



Maryam's Logbook

Maryam's Section:

January 8th, 2026:

Me (Maryam) and my partner Sarah began considering different possible ideas we can choose to work on for our science fair project, as we wanted to research something both of us were passionate and interested about. On the same date, January 8th, 2026, me (Maryam) and my partner Sarah collectively decided to pursue the extensive research regarding wormholes and why they remain strictly as theories and not realistically ideal structures, reality wise. Despite this being a more advanced and complicated topic, me and my partner both agreed the topic was something we liked and decided to move forward with it.

January 9th, 2026:

we decided to think ahead of time, keeping in mind the complexity of the project we were working on as my partner organized a plan to help the both of us move forward with the project and stay on the right track, avoiding the research of anything that doesn't directly have any significance or relevance to what we were particularly working on. The title of our research went as follows: *The Wormhole Theory: Why Is The Wormhole Theory Just A Theory, And What Are The Different Factors That Affect Its Possible Existence?*

January 16th, 2026:

This was the day when our science teacher, Ms. Elkadri approved our topic and gave insightful feedback to the work which we had already completed

January 23rd, 2026:

This was the day when I (Maryam) began working on my part of the research that needed to be completed for my project. I finished one of the three sections that needed to be finished by me.

My research for this day included: *The Geometry Of Space Time*

- The Fabric of space: explain Einstein's idea that gravity isn't a force
 - In broad terms, general relativity is physicist Albert Einstein's understanding of how gravity affects the fabric of space time. The theory, which was published in 1915 by Einstein, expanded his theory of space relativity which he came out with nearly 10 years earlier. Special relativity argued that space and time are inextricably connected, but the theory never acknowledged the existence of gravity itself. The decade between the publication of both theories was spent determining that massive objects warp the fabric of space time, a distortion that manifests as gravity.
 - **Understanding general relativity:** Firstly, gravity itself is the force of attraction that two objects exert on each other. The gravitational force tugging between two objects depends on how massive each one is and how far apart the two bodies lie. Even while the centre of the earth pulls

you towards it, your centre of mass pulls back at the earth. This is an effective example since the more massive body barely feels the tug from you, while your much smaller mass is firmly rooted due to that same force.

General relativity explains that gravity isn't really a "force" anymore. The gravitational field comes out of the description of general relativity as a result of the curved spacetime.

- Folding paper analogy: Describe how extreme gravity can fold this fabric, bringing two points together
 - The folding paper analogy is a visual, two dimensional representation of how Einstein's general relativity suggests the fabric of space time behaves under extreme gravity. Instead of travelling along a surface, extreme gravity, similar to that from the black hole, bends the fabric so severely that locations from distances are brought together.
 - **An explanation of how this analogy works:**
 - Space as a flat sheet:** Envision the fabric of space-time as a flat, two dimensional piece of paper
 - Two distant points:** In "normal" space, the shortest path between them is a straight line across the surface
 - The "fold":** extreme gravity, such as one from a massive object, curves the fabric of space time so severely that the sheet fold back on itself until the two distant points touch
 - The shortcut:** By piercing a hole through both points while they are touching, you create a tunnel through a higher dimension. This allows an object to step through and travel instantly between distant locations while traversing the vast space between them. While the analogy uses a literal fold, actual gravity warps space-times intrinsic curvature.
 - Theoretical statues:** Although wormholes are mathematically possible solutions to Einsteins field equations, they have never been observed
 - Stability requirements:** Most models suggest that such a tunnel would collapse instantly unless supported by "exotic matter" with negative energy, which is yet to be discovered in nature
- The Einstein-Rosen bridge: First mathematical model of a 'bridge' between two points
 - The Einstein-Rosen bridge, commonly referred to as a wormhole, is a hypothetical structure that connects two separate points in spacetime. The concept of the "wormhole" is derived from the equation of general relativity, which is the Einstein theory of gravity. This idea was developed by physicist Albert Einstein and

Nathan Rosen in a 1935 paper, which is the main reason as to why it is sometimes called the “Einstein Rosen Bridge”

