LA-UR-19-31190
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Title:	Why We Need (But Don't have) Quantum Gravity
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Intended for:	Guest lecture in continuing education class, future science outreach projects
Issued:	2019-11-05

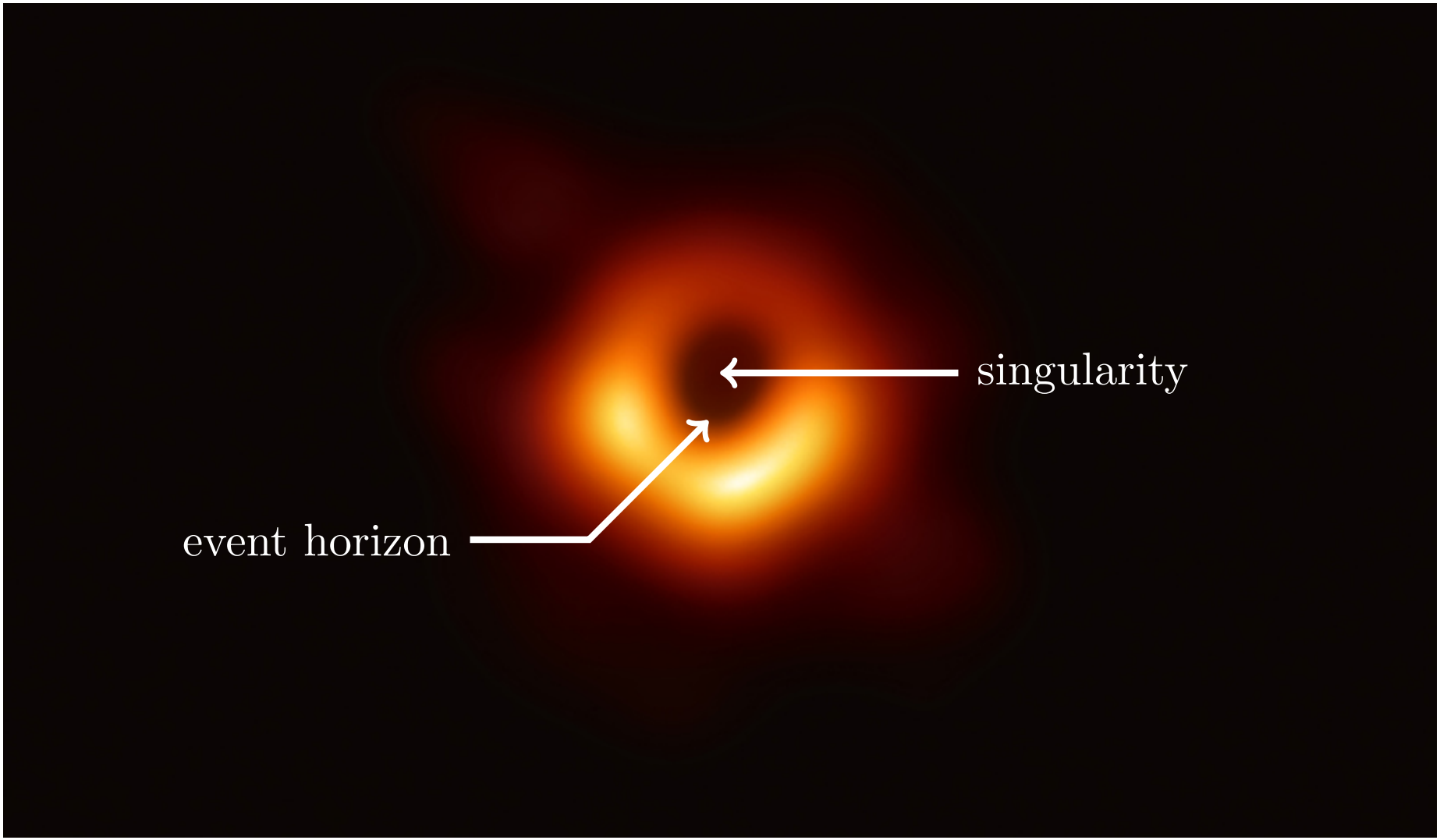
Why we Need (But Don't Have) Quantum Gravity

