Science & Science Fiction

"Future Physics"
and
The Multiverse Hypothesis

Today…

Is our universe the only one?

- **Reminder: Turn in Spacetime Project results and return equipment.**

- **Exploration Paper 1 due today**
  - ➢ **Choice of topics on Space & Time**
  - ➢ **Details on Canvas**

Announcements for Friday, Sept. 22

- **Quiz 2 Monday, September 25**
  - ➤ **What is the Nature of Space and Time?**
  - ➤ **Chapter 2 in the text + lecture material**
  - ➤ **Study Goals posted on Canvas**
  - ➤ **Given on Canvas; 100 points**
  - ➤ **1 hour to complete; submit by midnight**

Coming attractions…

- **Problem 3 due next Wednesday, Sept. 27**
  - ➤ **Topic: Black Hole & Schwarzschild radius**
  - ➤ **Details on Canvas**

Coming Attractions (continued)

Experiencing Einstein's Principle of Equivalence in an Elevator

When the elevator starts or stops, are you in a *non-inertial* reference frame (accelerating)…

… or are you momentarily experiencing a change in the force of gravity?

Einstein's Principle of Equivalence

Experiencing Einstein's Principle of Equivalence in an Elevator

Campus-wide average acceleration experienced in a passenger elevator:

Fall 2022 $a = (0.096 \pm 0.003) \times g$

Spring 2023 $a = (0.106 \pm 0.001) \times g$
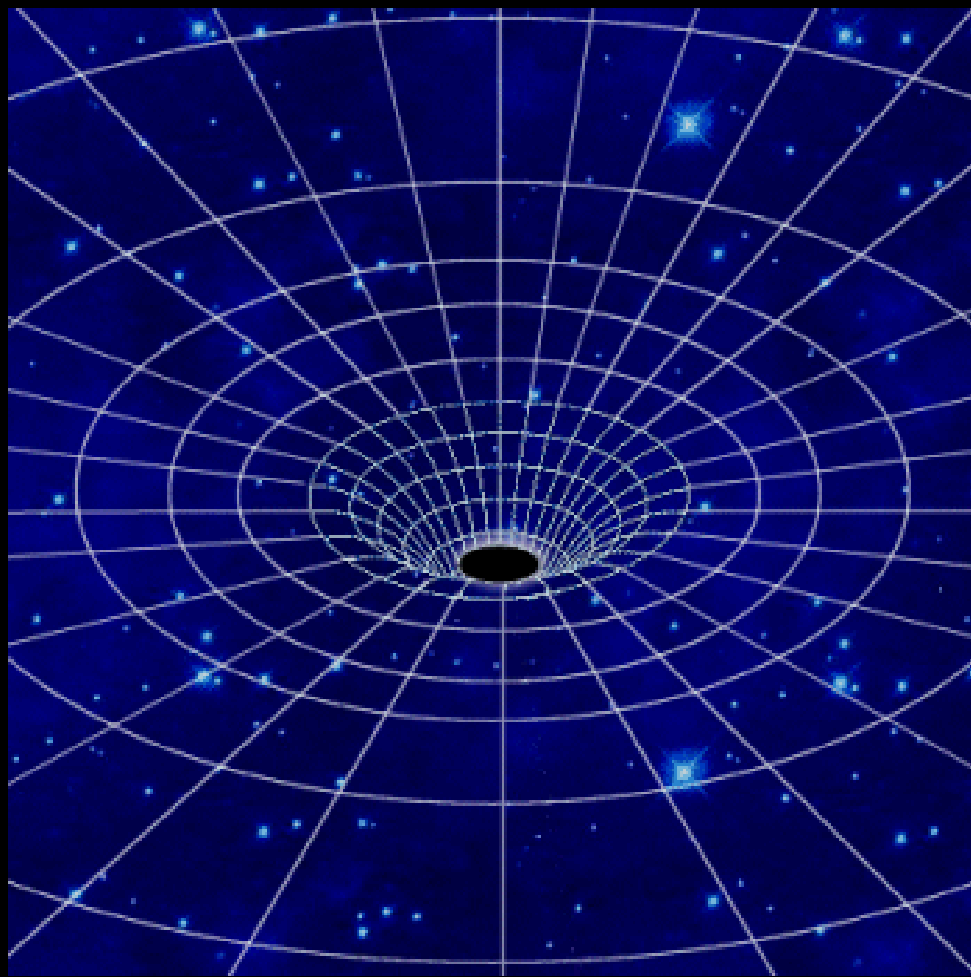
Fall 2023 $a = (0.093 \pm 0.001) \times g$

(or approximately $0.1 \times g$)

Data from Spacetime Team Project (detailed results for this semester to be presented next week)

Star Trek IV:
The Voyage Home

Directed by Leonard Nimoy

Paramount (1986)