- **Key concepts and points from the Einstein Rosen bridge:**
 - Topology of spacetime:** Spacetime is a 4-dimensional continuum that combines the 3-dimensions of space with the dimensions of time. The concept of a wormhole involves a distortion of spacetime that creates a tunnel-like structure.
 - Shortcut Through Spacetime:** A wormhole is envisioned as a shortcut or tunnel that connects two distant points in spacetime. Instead of travelling through 3-dimensional space, one could traverse through the wormhole to reach the other end quicker than if the journey were made through conventional space.
 - Throat and Mouth:** The geometry of a wormhole is often described as having a “throat” connecting two “mouths”. The mouths represent the entry and exit points of the wormhole while the throat is the region connecting them
 - Exotic Matter:** The existence and stability of a traversable wormhole would require the presence of exotic matter with negative energy density
 - Time travel possibility:** Theoretical discussions about wormholes often include the possibility of time travel. Depending on specific characteristics of a wormhole, it may allow a type of time dilation or time loop, enabling a traveler to experience time differently than in a non-wormhole scenario
 - Unproven and speculative:** While the mathematics of general relativity allow for the existence of solutions that could represent traversable wormholes, their actual existence remains speculative.
- Wormholes are mathematical solutions to General Relativity, but modern research often views them as potential "projections" of higher dimensions.
 - While wormholes are consistent with the general theory of relativity, whether they have actual real existence is not yet determined. Many physicists postulate that wormholes are merely projections of a fourth spatial dimension, analogous to how a 2-dimensional being could experience only part of a 3-dimensional object

February 1st, 2026:

This was the day when I started the second section of my research, moving forward with the project. I was incapable of completing the part within that same day, and as of result, completed roughly half of this section.

The research that I have completed within the time frame include: *Making A Wormhole Walkable*

- The Throat of the Hole: Explain the "tunnel" part of the wormhole and how wide it needs to be for a traveler to fit.
 - In order to construct or build a wormhole, you would need to glue together different sections of the universe, connecting them by a bridge or tunnel, commonly identified as a "throat". This throat can be as large or as long as you desire, however, you would want it to be shorter than the normal distance to your destination. In Albert Einstein's theory of general relativity, building a wormhole is described as a surprisingly straightforward procedure: You would, in this case, build a black hole that connects to a white hole (the literal opposite of a black hole). After completing this process, you will be left with a tunnel through space time.
- Surviving Gravity: Discuss "tidal forces"—the gravity must be gentle enough so it doesn't crush or stretch a person into a thin string.
 - Wormholes are subject to severe restrictions from quantum field theory. To allow for the possibility of interstellar travel, a macroscopic wormhole would need to maintain sufficiently low radial tidal forces. The assumption of zero tidal forces, for instance, the limiting case, is sufficient for overcoming the restrictions from quantum field theory. The feasibility of this approach is subsequently discussed by firstly, introducing the additional conditions needed to ensure that the radial tidal forces can indeed be sufficiently low and secondly, viewing traversable wormholes as emergent phenomena, thereby increasing the likelihood of their existence. One of the greatest obstacles faced when it comes to the wormhole is the possible existence of large radial tidal forces, which lead to what is commonly referred to as "spaghettification" (noodle effect): The vertical stretching and horizontal compression of objects into long, thin shapes in a very capable, non homogeneous gravitational field. The tools required to reduce the tidal forces to manageable levels can essentially eliminate the other challenges, as it suggests that traversable wormholes are indeed theoretically possible.

February 2nd and 3rd, 2026:

Between the time frame of both of these dates, I had finally completed the full second section out of the three that I aimed to finish.

The last section of this part included the following information: Stability: Explain why most mathematical wormholes would collapse the moment a single particle of light enters them.

- The instability of a wormhole mainly exists because creating a wormhole in the first place requires great precision and careful arrangement of matter. Anything that could possibly disturb or wreck this delicate balance, whether it be a single packet of light or photon- would trigger the instant collapse of the wormhole entirely. The wormhole, in this case, would tear itself apart, similarly to that of an overstretched rubber band faster than the speed of light, preventing anything from travelling through it. Additionally, physicists more so think or believe that white holes do not exist in our universe. Unlike their siblings, white holes are astonishingly unstable. According to the math, once even a single crumb of matter falls towards them, they instantly explode. So, despite the fact that white holes are naturally formed, they wouldn't, in the majority of cases, last very long. The combination of the uncertainty of the existence of white holes, alongside the instability of the Einstein-Rosen bridge and the relative, non-utility of them means that if wormholes do exist, they likely aren't Einstein-Rosen bridges.
- **A spinning singularity:** There may be a possible way to build wormholes from a more complicated kind of black hole-taking their spinning into account. Use a model to compare the Morris-Thorne metric (traversable) against the Schwarzschild metric (collapsing). This is one of the most disadvantaged characteristic of a wormhole, where the enormous gravitational strength, rip them apart faster than the speed of light, which makes them rather useless as actual shortcuts through spacetime

February 6th, 2026:

By this time, I had completed all three parts of my half of the research.

