Static vs. Expanding

Ashling, Devin, Logan and Matt

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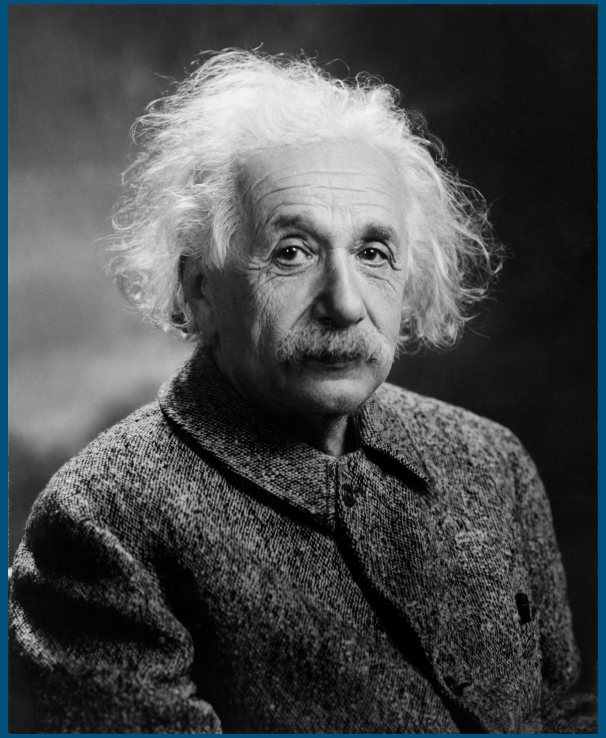
Who is Albert Einstein

Born 1879 in Germany

He was a Theoretical Physicist known for his deep curiosity about space, time, and gravity

Known in Astronomy for his General Theory of Relativity and his Cosmological Constant



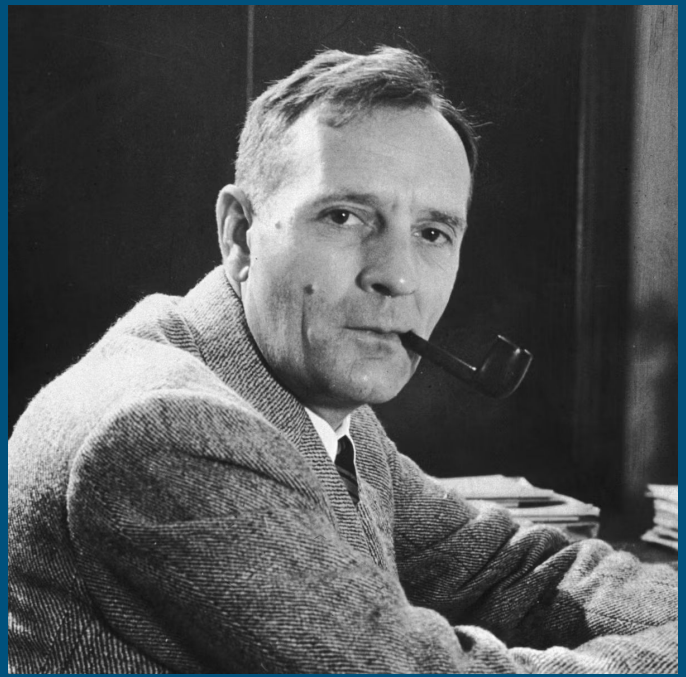
Albert Einstein. (n.d.). *Albert Einstein* [Photograph]. Wikipedia. https://en.wikipedia.org/wiki/Albert_Einstein

Who is Edwin Hubble

Born 1889 in Missouri USA

Edwin became an Astronomer at Mount wilson Observatory in 1919

Some of his key contributions was his work around galaxies beyond the Milky Way and Hubble's Law



Biography.com Editors. (n.d.). Edwin Hubble [Photograph]. Biography.com. https://www.biography.com/scientists/edwin-hubble

