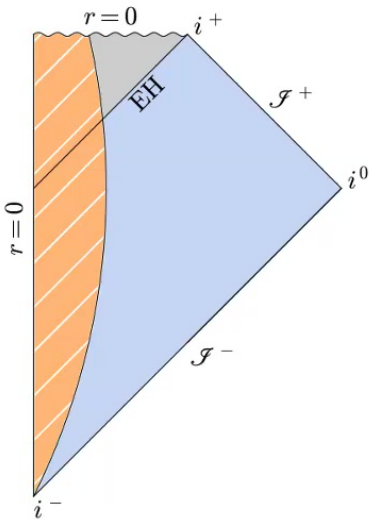
Choose action
(e.g., regular BH: add terms to Einstein-Hilbert)

Choose boundary condition
(e.g., final state proposals)

Understand black hole/cosmological solutions in detail
(e.g., BKL considerations)

…

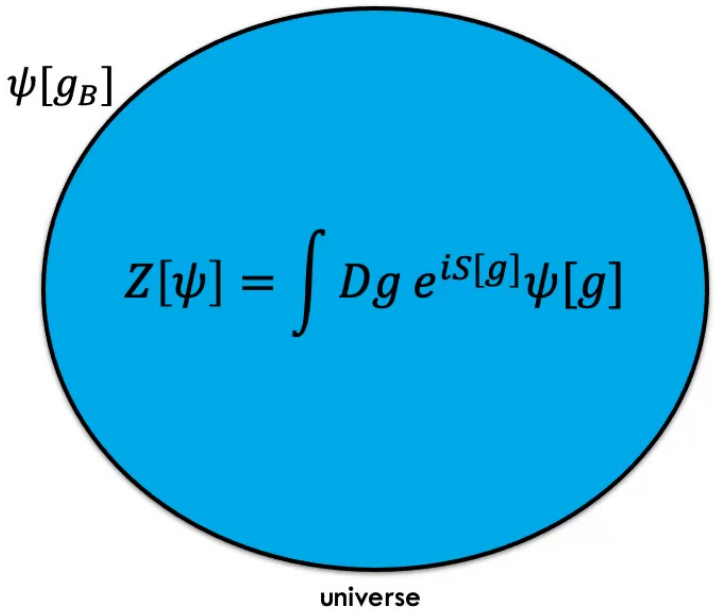
I WANT TO PRESENT A TRIVIAL IDEA ABOUT SINGULARITY RESOLUTION



Key:

Singular spacetimes don't belong to gravitational path integrals

ASSUMPTION: GRAVITATIONAL PATH INTEGRAL



Pick a theory you like

Can include matter

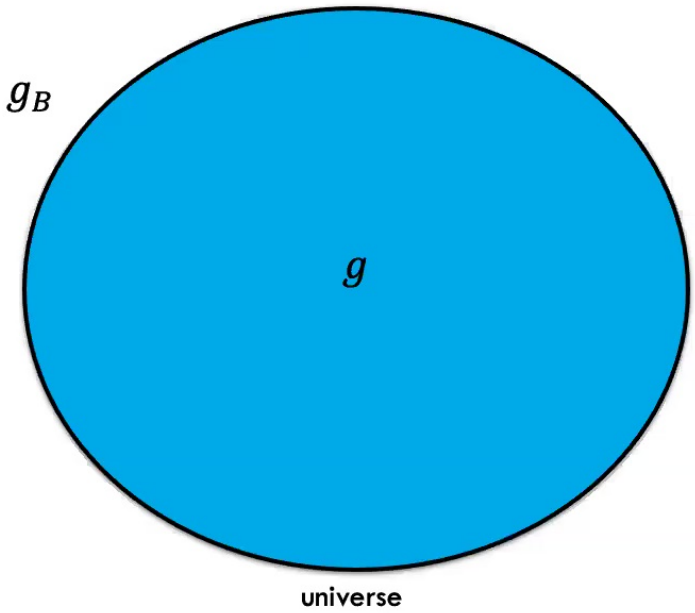
$$Z[\psi] = \int Dg\, D\phi\, e^{iS[g,\phi]}\psi[g_B, \phi_B]$$

