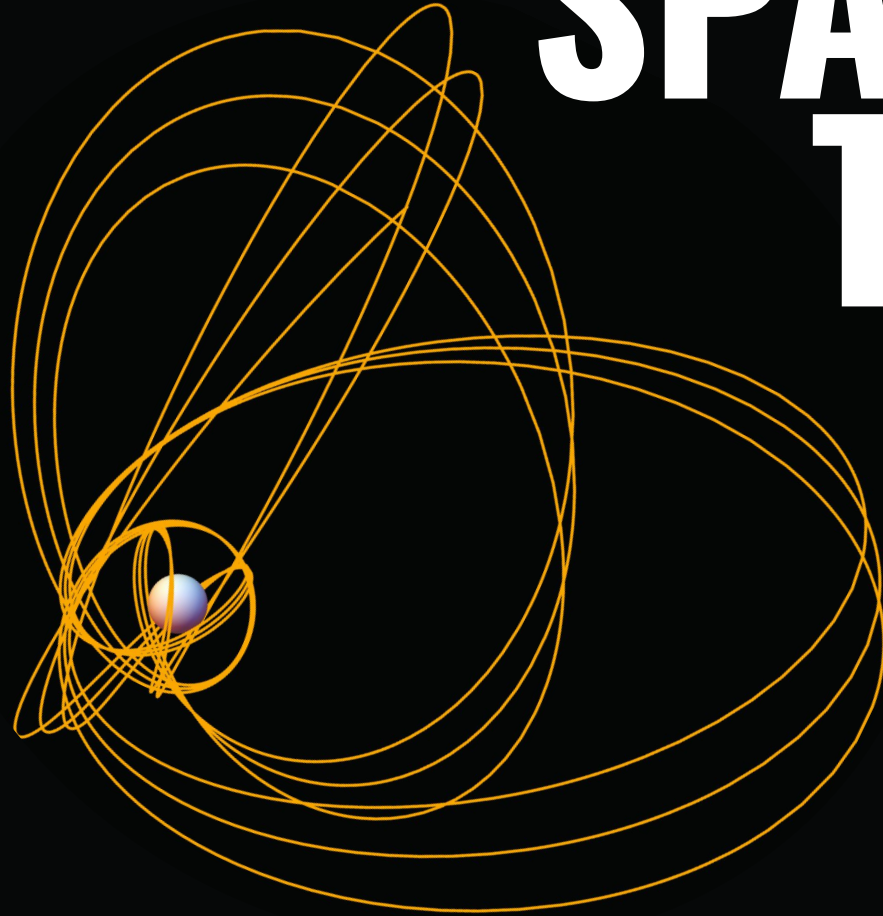


# SPACETIME TEATIME



*Presented by:  
Prof. Scott Hughes and  
Devin Becker*



**What is time?**

# What is time?

Time is the quantity that we measure using clocks.

**What are clocks?**

# What are clocks?

Clocks are devices that regularly “tick” in a way that lets us reliably track when things happen.

# What are clocks?

Clocks are devices that regularly “tick” in a way that lets us reliably track when things happen.

Time depends on how clocks work!

**First common clock:**

**Rise and set of sun.**

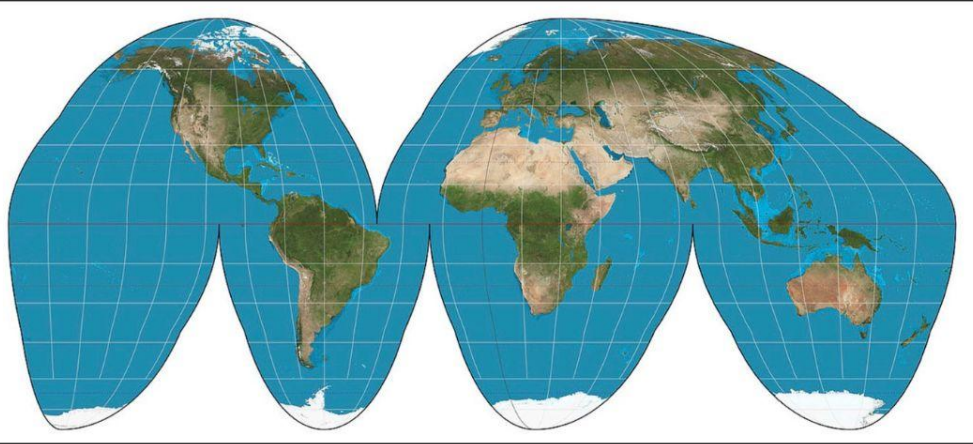
When the sun rises (or sets) defines the start of a new day. Allowed people to define calendars, make regular schedules.