Einstein's General Relativity Theory

- First theory that attempted to explain the mathematics behind the universe.
- His theory of gravitation was able to explain consistent mathematical models for entire universes.
- Proposed a static universe in 1917, stating that the universe is unchanging.
- Cosmological Constant (Λ)

Hubble's Theory of An Expanding Universe

- In the 1920’s, Edwin Hubble observed that in galaxies further distant out from our own galaxy that they appeared to shift to the red light end of the visible light spectrum.
- He observed that the shift in the red light had a direct proportional correlation to the distance between us and the galaxy.
- Edwin noted how the redshifting he noticed was characteristic of what is known as Doppler Shift created from backwards radiation.
- These observations became the founding principles and basis for the construction of the expanding universe theory by Edwin Hubble.

Hubble Vs. Einstein

- Both Hubble and Einstein studied astronomy but their methods of study strongly differed.
- Hubble would make educated and informed observations through methodical scientific processes.
- Einstein came from a more mathematical background and as a result approached astronomy much differently, with a history of developing theoretical physics theories.
- Einstein used his own theoretical physics theories to approach developing a new theory to encompass an equation to calculate his mathematical model.

Einstein's Equation Vs. Hubble's Equation

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$v = H_0 r$$

v = recessional velocity

H_0 = Hubble constant

r = distance

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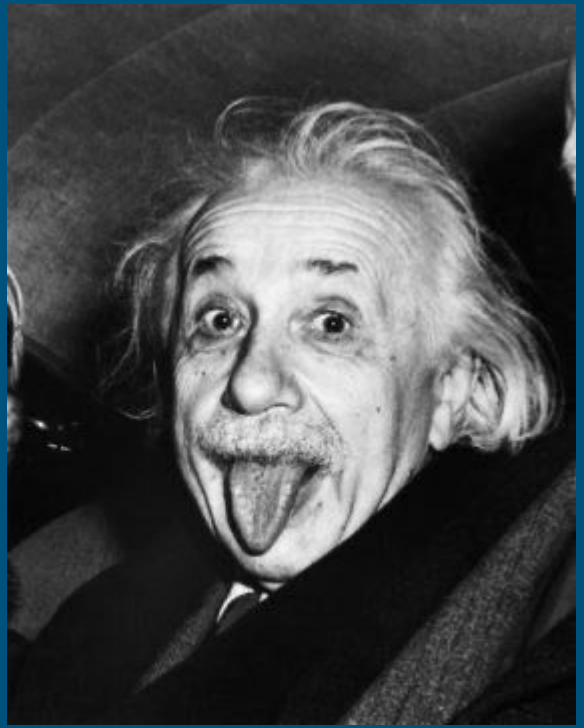
Fiveable Content Team. (n.d.). *13.3 Expansion of the universe and Hubble's law.* Fiveable. https://fiveable.me/astrophysics-i/unit-13/expansion-universe-hubbles-law/study-guide/PiTOrAfyRdsTRVeU

Why did Einstein believe in this theory?

- Scientific Consensus in the early 1900's
- Philosophical assumptions inherited from earlier cultures
- There was no observational evidence



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Why did Hubble believe in his theory?

- Access to new technology for observations
- Discovered other Galaxies
- Had other Astronomers who were open to an expanding universe

Discussion Questions

Break into 4 groups

1 Minute to discuss

Pick one person to report your answers

Question #1

Why might Einstein have wanted to believe the universe was static?

Question #2

What kind of evidence convinced Hubble that the universe is expanding?

