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Title:	Why We Need (But Don't have) Quantum Gravity
Author(s):	Miller, Jonah Maxwell
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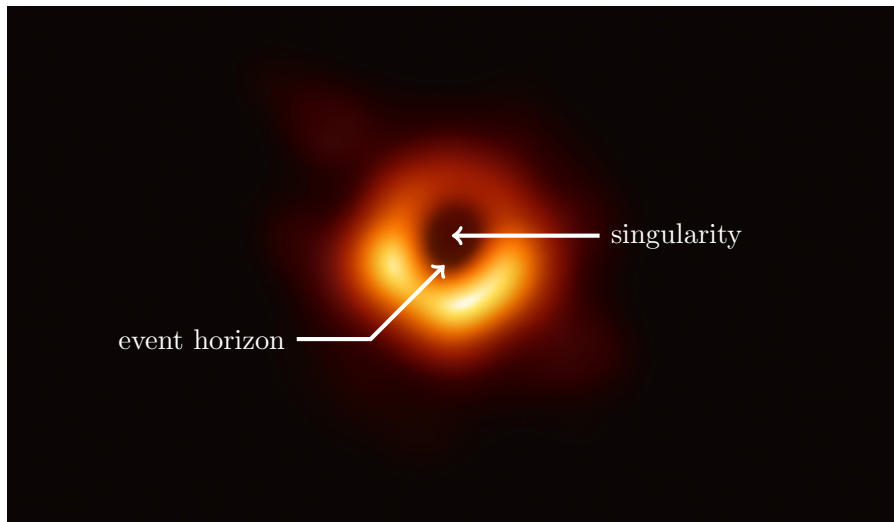
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Why we Need (But Don't Have) Quantum Gravity

Jonah M. Miller

UNM Continuing Education Class

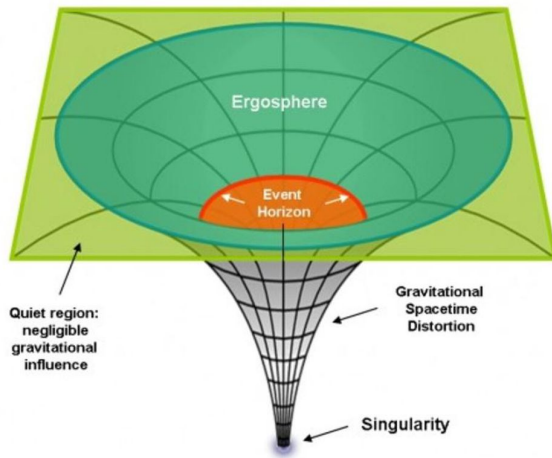
Why we need quantum gravity



EHT Collaboration

The Singularity: A Point of Infinite Density?

Black Hole Regions

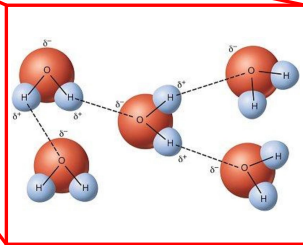


We've seen this before...



Ensign John Gay, USS Constellation, US Navy/USGS

We've seen this before...



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Why we need quantum gravity

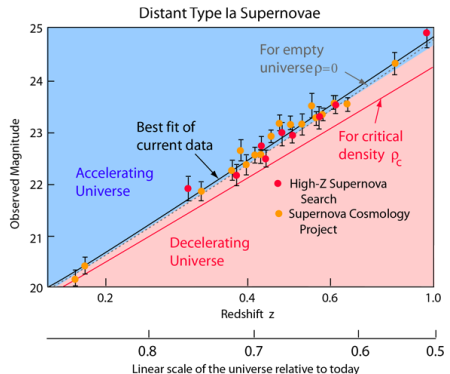
- When the fluid approximation for air breaks down...
 - We must understand it as a collection of molecules...
 - which are quantum
- When the continuum approximation for spacetime breaks down...
 - We must understand it as...?
 - Which is quantum?

Why we won't get it

The Accelerating Universe

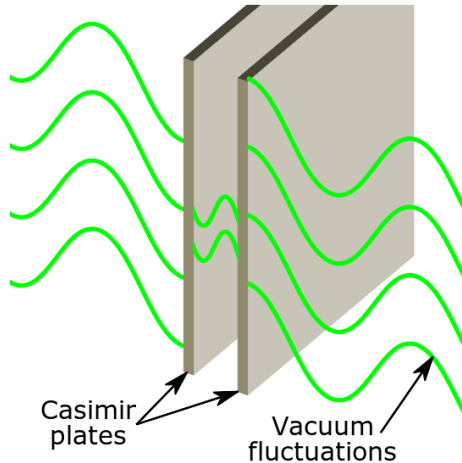


2006 Shaw Prize, Wikimedia
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Carroll and Ostlie

The Cassimir Effect

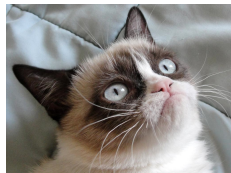
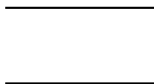
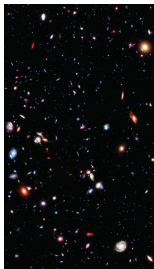