**Responsible for the first  
known “time traveller”**

# **Responsible for the first known “time traveller”**

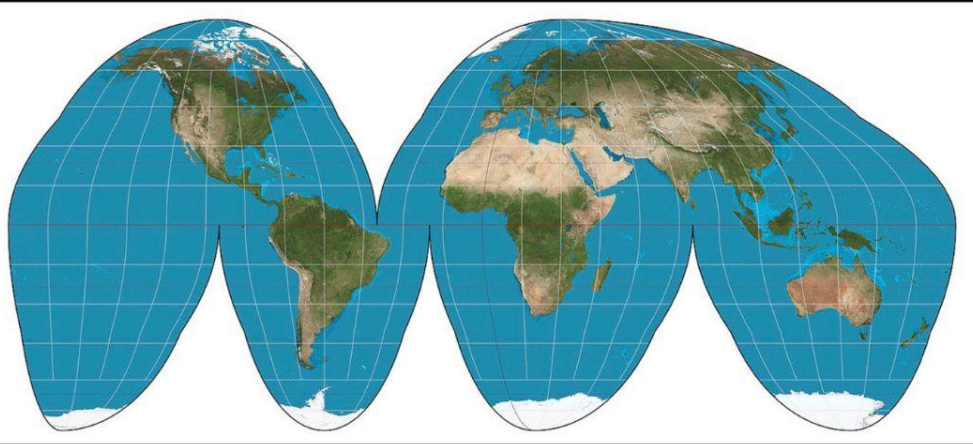
**Juan Sebastián Elcano: Travelled through  
time by one day in the year 1522!**

# Voyage of Magellan



**20 Sept 1519: Ferdinand Magellan departs Spain with 5 ships and about 270 men, seeking a new route to the “Spice Islands”**

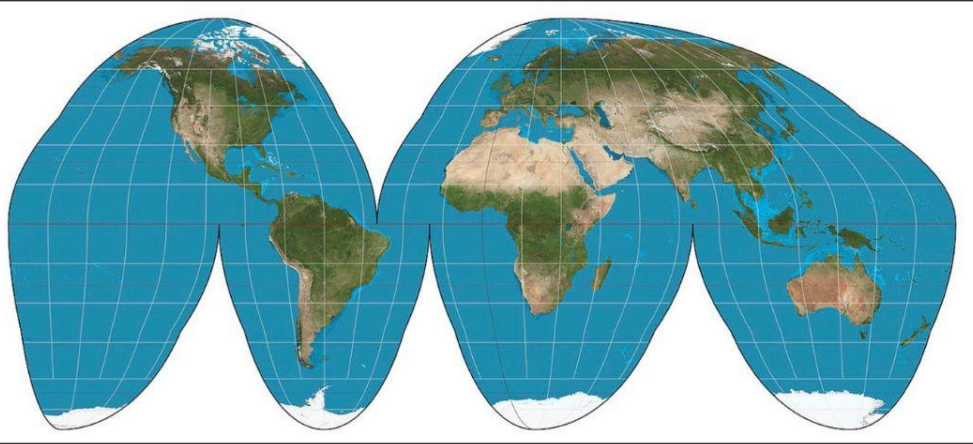
# Voyage of Magellan



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**9 July 1522: Elcano leads the last ship and 18 survivors to Cape Verde, Portugal.**

# Voyage of Magellan



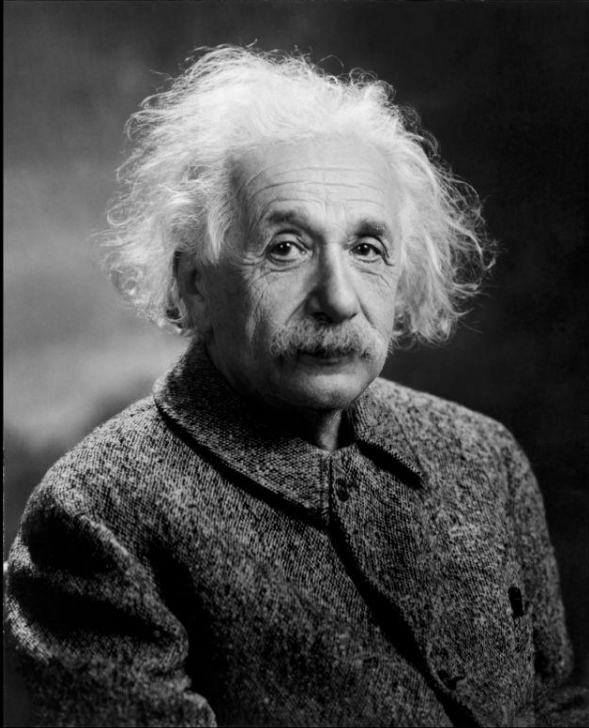
20 Sept 1519: Ferdinand Magellan departs Spain with 5 ships and about 270 men, seeking a new route to the “Spice Islands”

9 July 1522: Elcano leads the last ship and 18 survivors to Cape Verde, Portugal.

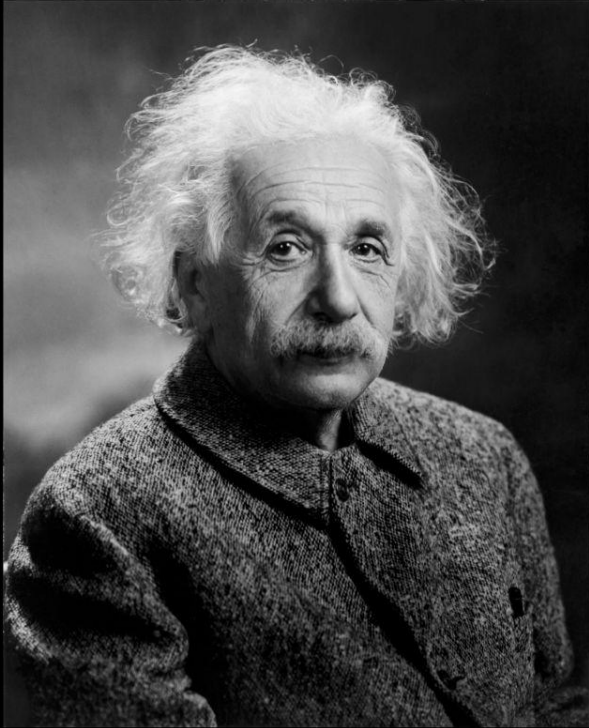
Discover that the local date is 10 July 1522

# Einstein & time

By the 1700s, we had a good understanding of “mechanics”: the science of physical objects.