Question #3

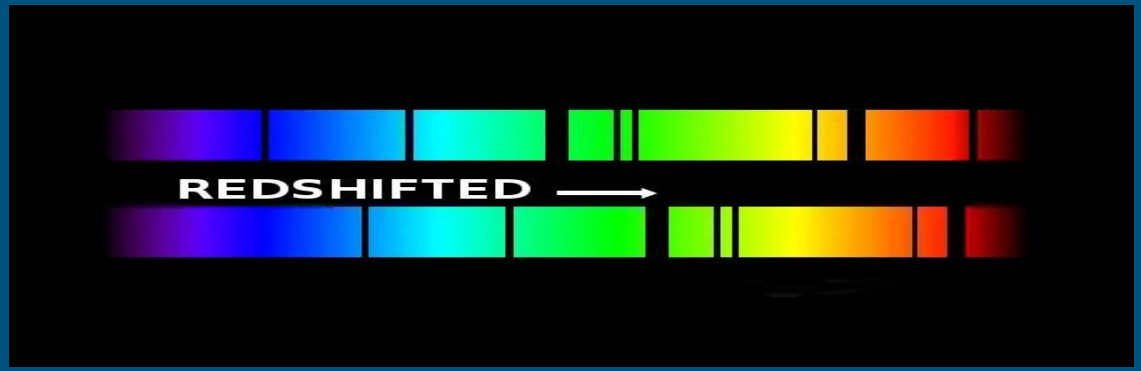
Whose view is more scientific?

Question #4

What does this debate teach us about science and why?

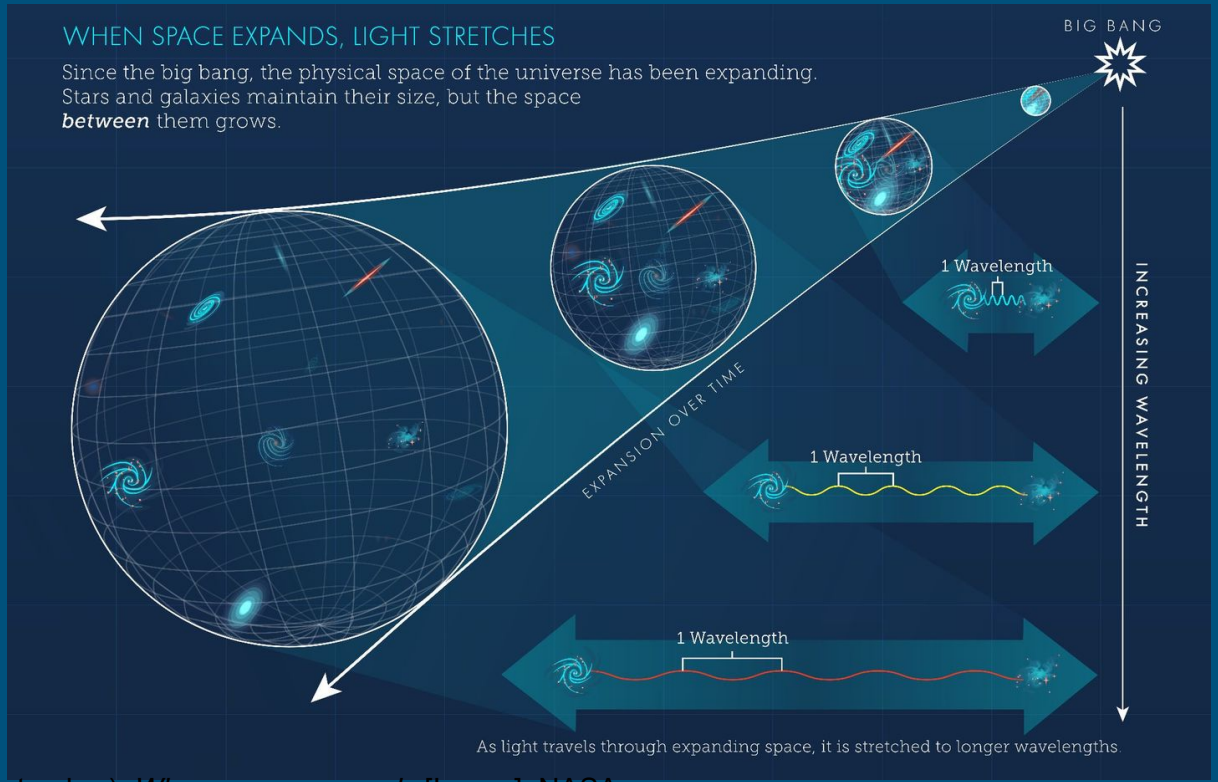
What Really Happened?