Jonah M. Miller

UNM Continuing Education Class

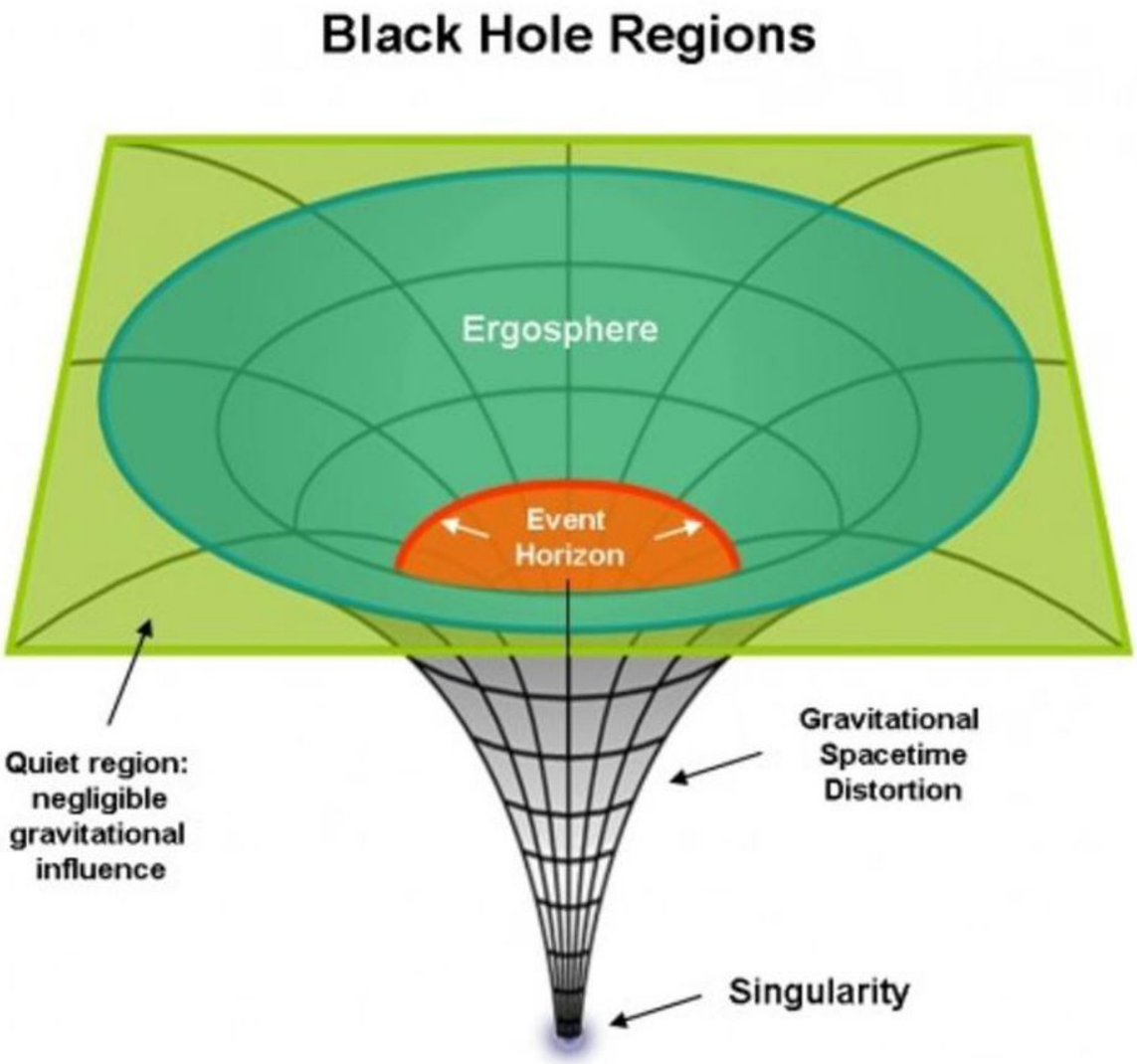
Why we need quantum gravity

Black Holes



EHT Collaboration

The Singularity: A Point of Infinite Density?