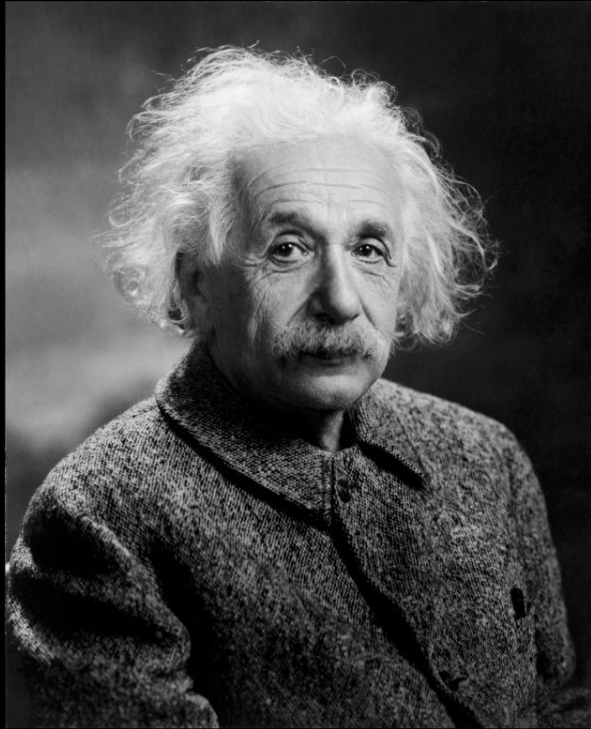
# Einstein & time



By the 1700s, we had a good understanding of “mechanics”: the science of physical objects.

By the late 1800s, we had a good understanding of electricity and magnetism ... and of light.

# Einstein & time



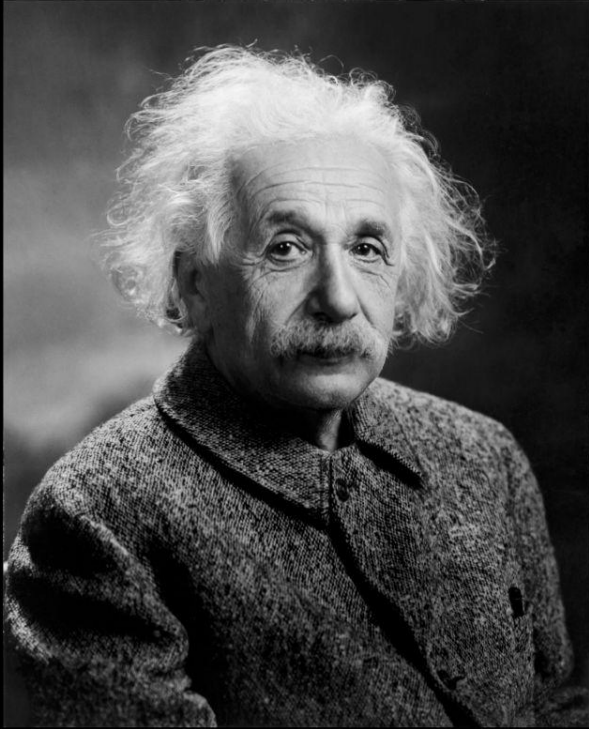
By the 1700s, we had a good understanding of “mechanics”: the science of physical objects.

By the late 1800s, we had a good understanding of electricity and magnetism ... and of light.

**BUT:** these two understandings were in conflict with each other!

# Einstein & time

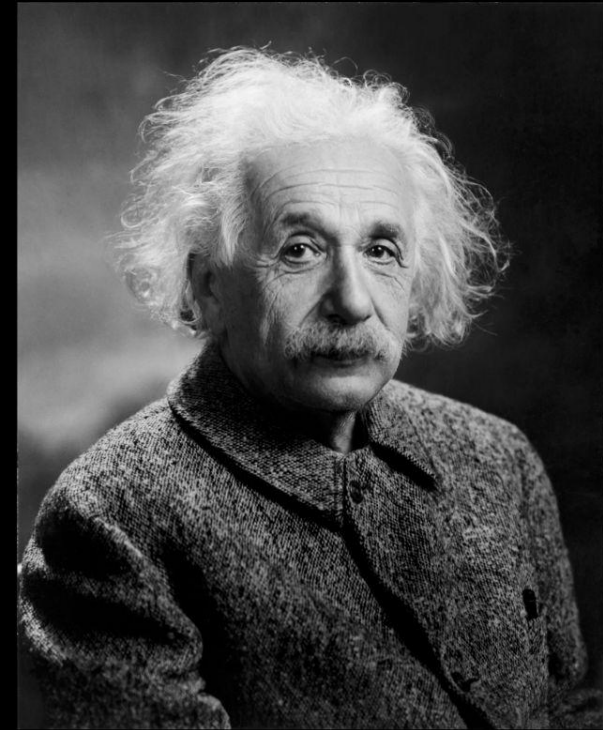
Key disagreement: laws of light  
tell us that the speed of light is  
the same to everyone.



