

Science & Science Fiction

“Future Physics” and The Multiverse Hypothesis

This week...

“Future Physics”

- **Reminder: Turn in Spacetime Project results and return equipment.**
- **Exploration Paper 1 due Friday, 9/22**
 - **Choice of topics on Space & Time**
 - **Details on Canvas**

Announcements for Wednesday, Sept. 20

■ 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)

“Future Physics”

- **Wormholes**
- **Quantum gravity**
- **Time travel into the past?**
- **The Multiverse Hypothesis**

Last time...

**A third perspective on Major Question 1:
What is the Nature of Space and Time?**

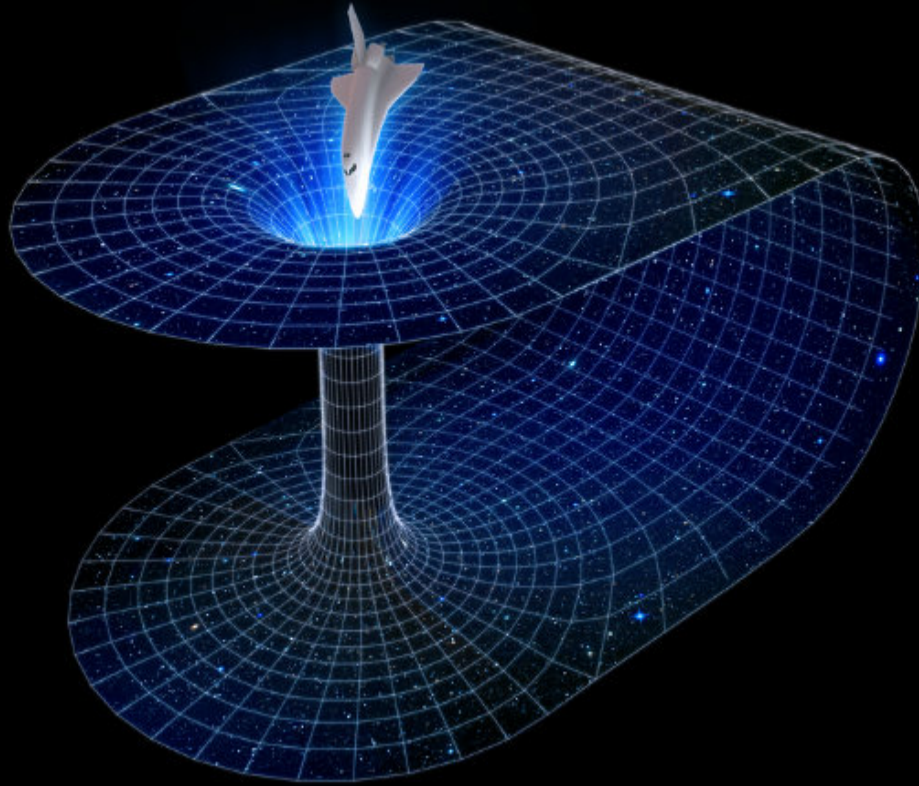
**What does spacetime look like at
the quantum scale?**

No longer Einstein's continuous 4-D "fabric"

More like a "quantum foam"