Edwin Hubble’s observations from Mount Wilson showed that distant galaxies appear red from a phenomenon known as **Cosmological Redshift**.



NASA Science. (2024, September). *Hubble redshifted spectrum* [Image]. NASA. https://science.nasa.gov/wp-content/uploads/2024/09/hubble-redshifted-spectrum.jpg

What is Redshift?



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Hubble’s Law

Hubble's Law states that the recession velocity of a galaxy is directly proportional to its distance from earth.
The further away the galaxy the faster.

$$v = H_0 r$$

v = recessional velocity

H_0 = Hubble constant

r = distance

This laid the foundation for the big bang theory.

If galaxies are moving away really fast, what happens when we roll back the clock?

A hotter and more concentrated universe.

What about Einstein?

Upon hearing about Hubble's observation of the redshifted galaxies, Einstein went to Mt. Wilson Observatory to see for himself. Einstein humbly accepted his mistake and it is widely reported that he called the cosmological constant of the static universe his "**biggest blunder**".

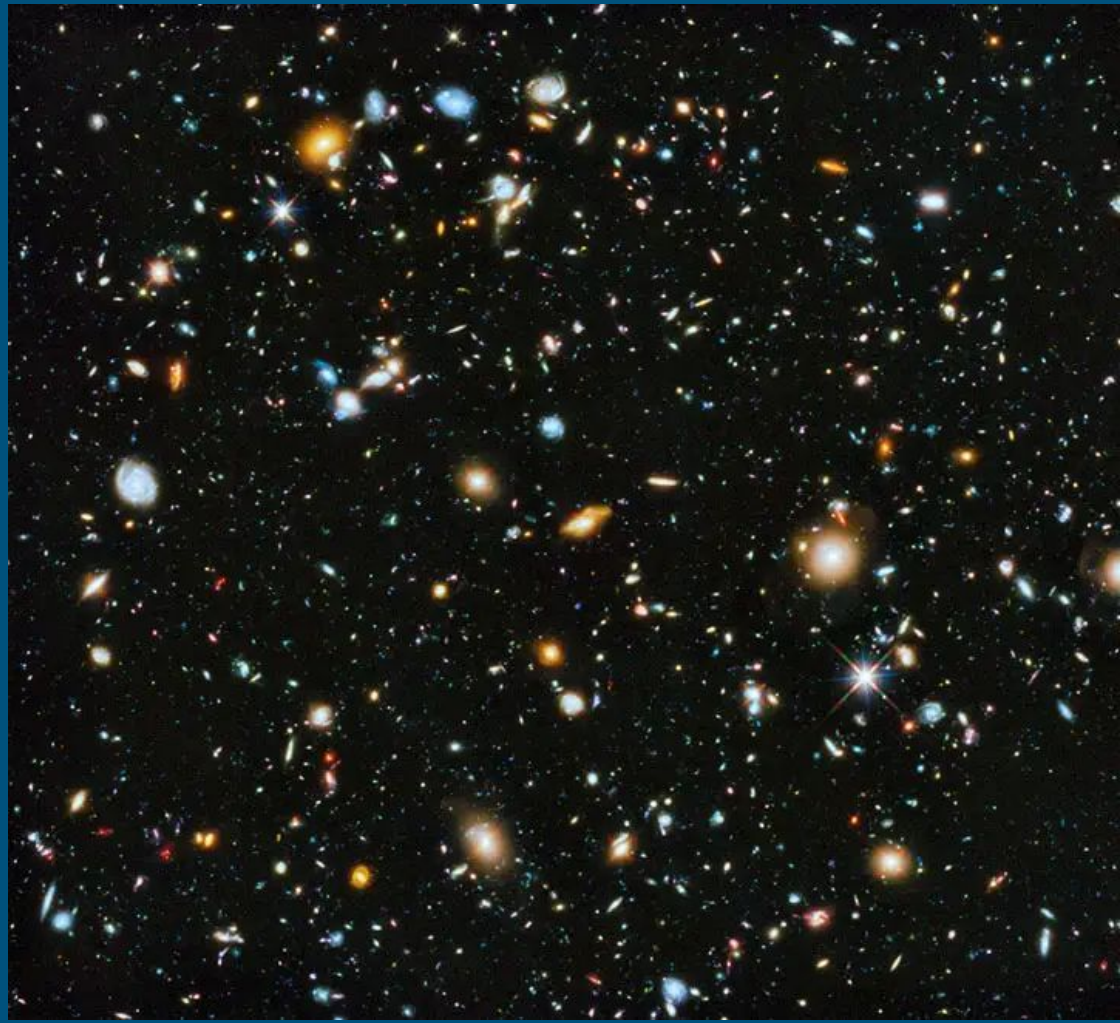
However...