# Einstein & time

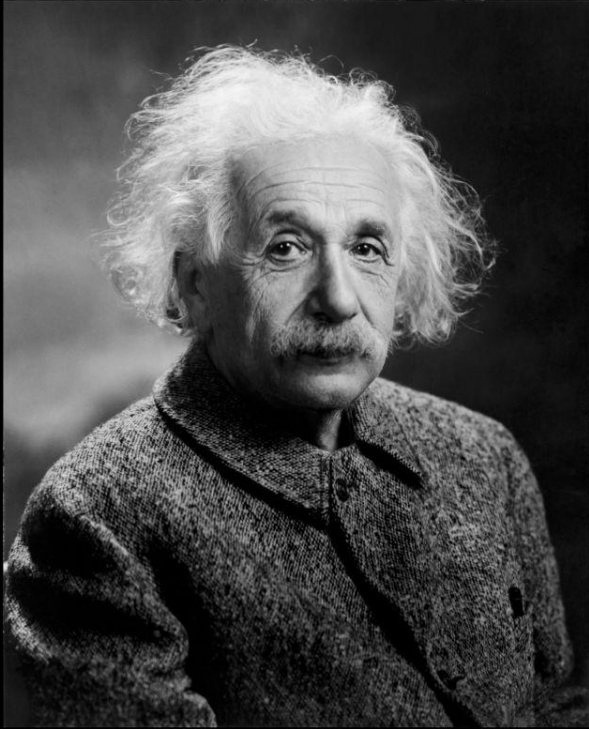
Key disagreement: laws of light tell us that the speed of light is the same to everyone.

But laws of mechanics tell us that speed of anything only makes sense relative to my own motion.

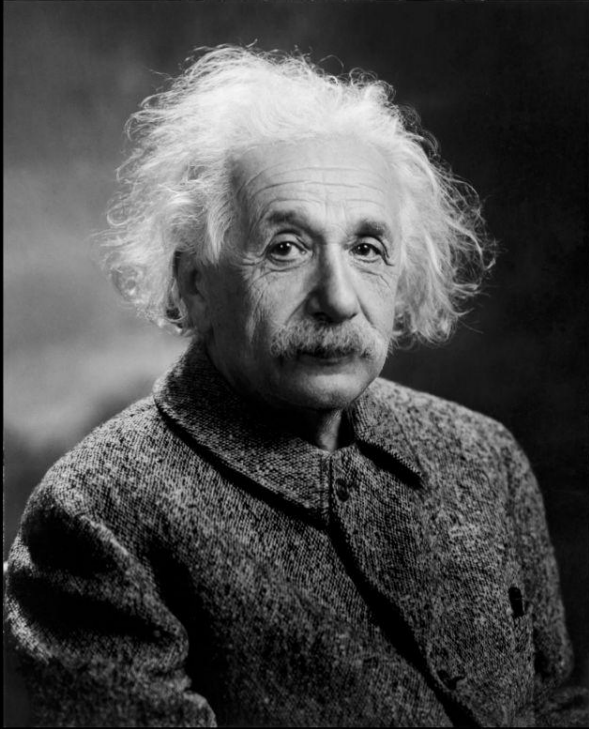


# Einstein & time

Einstein's insight: speed is  
distance per unit time.



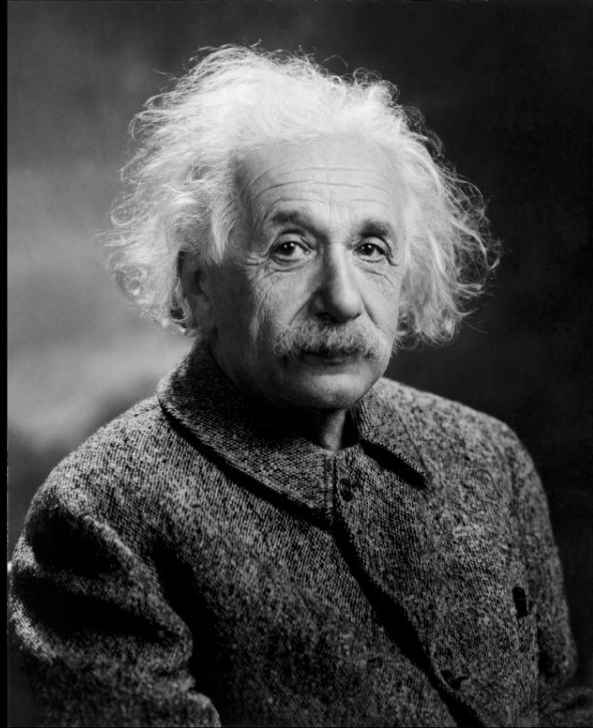
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Einstein's insight: speed is distance per unit time.

Time is what we measure using clocks.