UIUC Physics Department

We've seen this before...

Ensign John Gay, USS Constellation, US Navy/USGS

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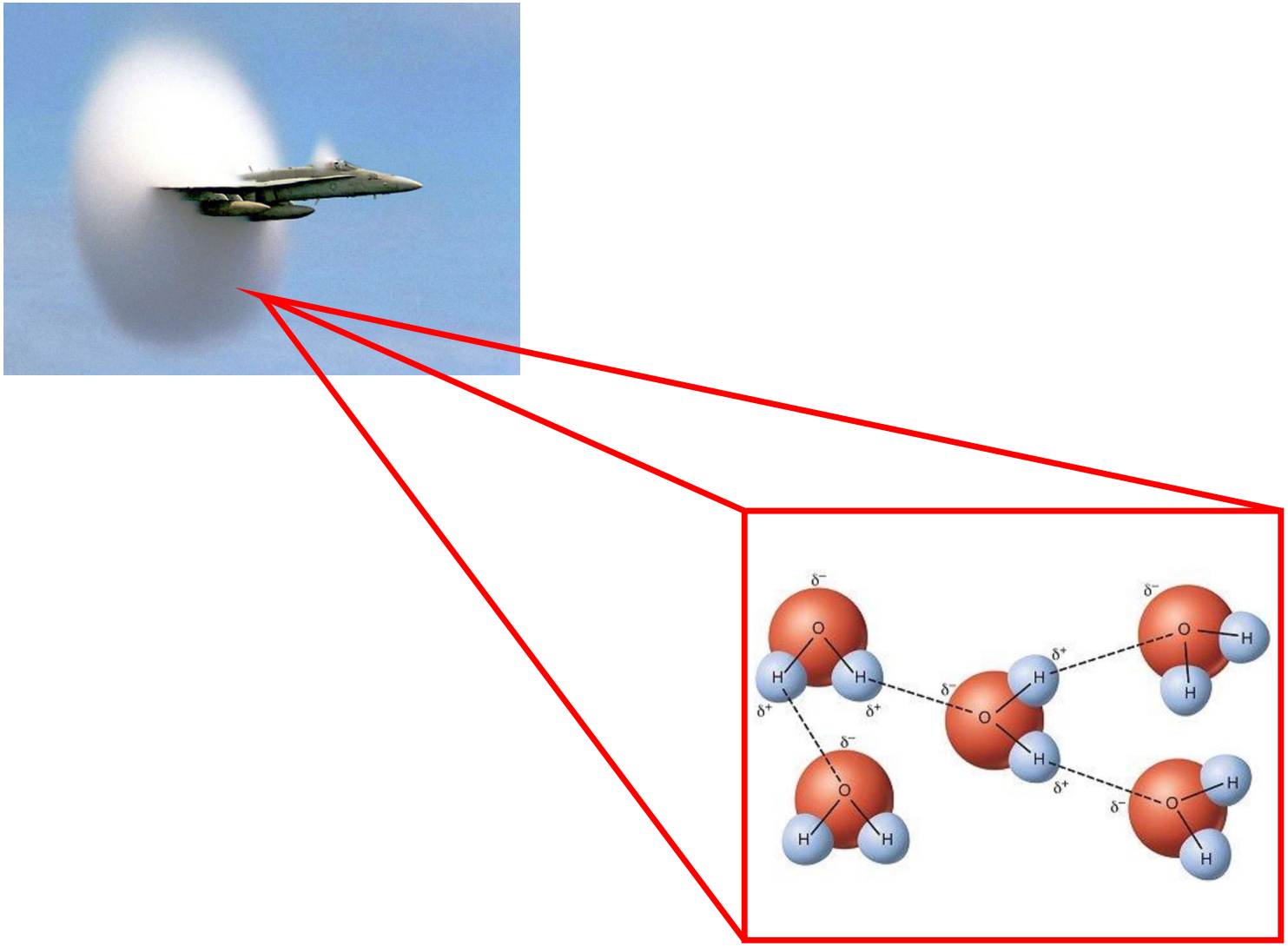