The final section of information involves the following: *The Need For "Exotic Matter"*

- Negative Energy: Explain that while normal gravity pulls things inward, "exotic matter" would push outward to keep the tunnel from snapping shut.
 - The geometry of a wormhole depends greatly on the distribution of matter and the energy around it. A traversable wormhole would require exotic matter to both stabilize and prevent its collapse. Exotic matter in itself is defined as a form of hypothetical matter that differs from the atoms and molecules that we are familiar with. Its peculiar characteristic and negative energy is what distinguishes it from ordinary, typical matter. Exotic materials have the property of lesser energy than normal matter. This partially explains why exotic matter has only been theorized and is not yet observed or confirmed to be seen by anyone at all.
 - Exotic matter is frequently discussed in the relation with the wormhole-which is commonly only the case since exotic matter has been believed to potentially prevent the collapse of the wormhole altogether
 - Wormholes that can be crossed in both directions, commonly referred to as a traversable wormhole, were believed to be possible only if exotic matter with negative energy density could be used to stabilize them. Later on, physicists reported that microscopic traversable wormholes may be possible and not require any exotic matter, instead requiring only electrically charged fermionic matter with small enough mass that it is incapable of collapsing into a charged black hole. A simple analogy that effectively explains how a scenario such as this could possibly occur in reality-goes as the following: imagine you have a constructed tunnel made of flexible material in which you wish to

keep open so that you are capable of passing through. The turning point is that the tunnel is prone to collapsing due to its own weight. To prevent this particular wormhole from collapsing, you would need an object that pushes the walls outwards, providing support that keeps the tunnel open. This is a similar concept relevant to the context of a wormhole where instead of physical walls, we are dealing mainly with the fabric of spacetime.

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- Anti-Gravity Effects: Detail how this matter would have "negative pressure," acting like a pillar holding up a collapsing ceiling.
 - Exotic matter features two impactful features: 1. Negative energy density, or 2. Negative pressure is strong enough to oppose gravity. This type of matter produces repulsive gravitational effects, pushing spacetime outward rather than pulling it inwards. Exotic matter, in particular, acts as anti-gravity, stabilizing the wormhole throat and preventing its collapse.
 - At the throat of the wormhole, three particular things must occur: 1. Gravity must push outward 2. Tidal forces must be and remain finite. And 3. The structure must be and remain stable. Exotic matter creates a repulsive gravitational field that counterbalances the intense inward pull caused by spacetime curvature. To things that would happen without this repulsion would be the throat collapsing into a black hole, or pinching it off completely. From this explanation, we can understand that exotic matter is not optional but more so fundamental
 - Dark energy may be described as a fluid with negative pressure. It is said that this negative pressure counteracts gravity and accelerates the expansion of the universe. Perchance, consider a star. Gravity would contract the star, however positive (thermal) pressure would counteract the collapse. This is rather confusing for many as both cases have gravity as an inward force, and in both cases the pressure would be counteracting gravity. Furthermore, in a single case, one is positive and the other would be negative.

- The Casimir Effect: Mention that scientists have seen tiny amounts of negative energy in labs, which suggests the "glue" might actually exist.
 - The casimir effect is an effect **arising from the quantum theory of electromagnetic radiation** in which the energy present in empty space might produce a tiny force between two objects. This effect was first postulated in 1948 by Dutch Physicist Hendrik Casimir.
 - When two metal plates are placed extremely close together in a vacuum, three things would likely happen: **1. Quantum fluctuations** are suppressed between the plates **2. Energy density** becomes negative **3. This has been experimentally measured.** However, despite these important causes, the effect is rather tiny, it only works at microscopic scales, and producing a relevant quantity of exotic matter would be astronomically difficult
 - **How virtual particles cause the casimir effect:**
 - Some virtual particles are similar to the qualities of tiny waves of light, commonly referred to as virtual photons. Just imagine these waves bouncing all over the place!
 - **Outside the plates:** In the wide-open space outside the two metal plates, all kinds of different virtual waves can exist. They are capable of having any wavelength (The distance between two peaks of a wave)
 - **Between the plates:** Inside the tiny gap between the two metal plates, things are rather different. Only certain virtual waves can fit in this smaller space. An easy way to understand is by thinking of it like a guitar string: Only certain and specific notes (being the wavelength) can be played on it. Waves that don't fit perfectly can and will cancel themselves out. This means that there are fewer virtual waves bouncing around inside the plates compared to the outside.