# Einstein & time

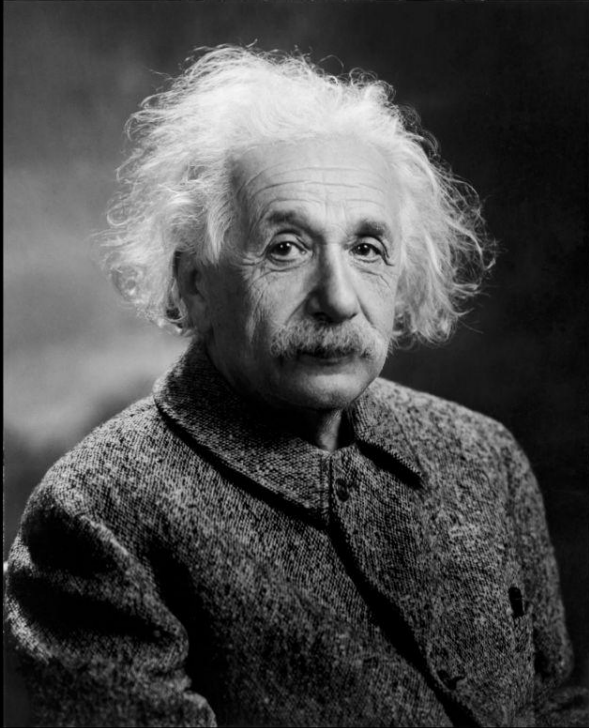


Einstein's insight: speed is distance per unit time.

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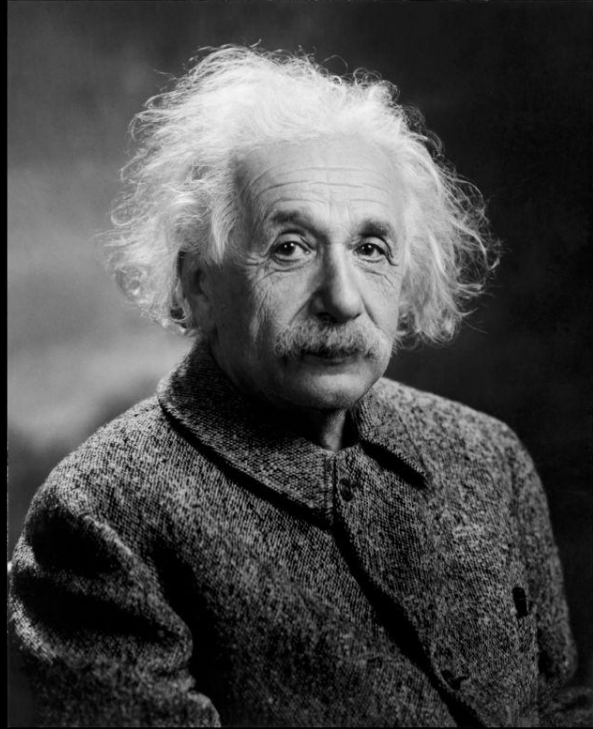
The inconsistency goes away if the clocks of a moving observer run slower than the clocks of an observer at rest!

# Einstein & time



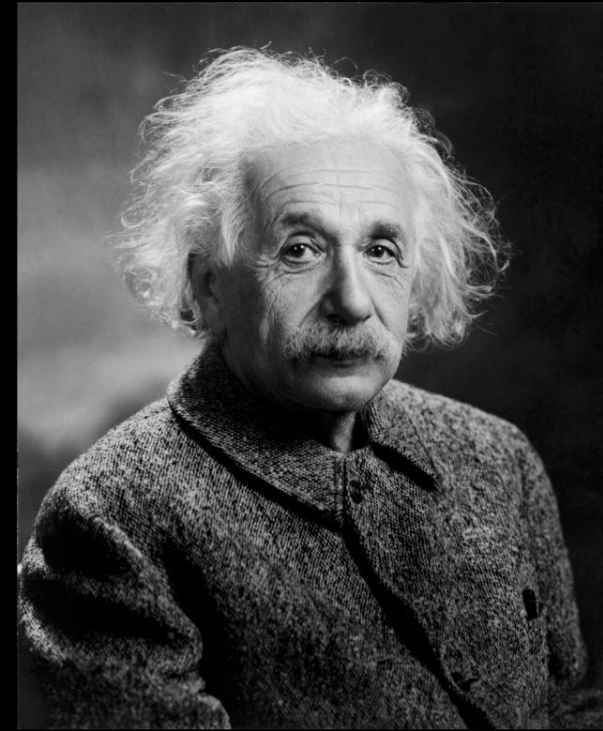
This is very precisely measured by particle physicists every day: Radioactive particles take longer (sometimes MUCH longer) to decay when they move very quickly.

# Einstein & time & gravity



10 years later, Einstein showed that gravity is connected to the behavior of space and time ... combined into spacetime.