Ensign John Gay, USS Constellation, US Navy/USGS

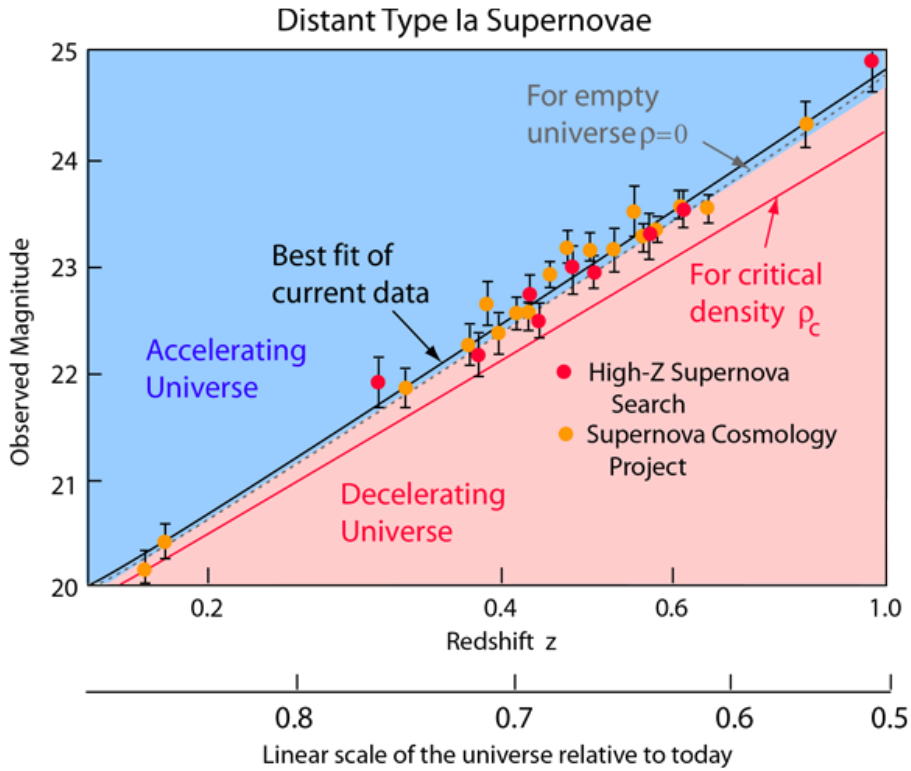
Why we need quantum gravity

- 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 understnand it as...?
  - Which is quantum?