Bubbles and wormholes

**"Future Physics"
Wormholes**



<http://space-engine.wikia.com/wiki/Wormhole>

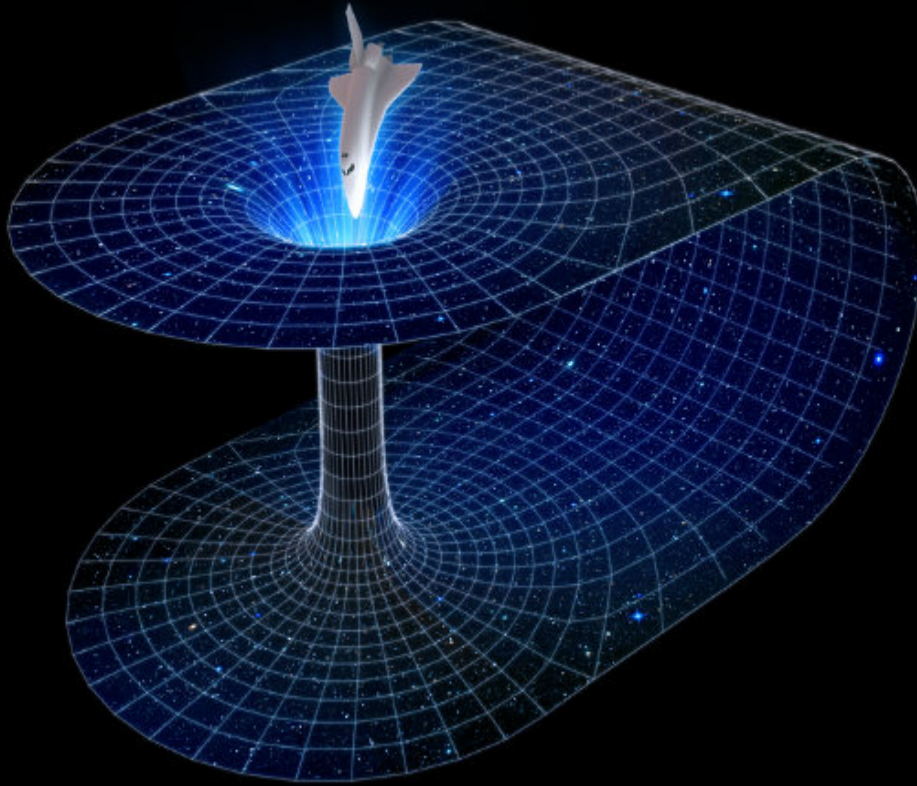
- **Shortcut through spacetime**
- **Existence is hypothetical**
- **Quantum-scale; highly unstable**
- **Enormous energy needed to keep one open long enough to be useful**

Properties of Wormholes

Contact

**Directed by Robert Zemeckis
Warner Brothers (1997)**

**Giant machine opens wormhole
to distant part of galaxy**



<http://space-engine.wikia.com/wiki/Wormhole>

- **YES!**
- **Shortcut through *spacetime***
- **Could be used to travel through *time*, as well as through space**
- **Lots of technical difficulties...**