Last time…
Time Travel by combining Special Relativity and General Relativity?
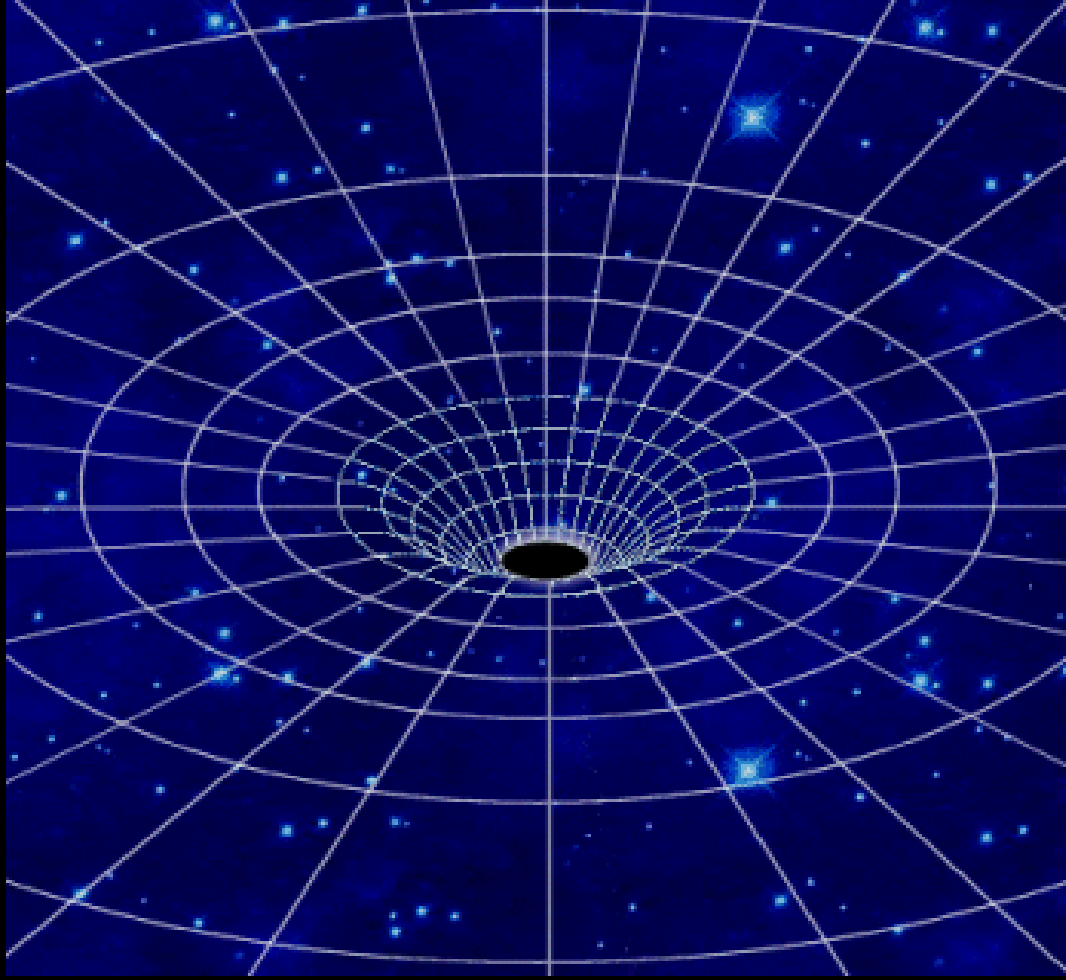
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General Relativity:

Fabric of spacetime distorted (stretched) near large mass.
What happens to spacetime if the large mass is *spinning*?

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We know that the universe is *expanding* ever since the Big Bang.

What if the fabric of spacetime is not just *expanding*, but also *spinning*?

The *Gödel Universe:*

Could time travel into the past be possible?

The universe <u>is</u> expanding.
(More on this in Chapter 3)

"Frame dragging": <u>evidence</u> that the fabric of spacetime twists in the presence of a massive spinning object.

But <u>no evidence</u> that the *universe as a whole* is also spinning.

Could "frame dragging" be the answer to time travel into the past?

- **The Multiverse Hypothesis**
  - **Could parallel universes exist?**
  - **Is there any way to find out?**
    - **Is the hypothesis testable?**
    - **If not, is it really science?**

Today…
Final topic under Major Question 1:
What is the Nature of Space and Time?

- **Explain away the apparent fine-tuning of physical constants (more on this later)**

- **"Many Worlds" interpretation of quantum mechanics (Anything that can happen does happen in some universe.)**

Motivation for postulating the Multiverse

"Level 1 Multiverse"

➤ **The universe may extend beyond our (finite) visual horizon.**

➤ **Parts of the universe that we can't see may be similar or very different.**

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

(U2)

(U3)

Our Universe
(U1)

(U5)

(U4)

"Level 1 Multiverse"
Finite visual horizon allows for other "universes"
to exist beyond what we can see.

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"Level 2 Multiverse"

- ➤ **Other universes co-exist with our own**

- ➤ **Physical constants may be similar or different from those in our universe**

- ➤ **Multiple versions of ourselves living very different lives**

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

Fringe

"Peter"

Teleplay by Jeff Pinkner, J.H. Wyman, Josh Singer

Warner Brothers (2010)

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

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Star Trek: The Next Generation
"Parallels"

Written by Brandon Braga
Paramount (1993)

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

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Is the Multiverse Hypothesis testable?

- **Level 1: NO**

  - ➢ **Causally disconnected from each other**

  - ➢ **Beyond our visual horizon**

  - ➢ **No way to communicate**

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

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Is the Multiverse Hypothesis testable?

- **Level 2: Maybe, hypothetically**

  ➢ **Unimaginable energy needed to probe**

  ➢ **About as likely as opening a stable wormhole and time travel into the past**

The Multiverse Hypothesis:
Does the nature of space and time allow for the possibility of alternate or parallel universes?

Major Question 2:

What is the universe made of?
(matter, energy and interactions)

Chapter 3 in the text,
Exploring Science Through Science Fiction

Next week