Why we won't get it

The Accelerating Universe

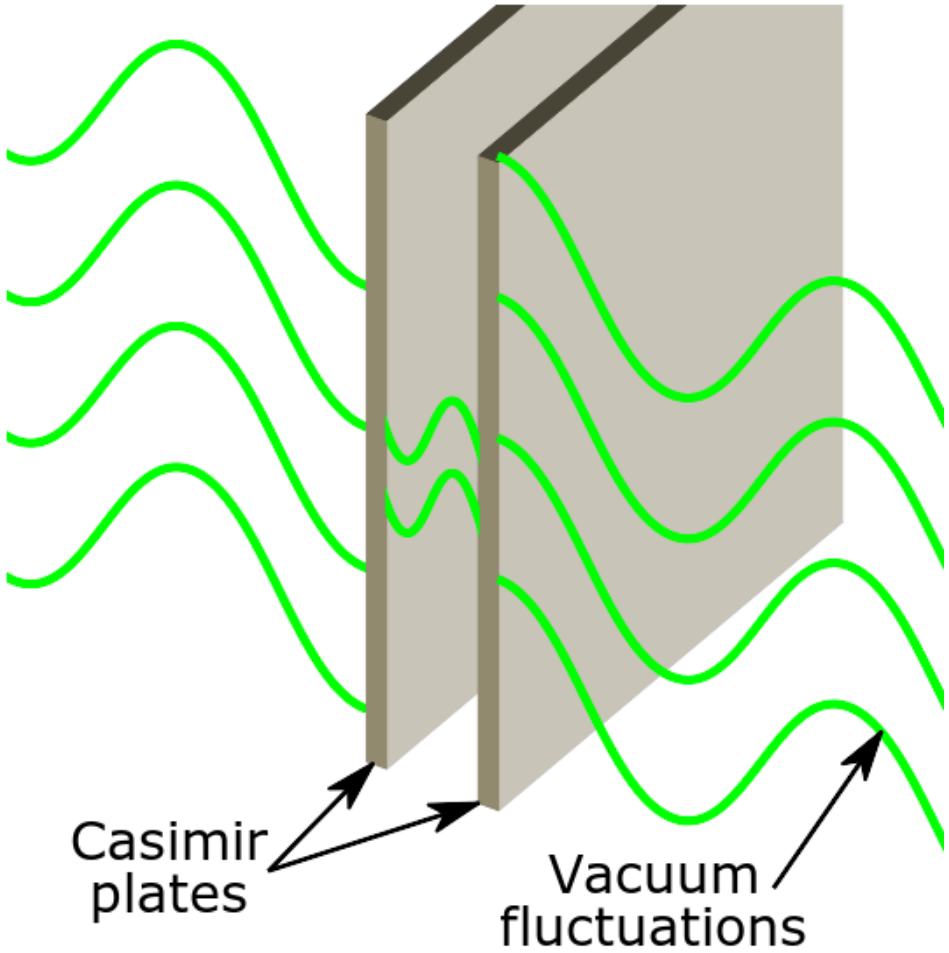
2006 Shaw Prize, Wikimedia Commons



Carroll and Ostlie

The Cassimir Effect

The Royal Dutch Academy of Sciences



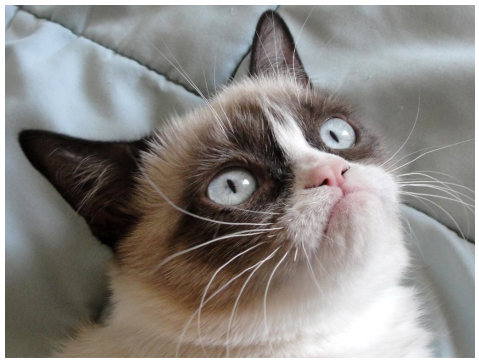
Wikimedia Commons

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

$$\frac{E\left[\Lambda\right]}{}$$

$$=$$

$$\frac{}{}$$



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)

Guidance?