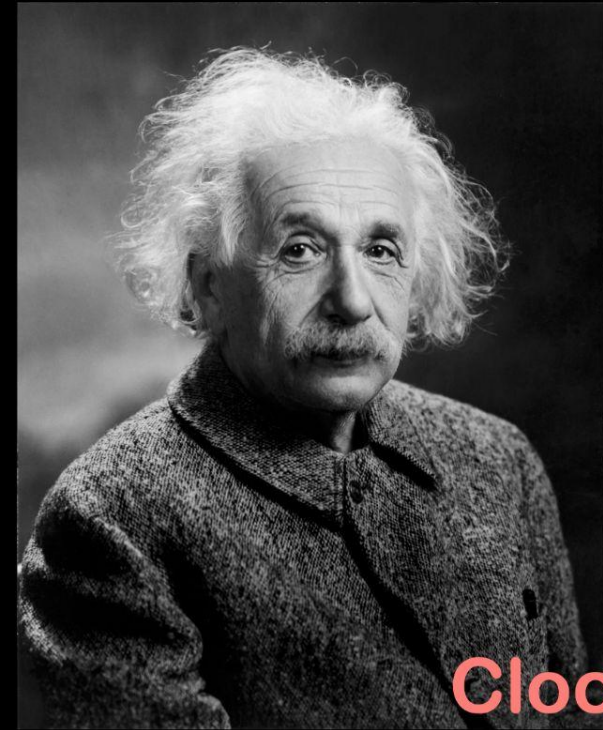
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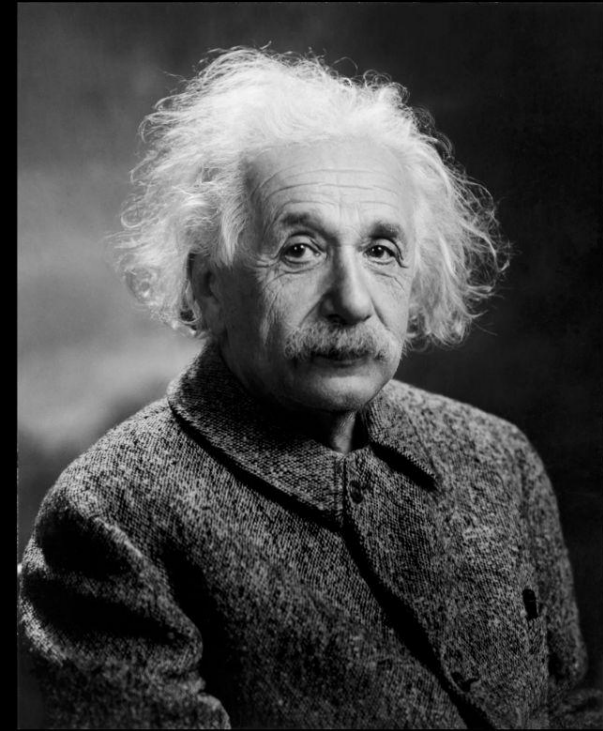


10 years later, Einstein showed that gravity is connected to the behavior of space and time ... combined into spacetime.

Affects how clocks behave ... we can measure this very precisely!

Clocks close to a source of gravity run slower than those that are farther away.

# Einstein & time & gravity



10 years later, Einstein showed that gravity is connected to the behavior of space and time ... combined into spacetime.

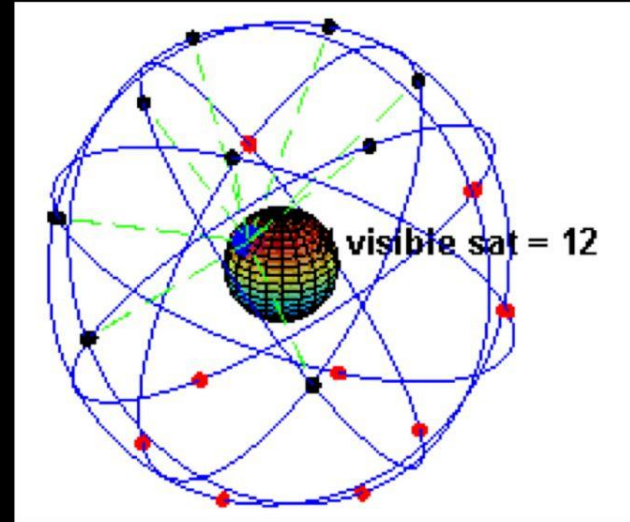
Affects how clocks behave ... we can measure this very precisely!

Means that your head is older than your feet!

# Not an abstract result

The Global Positioning System (GPS) works by comparing clocks in orbit with clocks on the Earth's surface.

Must correct for the fact that Earth-surface clocks run slower than clocks which are in orbit.



Without accounting for Einstein, GPS would degrade in accuracy by 8 meters per minute.

Film #1:

FROM CHRISTOPHER NOLAN

# INTERSTELLAR













1 hour



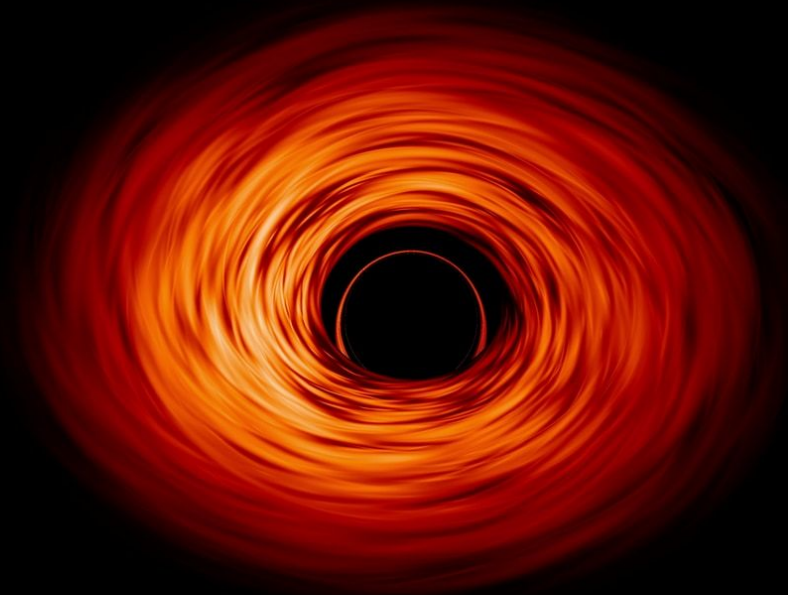
7 years

**Brainstorm: What  
about Miller's  
planet and  
Gargantua gives us  
this extreme  
dilation?**



**ANSWER 1: MILLER'S PLANET  
IS EXTREMELY CLOSE TO  
GARGANTUA**

*To inherit such extreme time  
dilation, Miller's planet could be  
on the **Innermost Stable  
Circular Orbit (ISCO)***