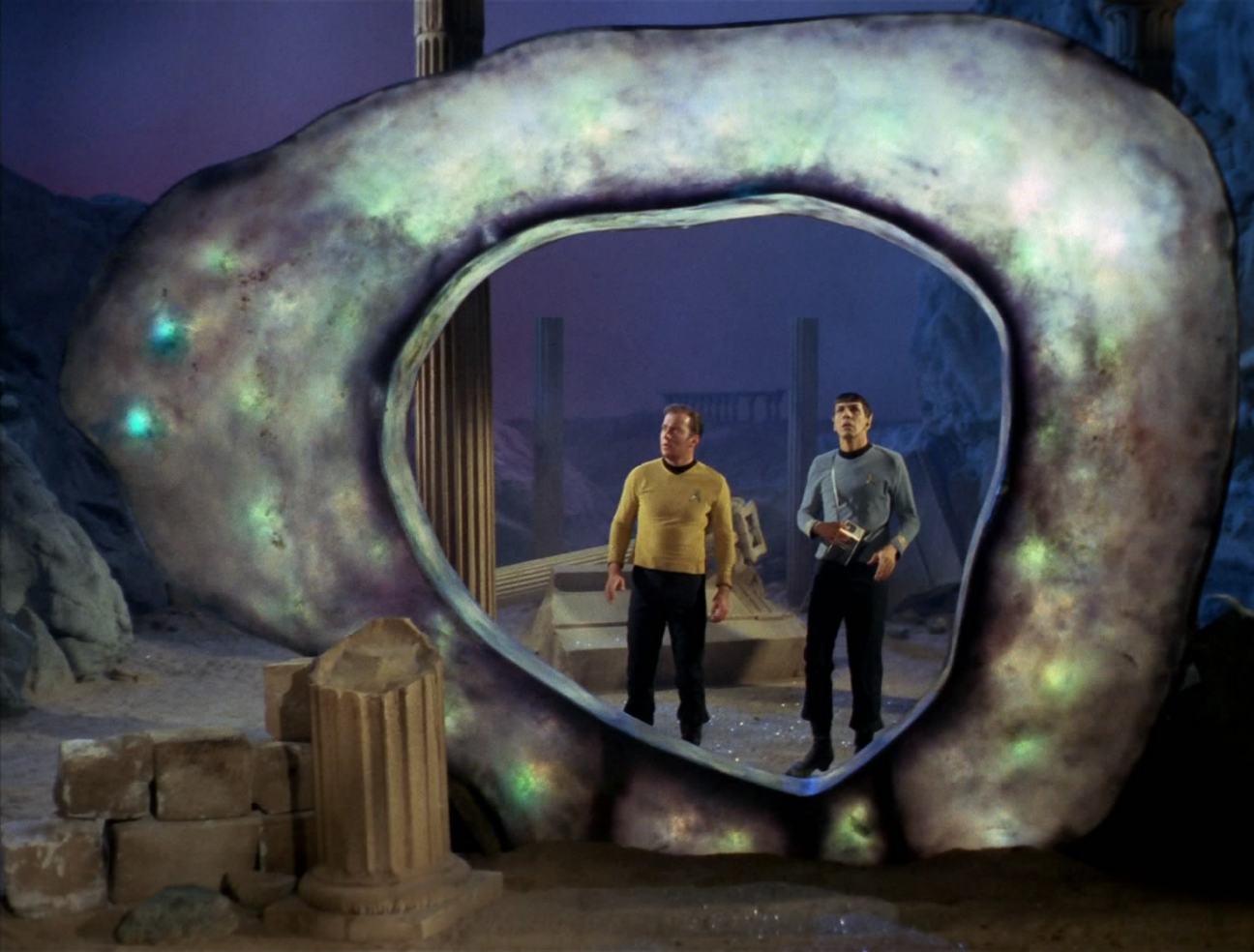
Could a wormhole be used as a time machine?

Star Trek

“The City on the Edge of Forever”

**Written by Harlan Ellison
Paramount (1967)**

Could a wormhole be used for time travel?