Since we observed that there are more virtual particles pushing on the outside of the plates compared to the inside, the plates are gently pushed towards each other. This sums up the casimir effect, which is a tiny yet real force!

February 14th-23rd, 2026:

During this time period, we needed to put some information into slides. Since we had a larger quantity of it, I (Maryam) began to summarize my part, ensuring that only the key and most important points are added onto the slides. This was done to reduce the complexity of the topic and make it easier to understand.

The completed summary I used for my section of the slides goes as the following:

The Geometry of Spacetime

Einstein's Idea: Gravity Is Curved Spacetime

In 1915, Albert Einstein introduced the theory of general relativity, expanding on his earlier theory of special relativity. Special relativity showed that space and time are connected into one four-dimensional structure called spacetime. However, it did not acknowledge gravity.

General relativity completely changed how we understand gravity. Instead of being a pulling force between objects, gravity is the result of mass and energy bending the fabric of spacetime. The more massive an object is, the more it curves spacetime around it.

For example, Earth pulls you toward its center — but you also pull back on the Earth slightly. Because Earth has far more mass, you feel the effect much more strongly. According to Einstein, gravity is no longer considered a force. Instead, the gravitational field comes from the description of general relativity as a result of the curved space time. Simply put, gravity is the curved spacetime.

The Folding Paper Analogy

To visualize this idea, imagine spacetime as a flat sheet of paper.

- In normal space, the shortest distance between two points is a straight line.

- When extreme gravity is present (such as near a black hole), the “sheet” bends so severely that it folds back on itself until the two distant points touch.
- If the paper folds so that two distant points touch, a hole punched through them would create a shortcut.

This shortcut represents a wormhole, a tunnel connecting two distant regions of spacetime.

While the analogy uses a 2D fold, actual gravity warps spacetime's intrinsic curvature.

Wormholes are mathematically allowed in Einstein's equations, but have never been observed.

Most models suggest they would collapse instantly unless stabilized by unfamiliar special forms of matter, like exotic matter with negative energy.

The Einstein–Rosen Bridge

In 1935, Albert Einstein and Nathan Rosen proposed the first mathematical model of a wormhole, known as the Einstein–Rosen bridge.

A wormhole is a hypothetical tunnel that connects two separate points in spacetime. Since spacetime combines three dimensions of space with the dimension of time, this tunnel would distort the structure of the universe itself.

A typical wormhole model includes:

- Two mouths, being entry and exit points
- A throat, being the region connecting them
- A shortcut through spacetime: wormholes are described as shortcuts that connect to distant points. (Instead of travelling through conventional space, one could traverse the wormhole to make the journey quicker.)
- Theoretical time dilation effects: a wormhole may allow a type of time dilation, letting a traveller experience time differently.
- Exotic matter, which is required for the existence and stability of a traversable wormhole

Although general relativity allows equations that describe wormholes, their real existence remains speculative. Some modern theories suggest wormholes could be projections of higher dimensions, similar to how a 2D being would only see part of a 3D object.

Making a Wormhole Traversable

The Throat of the Wormhole

For a wormhole to be “walkable” or traversable, you would glue together separate sections of the universe connected by a tunnel known as the throat. While it can be as large or long as wanted, the throat must be shorter than the regular distance to your destination.

The theory of general relativity suggested a connection between a black hole and a white hole to create a tunnel through spacetime. However, white holes are extremely unstable and likely do not exist in our universe, making this version unrealistic.

Surviving Gravity: Tidal Forces

wormholes are subject to severe restrictions from quantum field theory

Extreme gravitational differences, called large tidal forces, have a possible existence which leads to an effect often referred to as “spaghettification,” where an object is stretched vertically and compressed horizontally into a long, thin shape in a very capable, non homogeneous gravitational field.

To allow for the possibility of interstellar travel, a macroscopic wormhole would need to:

- Maintain low radial tidal forces
- Gravity must not crush or stretch travelers
- The wormhole must stay structurally stable

Some theoretical models suggest that if tidal forces are low enough, a traversable wormhole could exist, but controlling these forces is a major challenge. Tools required to reduce tidal forces can eliminate other obstacles as well.

Stability Problems

Wormholes are extremely delicate structures. Creating one would require precise arrangements of matter and energy. Even a single photon (particle of light) entering the tunnel could disturb this balance and cause instant collapse.

White holes are also predicted to be highly unstable. Mathematical models suggest they would explode if even a small amount of matter approached them. Because of this instability, many physicists believe that if wormholes do exist, they are unlikely to be simple Einstein–Rosen bridges.