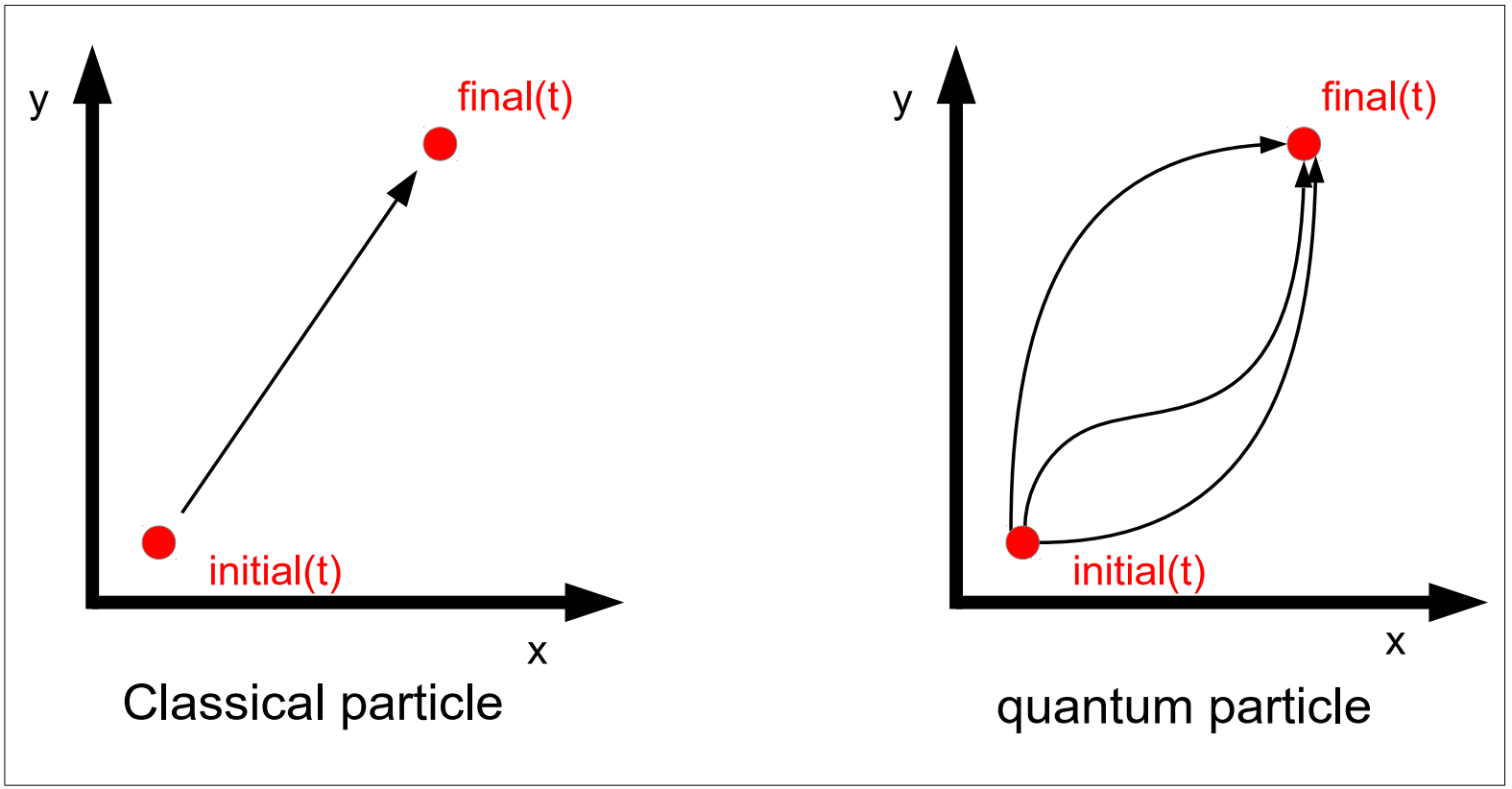
- Essentially no measurements
- Black holes could offer clues
- So could the early universe

Let's discuss

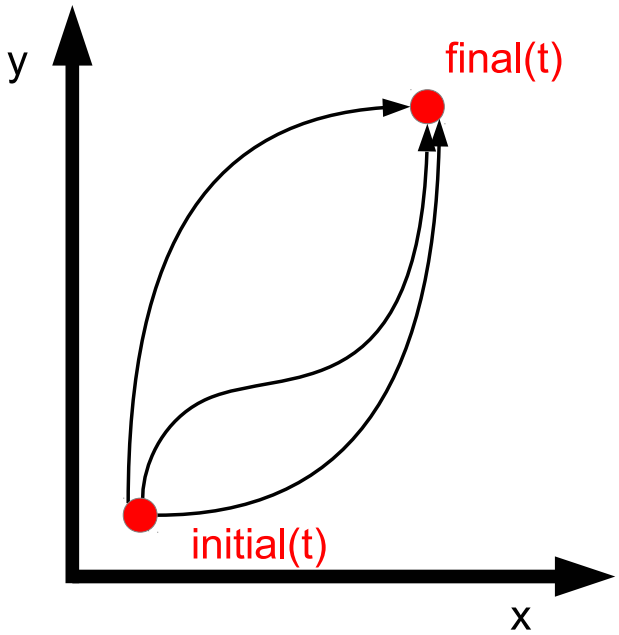
- Summary
  - We need quantum gravity:
    - Just as the fluid approximation sometimes breaks down for air, the continuum approximation breaks down for gravity
  - We're not going to get it:
    - This is the hardest problem in physics, with the worst prediction in the history of physics
    - No experimental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