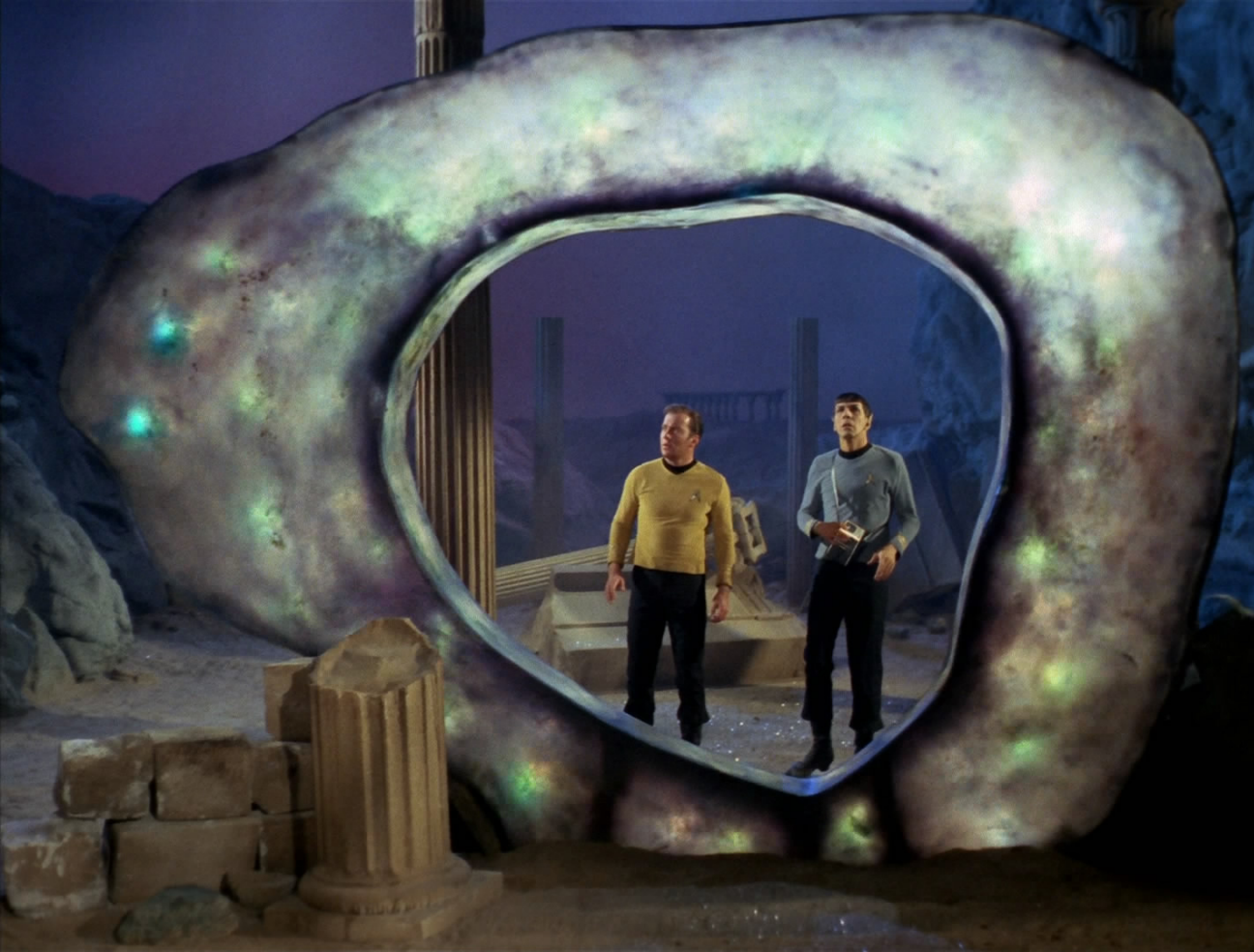


Could something like *the Guardian of Forever* actually exist?

“For this to do what it does is impossible, by any science I understand.”

- Spock

The Guardian of Forever
(*STTOS*: “The City on the Edge of Forever”, 1967)