A New Mystery

In 1998, researchers using the Hubble Space Telescope discovered that the expansion of the universe is actually accelerating.

Astronomers named this mysterious force **dark energy.**

Ironically, Einstein's **cosmological constant** reemerged to explain **dark energy**.



Not a Blunder

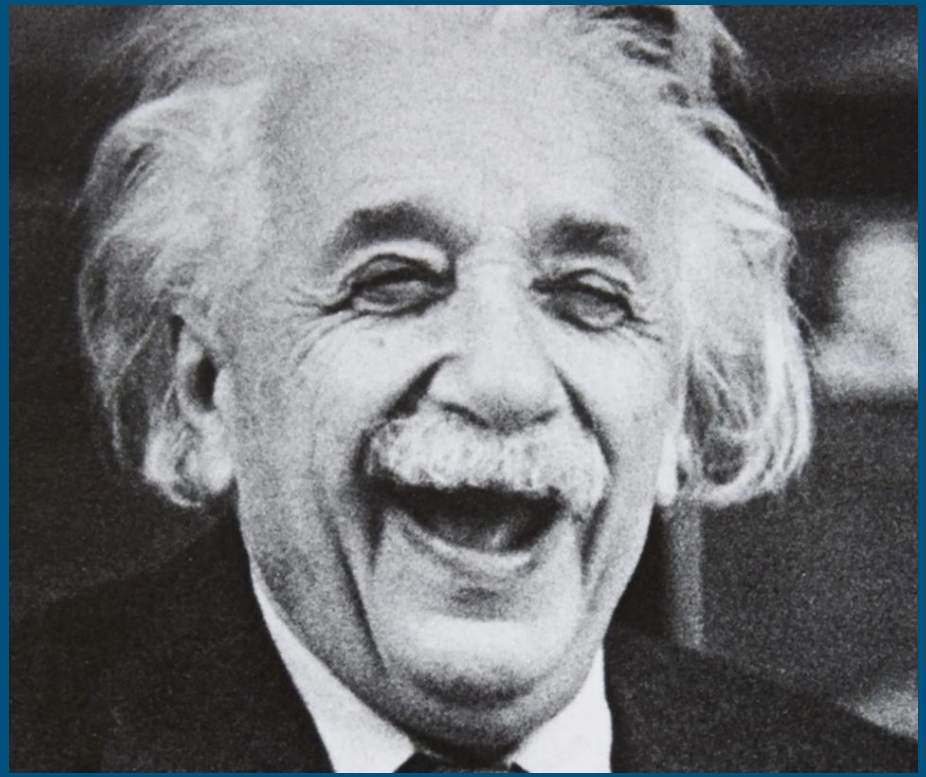
Einstein's cosmological constant = Λ

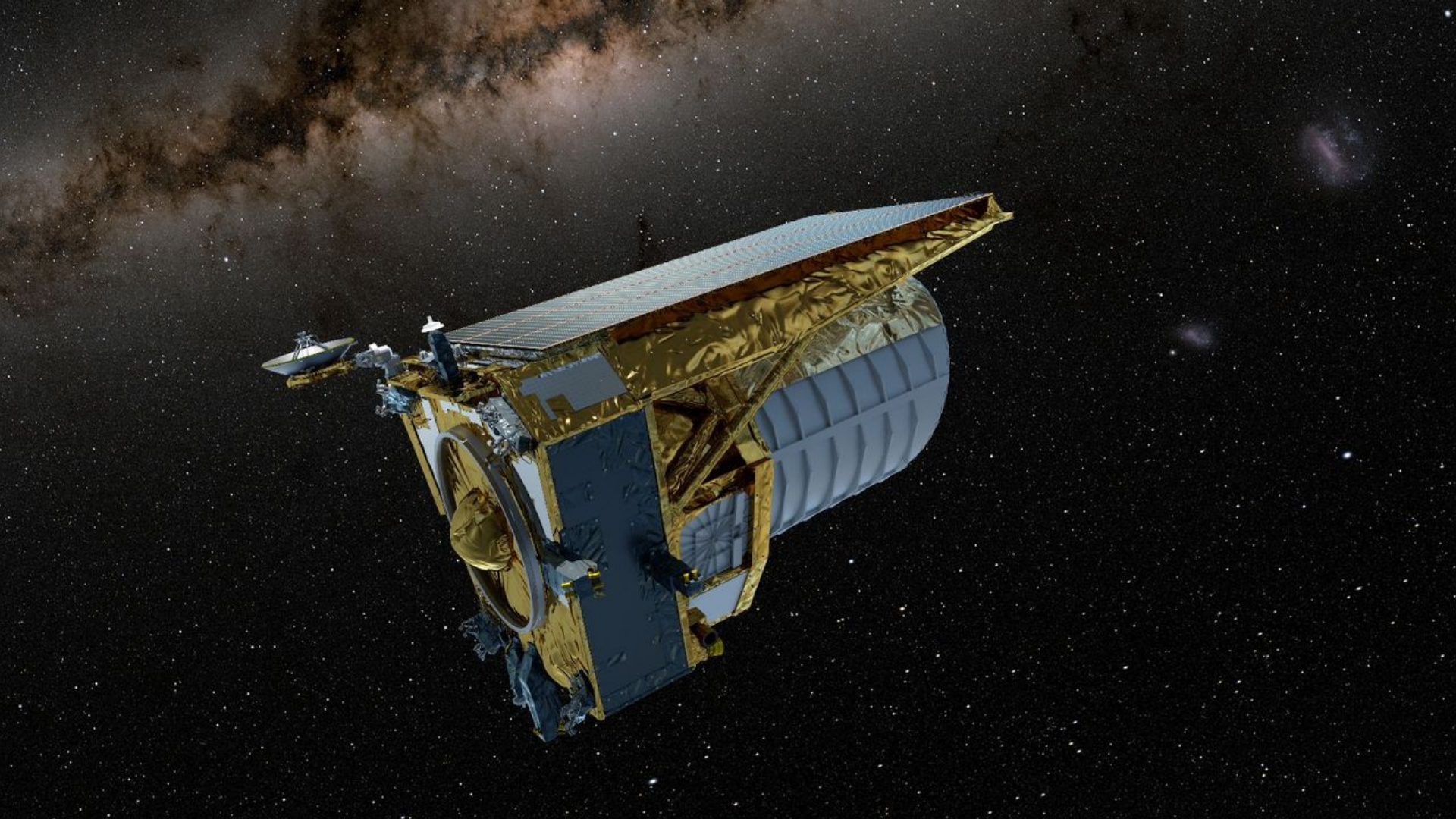
In general relativity, a positive Λ...

Acts like vacuum energy,

Produces negative pressure,

And accelerates expansion





Thanks for Watching!