The Feynman Path Integral

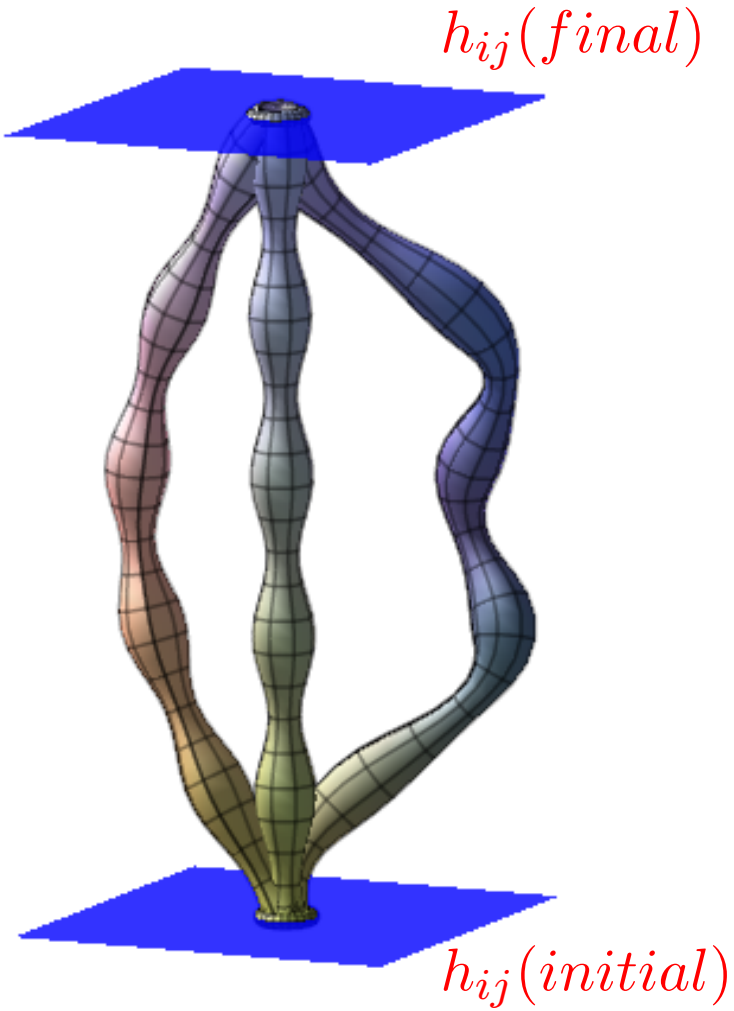
$$\frac{dL}{dp} = \frac{d}{dx}\frac{dL}{dq} \longrightarrow \mathcal{A} = \int \mathcal{D}g e^{iS}$$