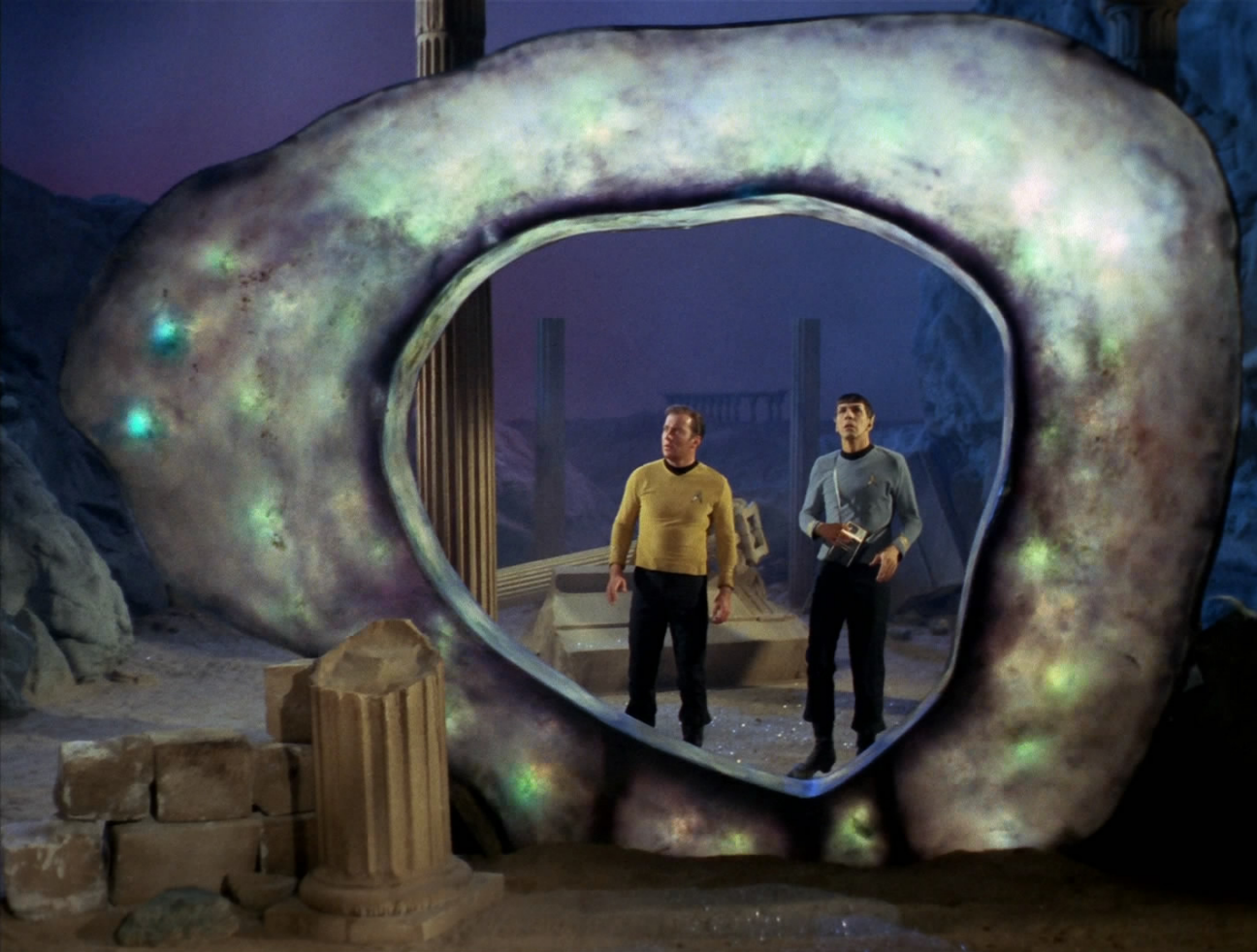


**What is the
Guardian of
forever?**

**“A time portal,
Captain.
A gateway to
other times and
dimensions, if I’m
correct.”**

- Spock

***The Guardian of Forever*
(STTOS: “The City on the Edge of Forever”, 1967)**



“As correct as possible for you. Your knowledge of science is obviously primitive”

- Guardian

The Guardian of Forever
(STTOS: “The City on the Edge of Forever”, 1967)

The Twilight Zone
“No Time Like the Past”

Written by Rod Serling
CBS (1963)

**If time travel into the past is possible,
could you go back and change history?
(Illustration of “Principle of Consistent Causality”)**

Principle of Consistent Causality...

Proposed by Igor Novikov

(Section 2.5 in the text)

**Attempting to change the past is like
attempting to defy the law of gravity!
(You can't succeed, even if you try.)**

**If time travel into the past is possible,
could you go back and change history?**

“Future Physics”

- **Other time travel possibilities**
- **Quantum gravity**
- **The Multiverse Hypothesis**

Today...
“Future Physics”
(continued)