Can include observations

$$Z[\psi, w] = \int DgD\phi\, e^{iS[g,\phi]}\psi[g_B, \phi_B]w[g, \phi]$$

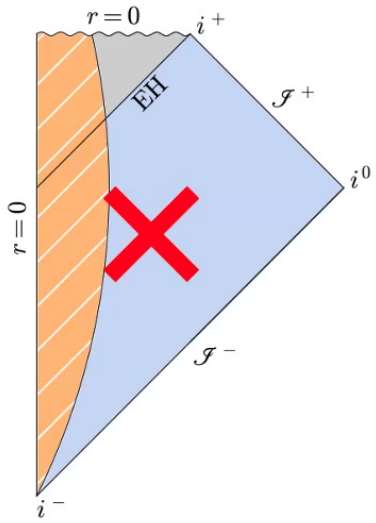
Can include mixedness (double path)

g_B HAS TO EXIST!



For all g in $\int Dg$,
g_B has to exist as some codimension-1 space(time) configuration

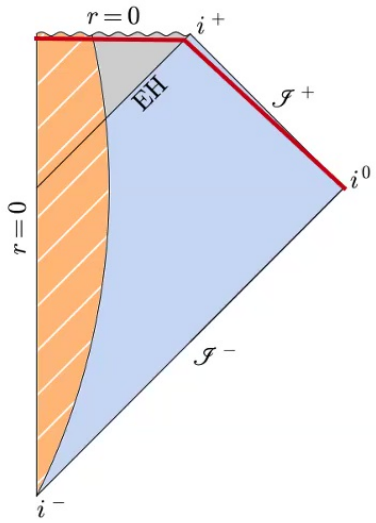
DO SINGULAR SPACETIMES BELONG?



g does not exist at singularities

Hence singular spacetimes do not belong to the path integrals

WHAT IF PICK BOUNDARY CLOSE TO THE SINGULARITY?



Then the restricted portion belongs, but there is no singularity!

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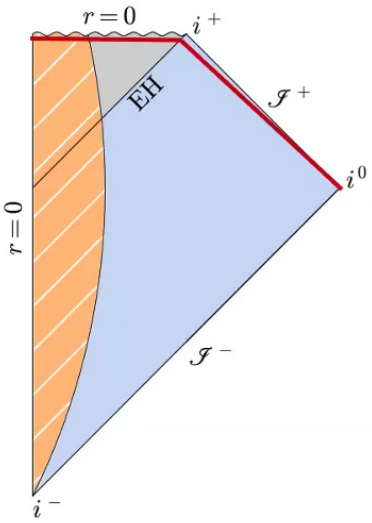

Then the restricted portion belongs, but there is no singularity!

The universe ends before any singular behavior takes place

SUMMARY: A TRIVIAL SOLUTION

DJ. "Is singularity resolution trivial?" arXiv:2204.12304

SUMMARY: A TRIVIAL SOLUTION

In GR, we care about a differential equation

Singular spacetimes are solutions to certain initial value problems, so they constitute an issue

In QG, we care about an integral

Singular spacetimes do not belong to the integral, so they do not constitute an issue

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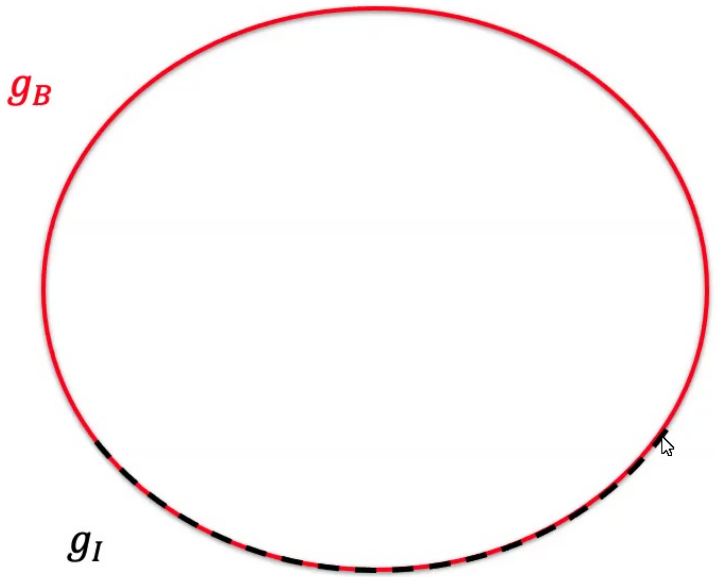
QUESTION 1: DO SINGULAR SPACETIME COME BACK IN CLASSICAL APPROXIMATIONS?