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The Vacuum Catastrophe: wrong by $10^{120} \times$

$$E[\Lambda]$$



Images: Hubble Deep Field, NASA, Grumpy Cat

The varied approaches to quantum gravity

- Start from quantum field theory, and try to add gravity (string theory)
- Start from general relativity and attempt to quantize it (loop quantum gravity)
- Start from discrete building blocks (causal sets, causal dynamical triangulations)

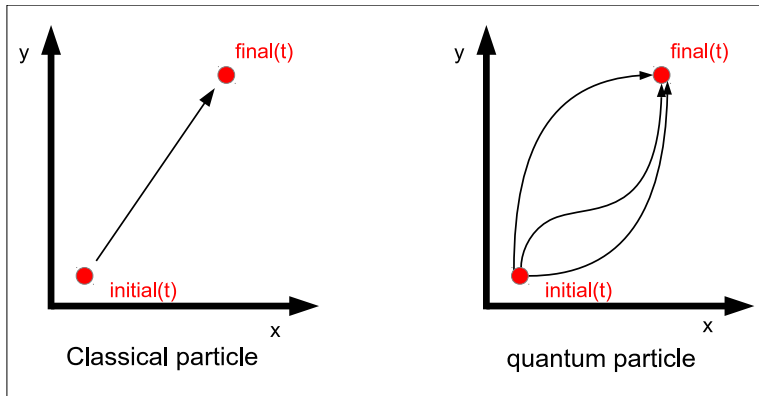
- Essentially no measurements
- Black holes could offer clues
- So could the early universe

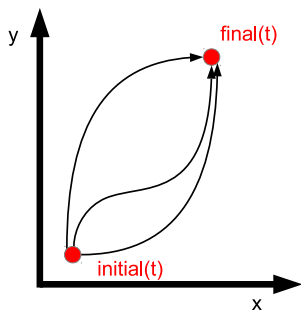
- Summary

- We need quantum gravity:
 - Just as the fluid approximation sometimes breaks down for air, the continuum approximation breaks down for gravity
- We're not going to get it:
 - This is the hardest problem in physics, with the worst prediction in the history of physics
 - No experimental guidance to send us in the right direction

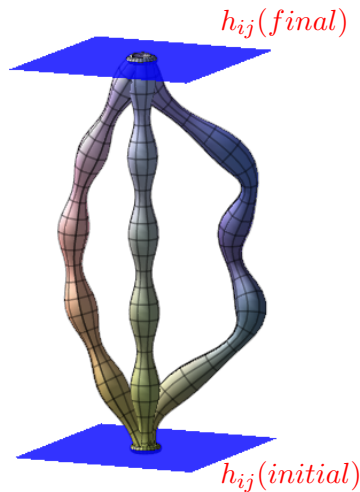
The Feynman Path Integral

$$\frac{dL}{dp} = \frac{d}{dx} \frac{dL}{dq} \longrightarrow \mathcal{A} = \int \mathcal{D}g e^{iS}$$





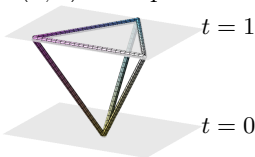
quantum particle



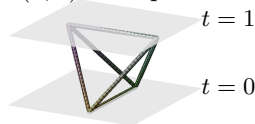
quantum spacetime

Causal Triangulations in 2+1 Dimensions

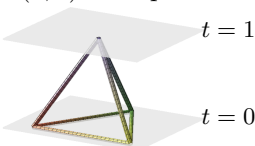
(1, 3) 3-simplex



(2, 2) 3-simplex



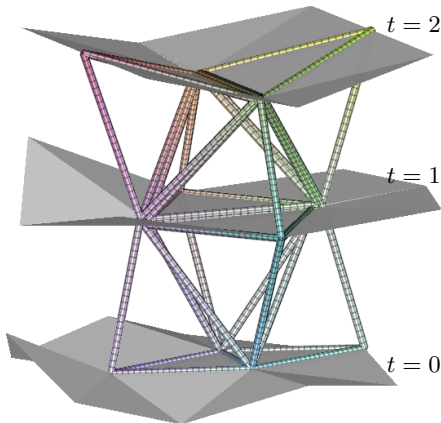
(3, 1) 3-simplex



$$l_{SL}^2 = a^2$$

$$l_{TL}^2 = -\alpha a^2$$

Segment of a causal triangulation



Forbidden spacetimes