Star Trek IV: The Voyage Home

**Directed by Leonard Nimoy
Paramount (1986)**

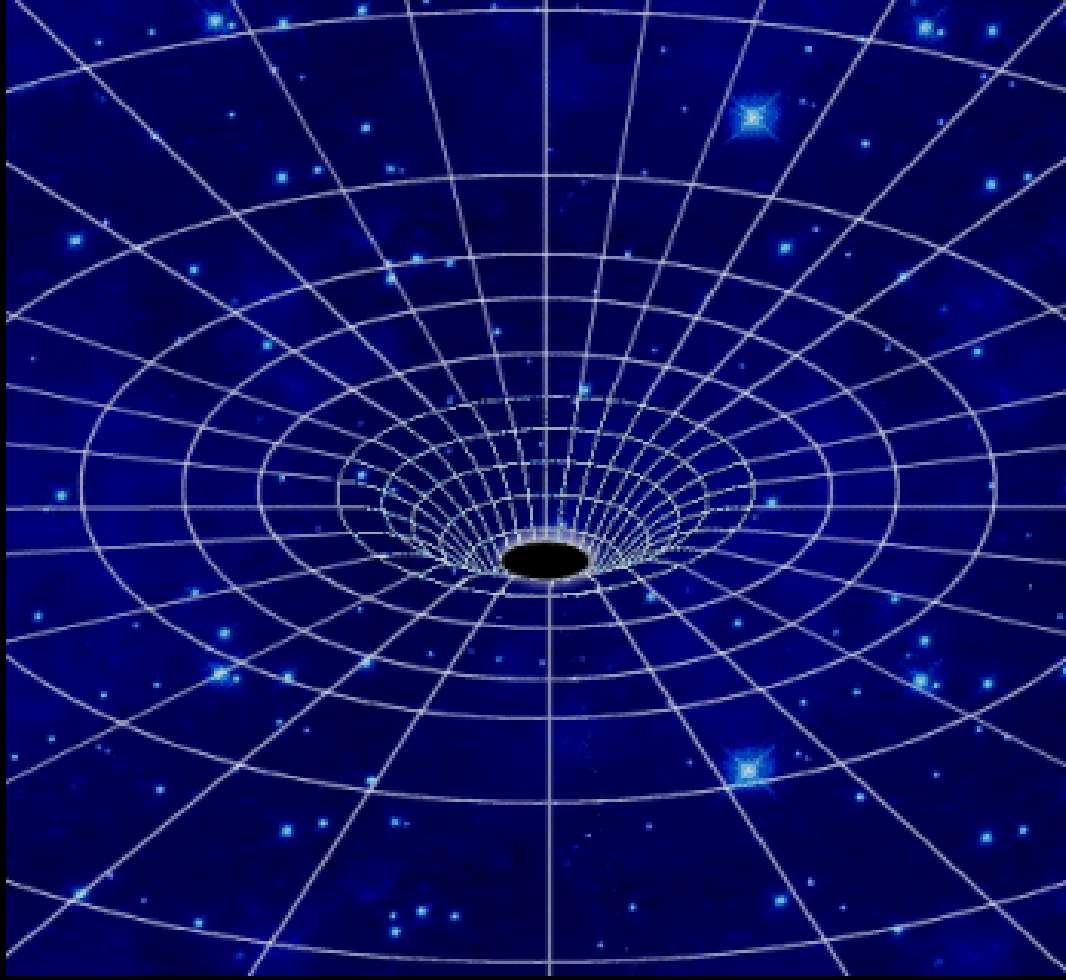
**Time Travel by combining Special Relativity and
General Relativity?**



General Relativity:

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

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 is expanding.

(More on this in Chapter 3)

“Frame dragging”: evidence that the fabric of spacetime twists in the presence of a massive spinning object.

But no evidence that the *universe as a whole* is also spinning.

Time travel into the past?

Time Travel into the **future is possible!**
(in both Special *and* General Relativity)

Time Travel into the **past is not possible**
(at least not in our universe), unless...

**Find some clever way to create a stable
wormhole big enough for travel.**

Summary of Possibilities for Time Travel

Why Quantum Gravity?

- **Only fundamental force not yet included the “Standard Model” of Particle Physics (more later)**
- **Sharp curvature of spacetime near black hole needs quantum physics to describe properly**

**Ongoing research in theoretical physics:
The quest for a theory of *Quantum Gravity***

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?**

The Multiverse Hypothesis

Next Time...