Sum-Over-Histories



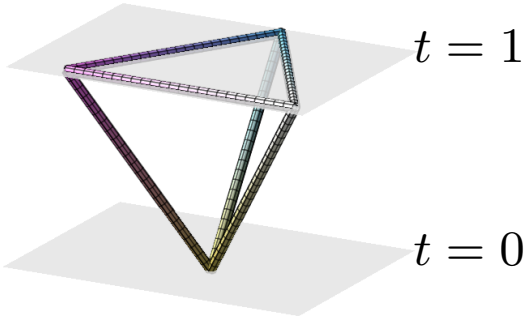
quantum particle



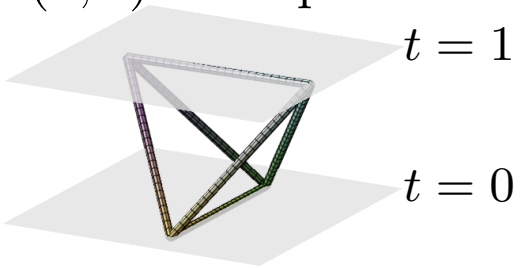
quantum spacetime

Causal Triangulations in 2+1 Dimensions

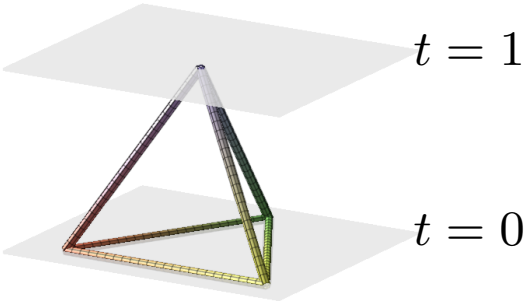
$(1,3)$ 3-simplex



$(2,2)$ 3-simplex

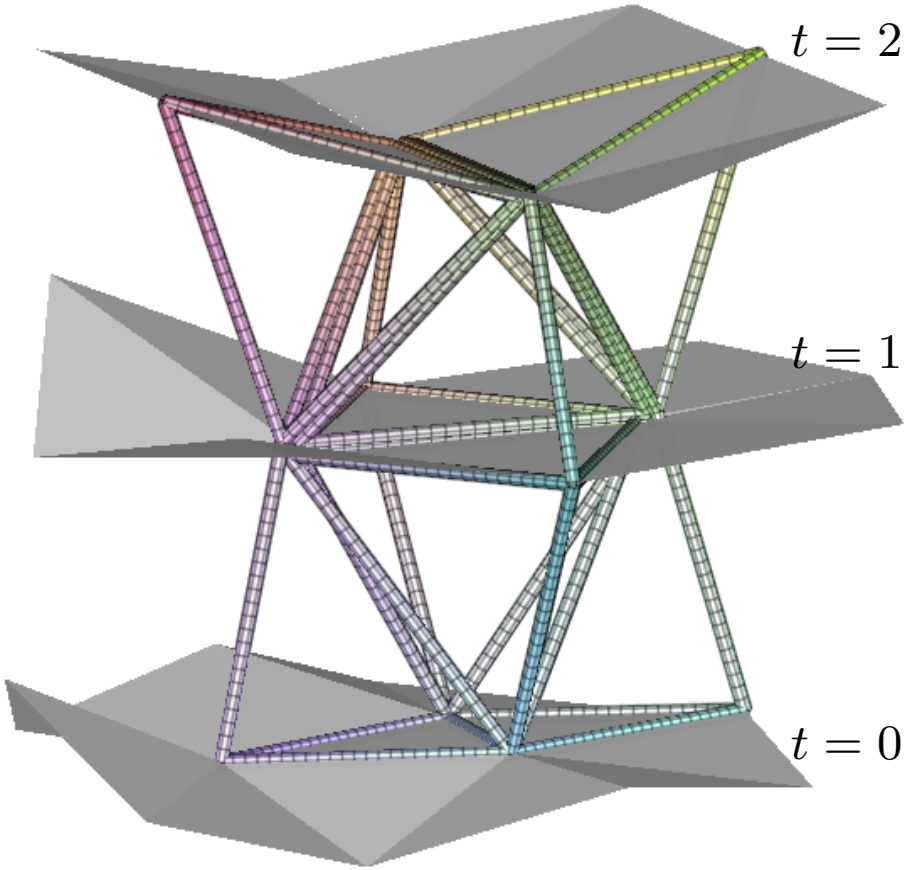


$(3,1)$ 3-simplex



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

Segment of a causal triangulation



Forbidden spacetimes