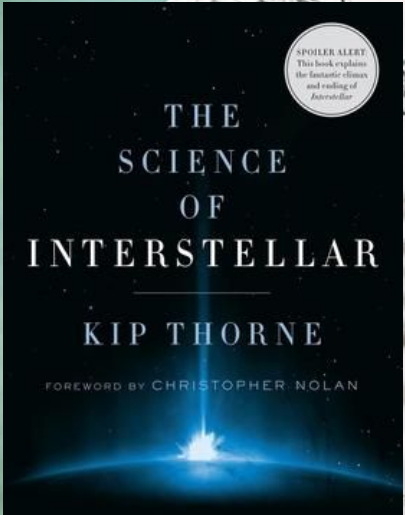


**ANSWER 2: GARGANTUA IS  
SPINNING EXTREMELY FAST**



Kip Thorne

Christopher Nolan



A woman in a white space suit is floating in the ocean. She is wearing a helmet with a clear visor and has a serious expression. The background is a vast expanse of blue water with gentle waves. The text 'INTERSTELLAR' and 'EXTENDED CLIP' is overlaid at the bottom. A black box with orange text is in the top left corner.

Clip is here:

<https://www.youtube.com/watch?v=60h6lpnSgck&t=121s>

We watched from 1:46 to 3:46 (exactly 2 minutes)

INTERSTELLAR

EXTENDED CLIP

**We were just on Miller's planet for 2 minutes**



**During this time, 85 days went by on Earth**

**The crew is on Miller's planet for 3 hours and 20 minutes...**



**...23 years, 4 months, and 8 days on Earth**

# Is **anything** allowed?

Lots of weird stuff seems possible in Einstein's theory of gravity and spacetime ("general relativity") ... what limits are there?

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\* Matter in the universe has positive density

# Is **anything** allowed?

Lots of weird stuff seems possible in Einstein's theory of gravity and spacetime ("general relativity") ... what limits are there?

\* Nothing can travel faster than light

\* Matter in the universe has positive density

\* Effects must follow causes

**What if start to play with  
those limits?**

# **What if start to play with those limits?**

**Cannot violate rule effects follow causes: when we break that, we lose any way to describe or predict.**

# **What if start to play with those limits?**

Cannot violate rule effects follow causes: when we break that, we lose any way to describe or predict.

This is why nothing can travel faster than light!

**What if start to play with  
those limits?**

**What if we allow matter to be “exotic”?**

# What if start to play with those limits?

What if we allow matter to be “exotic”?

Kip Thorne and Mike Morris examined what would happen if you (somehow) put together a lot of material with “negative energy density.”

**Result: A wormhole**

# Result: A **wormhole**

You create a weird tunnel in spacetime that connects a one “opening” to the other.

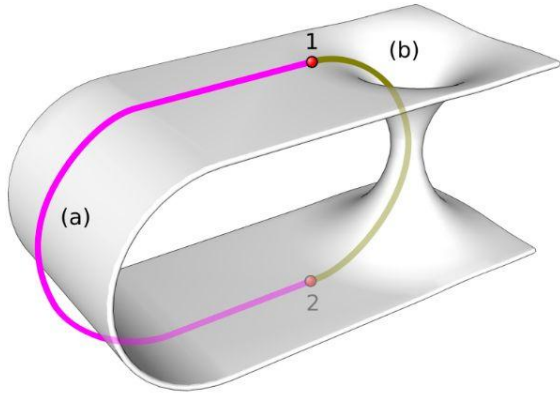


Image credit:

<https://en.wikipedia.org/wiki/Wormhole>

# Result: A **wormhole**

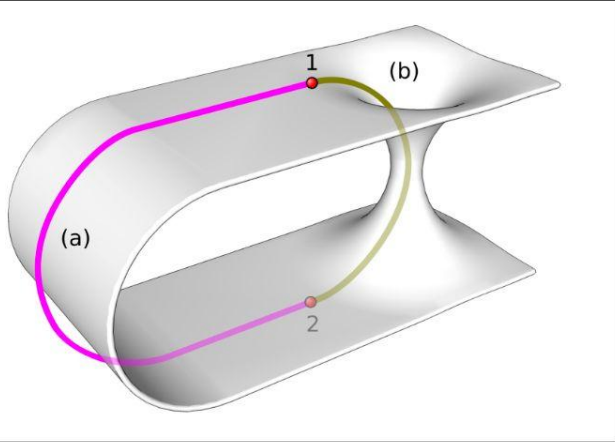


Image credit:

<https://en.wikipedia.org/wiki/Wormhole>

You create a weird tunnel in spacetime that connects a one “opening” to the other. Make a wormhole, hold on to one opening “mouth”, send the other “mouth” far away.