No!

Solve for stationary points: $\delta S[g] = 0$

Classical theory:

$$\delta S[g]|_{g_I}$$

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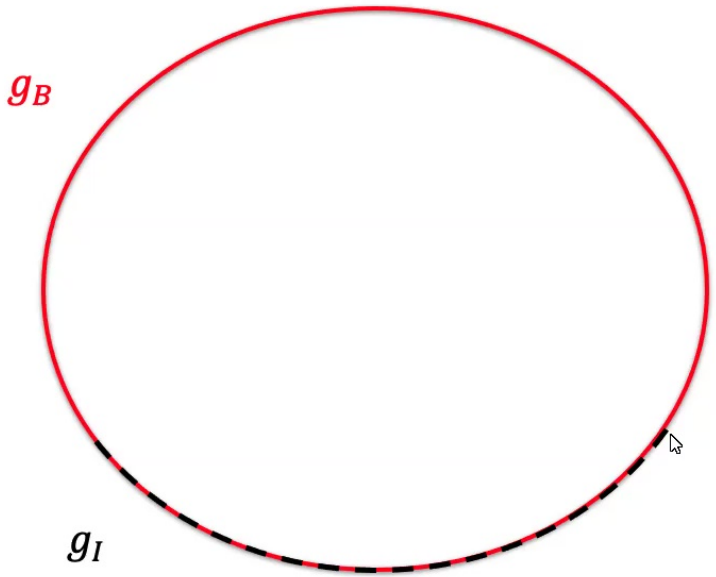

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Classical approximation of quantum theory:

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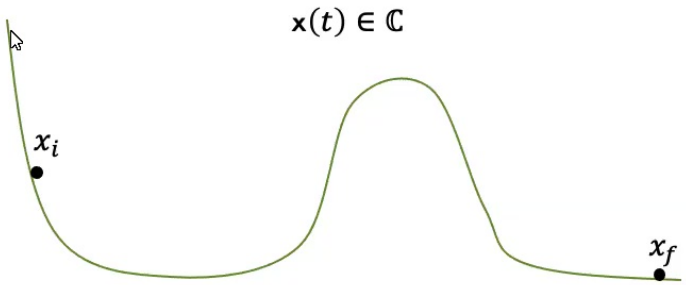
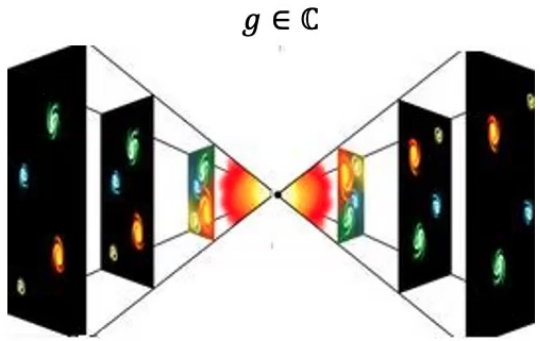
QUESTION 2: WHAT REPLACE SINGULAR SPACETIMES IN CLASSICAL APPROXIMATIONS?





Tunneling solutions!