Some research explores rotating black holes as possible alternatives, since their geometry may offer slightly better stability. However, the enormous gravitational strength of a wormhole, which rips them apart faster than the speed of light, still makes practical travel unlikely.

The Need for Exotic Matter

For a wormhole to stay open, something must push outward against gravity. Normally, gravity curves spacetime inward, which would cause the wormhole’s throat to instantly collapse. This is why physicists believe a special type of matter — called exotic matter — would be required.

Exotic matter is hypothetical and differs from normal atoms and molecules. Its most important properties are:

- Negative energy density (energy lower than empty space)
- Negative pressure strong enough to oppose gravity

Unlike ordinary matter, which increases inward curvature, exotic matter would create a repulsive gravitational effect, pushing spacetime outward. In simpler terms, it would act like a support beam holding the wormhole's throat open. Without it, the tunnel would either collapse into a black hole or pinch off completely.

at the throat of a wormhole, three things must occur:

1. Gravity must push outward
2. Tidal forces must be and remain finite
3. the structure must be and remain stable

Some scientists compare this idea to dark energy, which also has negative pressure and causes the universe to expand. However, dark energy has not been proven to stabilize wormholes.

Most early models suggested that traversable wormholes are only possible if exotic matter exists. More recent research proposes that microscopic wormholes might not require exotic matter, instead needing only electrically charged fermionic matter, however these would be far too small for travel.

The Casimir Effect

There is one real quantum phenomenon that suggests negative energy might exist: the Casimir Effect, first proposed in 1948 by Hendrik Casimir.

When two metal plates are placed extremely close together in a vacuum:

- Fewer virtual particles can exist between them
- The energy density between the plates becomes slightly negative
- A tiny measurable force pushes the plates inward

This happens because virtual particles (temporary quantum fluctuations) are more restricted between the plates than outside them. The effect has been experimentally measured, proving that small amounts of negative energy are possible.

However, the effect is extremely tiny and only works at microscopic scales. Creating enough exotic matter to hold open a full-sized wormhole would be extraordinarily difficult.

February 18th-27th, 2026:

All the way from February the 18th until the 27th, I (Maryam) was working on and off on the physical trifold for our science fair, which we require as a clean, artistic, and unique way to represent the topic we have researched.

 Sarah's Logbook

Date:	What Was Accomplished:
Jan 14, 2026	<p>We solidified the topic, problem, and planning for research.</p> <p>Planning:</p> <p>→ <u>Wormhole theory</u>: Why is the Wormhole theory just a theory? And how is it possible?</p> <ul style="list-style-type: none"> ◆ <i>The Geometry Of Space Time</i> <ul style="list-style-type: none"> • The Fabric of space: explain Einstein's idea that gravity isn't a force • Folding paper analogy: Describe how extreme gravity can fold this fabric, bringing two points together • The Einstein-Rosen bridge: First mathematical model of a 'bridge' between two points ◆ <i>Making A Wormhole Walkable</i> <ul style="list-style-type: none"> • The Throat of the Hole: Explain the "tunnel" part of the wormhole and how wide it needs to be for a traveler to fit. • Surviving Gravity: Discuss "tidal forces"—the gravity must be gentle enough so it doesn't crush or stretch a person into a thin string. • Stability: Explain why most mathematical wormholes would collapse the moment a single particle of light enters them. ◆ <i>The Need For "Exotic Matter"</i> <ul style="list-style-type: none"> • Negative Energy: Explain that while normal gravity pulls things inward, "exotic matter" would push outward to keep the tunnel from snapping shut. • Anti-Gravity Effects: Detail how this matter would have "negative pressure," acting like a pillar holding up a collapsing ceiling. • The Casimir Effect: Mention that scientists have seen tiny amounts of negative energy in labs, which suggests the "glue" might actually exist. ◆ <i>The Quantum Connection (ER=EPR)</i> <ul style="list-style-type: none"> • Entangled Particles: Explain the idea that two particles can be "linked" across the universe. • Microscopic Wormholes: Discuss the theory that these linked particles are actually connected by tiny, invisible wormholes. • Information Travel: Explore how this could explain how information moves across the universe instantly. ◆ <i>The Time Travel Problem</i> <ul style="list-style-type: none"> • Time Dilation: Explain how moving one end of a wormhole at high speeds makes time move slower at that end. • The Time Machine: Describe how entering one end and exiting the other could result in "arriving before you left." • The Paradox Wall: Discuss the Grandfather Paradox and why many physicists (like Stephen Hawking) believed the universe has built-in "rules" to prevent time travel. ◆ <i>Why Is It Still A Theory</i> <ul style="list-style-type: none"> • Looking Like Black Holes: Explain that from the outside, a wormhole might look exactly like a black hole, making them very hard to spot. • Hunting for "Echoes": Discuss how we use gravitational wave detectors to listen for "echoes" in space that would prove a wormhole is there.