# Result: A **wormhole**

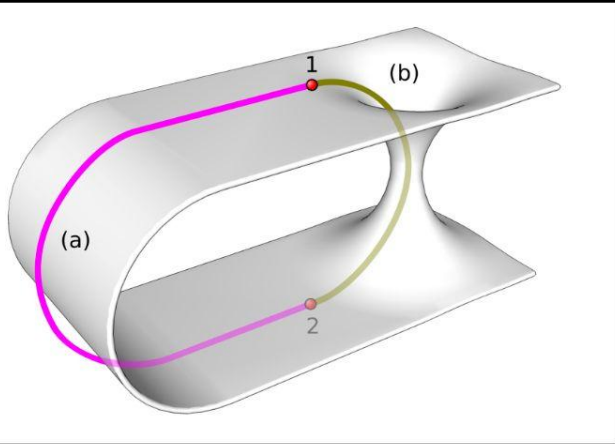


Image credit:

<https://en.wikipedia.org/wiki/Wormhole>

You create a weird tunnel in spacetime that connects a one “opening” to the other. Make a wormhole, hold on to one opening “mouth”, send the other “mouth” far away.

Length of the tunnel can remain short even if the mouths are widely separated in “normal” space ... you’ve made a shortcut in spacetime!!

# Film #2:

A message from deep space.  
Who will be the first to go?  
A journey to the heart of the universe.

A movie poster for the film 'Contact'. The background is a deep blue, starry night sky. In the foreground, a woman (Jodie Foster) is sitting on the ground, wearing a white button-down shirt and blue jeans, with large headphones around her neck. Behind her, a man (Matt Damon) in a dark coat stands looking towards the right. In the background, several large radio telescope dishes are visible, set against a landscape of rolling hills under a blue sky with white clouds. The overall color palette is dominated by blues and blacks.

# CONTACT

# CONTACT

Warner  
Bros.

Clip is here:  
[https://youtu.be/67suXuwW96I?si=Xy\\_Pip5ocohAakGy](https://youtu.be/67suXuwW96I?si=Xy_Pip5ocohAakGy)



INTERSTELLAR

Clip is here:

[https://youtu.be/u-EIPzExvPA?si=rh\\_rA-W5lo3TQkV3](https://youtu.be/u-EIPzExvPA?si=rh_rA-W5lo3TQkV3)

# TV Lightning Round!

# *Stranger Things, Season 5 (2025)*



Clip is here:

<https://youtu.be/AnDZaKIXtl?si=mxilNsO7Sxc0CK23>

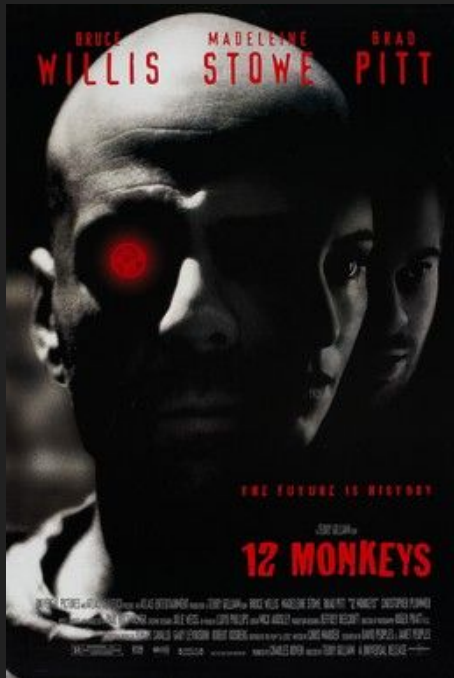
# *The Simpsons, Season 6 (1994)*



Clip is here:

<https://youtu.be/UP0CMaxCNc?si=xhf7AxSJB2Yg37hl>

# Official Watchlist



*12 Monkeys (1995)*



*Harry Potter and the Prisoner of Azkaban (2004)*

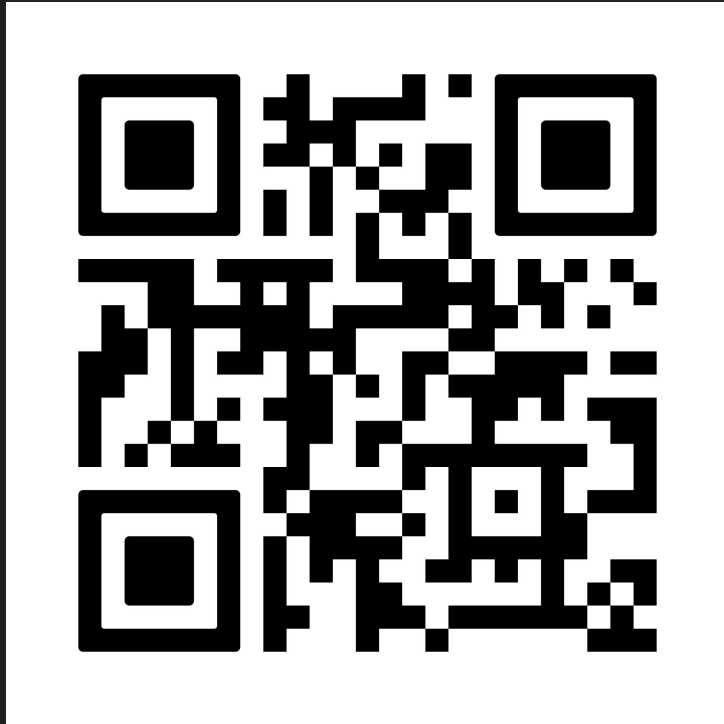


*Tenet (2020)*



*Project Hail Mary (March 2026)*

# Official Spotify Playlist



Featuring...



... and more!

*Thank you to our event organizers!*