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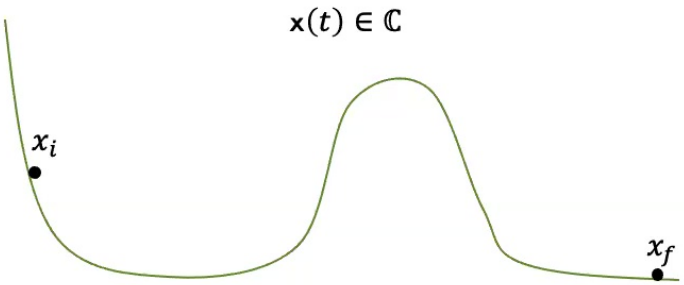

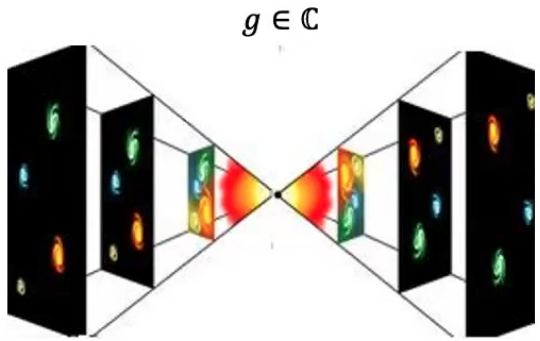

Tunneling solutions!

$\delta S = 0$ for black hole initial conditions: complex stationary configuration

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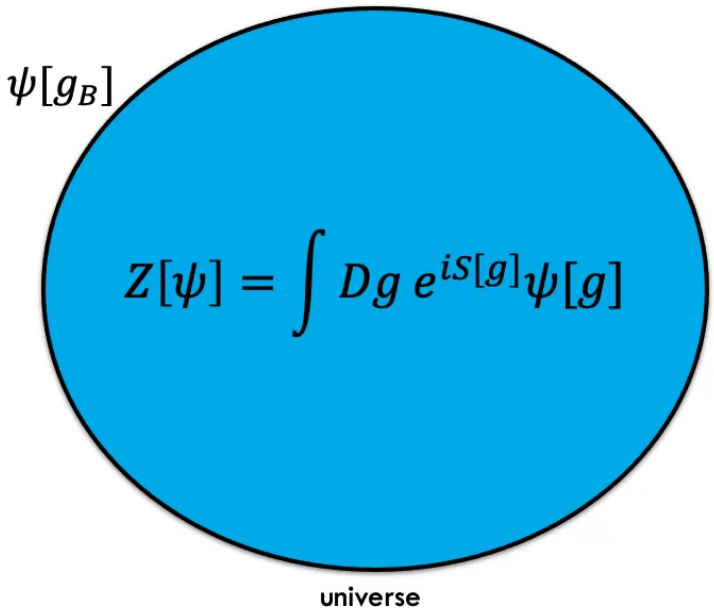

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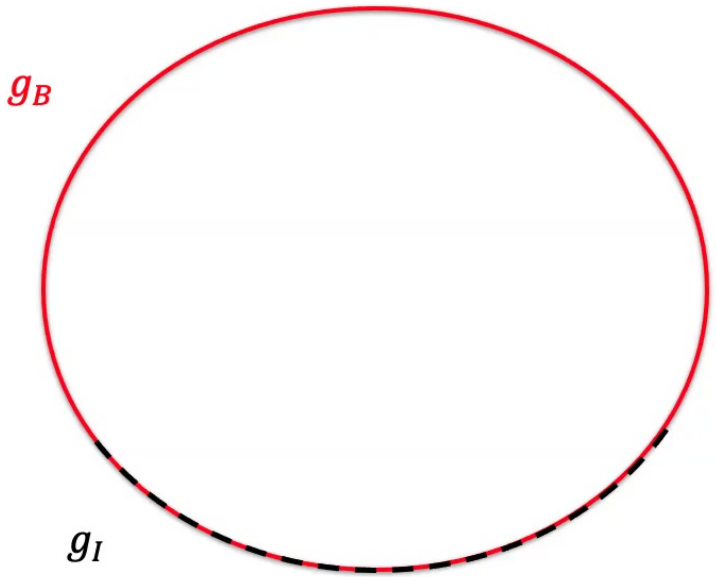

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