- Math vs. Reality: Summarize that while the math says "yes," we lack the technology and the "exotic matter" to prove it—or build one—right now.

Feb 4, 2026

Began research for three topics.

The Quantum Connection (ER=EPR)

- Entangled Particles: Explain the idea that two particles can be "linked" across the universe.
- 1. The Quantum State
 - A wavefunction, which encompasses all potential information about a system, is used in quantum mechanics to describe particles. This is OK for a single particle. When there are several particles, the situation rapidly gets worse. Two particles lose their individual wavefunctions when they become entangled. Rather, they have a single integrated wavefunction that characterizes the whole system.
 - Important realization: Neither particle can be adequately described by itself. Only in its entirety does the system make sense. Classical physics, where objects always have independent attributes, is fundamentally different from this.
- 2. Superposition + Correlation
 - Each entangled particle exists in a superposition of potential states prior to measurement.
 - For instance (spin): Both spin-up and spin-down are present in particle A. Although particle B is spin-up and spin-down, their results are connected. The state of the system is as follows: "If A is up, B will be down." "B will be up if A is down."
 - Crucially: As of yet, neither particle has a fixed value. The only thing that is specified is their relationship. Therefore, entanglement is about locked outcomes rather than hidden answers.
- 3. Measurement and Wavefunction Collapse
 - The shared wavefunction collapses when a single particle is measured. One of the permitted outcomes is chosen at random by the system. The state of the other particle is immediately fixed.
 - Regardless of distance, this occurs: A couple of meters, All across the planet, Throughout the galaxy.
 - Since nothing is moving between them, there is no time delay. Correlation without communication is what this is.
- 4. Why Distance Doesn't Matter

- Distance constraints have an impact in classical physics. Space does not act as a mediator of entanglement in quantum mechanics. Spacetime is not being used by the particles to transmit signals.
- A single mathematical object that is indifferent to separation describes them. From the standpoint of the theory: The system was always the same. Measurement just shows a portion of that. Entanglement seems to “ignore” space because of this.
- 5. Bell's Theorem
 - John Bell, a physicist, demonstrated that the predictions of quantum mechanics cannot be replicated by any theory based on local hidden variables.
 - To put it simply: Prewritten instructions are not being carried by the particles. Classical physics is unable to explain the relationships. Either non-local, non-realistic, or both describe reality.
 - Bell's predictions have been frequently validated by experiments.
 - Translation: Entanglement is an experimental reality, not a philosophical concept.
- 6. *No Information That Is Faster Than Light*
 - Despite the instantaneous correlation: Every measurement has a random result. You have no control over the outcome. A message cannot be encoded.
 - The pattern doesn't show up until findings are compared using classical communication.
 - Thus, relativity remains intact. Everyone calms down.
- 7. *The Reasons Physicists Are Serious About This*
 - Entanglement is quantifiable, is measurable, is utilized in practical technologies (such as teleportation protocols and quantum encryption, not science fiction teleportation).
 - More crucially: It implies that separateness might not be real. And it suggests that space may not be essential.
 - ER = EPR passes via this conceptual door.
 - If entangled particles behave as a single system despite being separated in space, it raises the possibility that spacetime itself may emerge from these quantum connections.
- Microscopic Wormholes: Discuss the theory that these linked particles are actually connected by tiny, invisible wormholes.
 - Introducing The Theory: The ER = EPR theory, which suggests a profound relationship between quantum entanglement and spacetime geometry, is the source of the concept of tiny wormholes. According to this theory, microscopic Einstein-Rosen bridges—a kind of wormhole anticipated by general relativity—may connect pairs of entangled particles, as described by the EPR conundrum. When quantum mechanics

and gravity are considered combined, these wormholes naturally arise from existing equations rather than being introduced as novel physics. According to the idea, what quantum physics refers to as “entanglement” can also be seen as a geometric link in spacetime.

- Nature Of These Wormholes: These little wormholes differ significantly from the big, science-fiction-style wormholes that are frequently shown in the media. They are absolutely undetectable with existing technology because they are so tiny—on the order of the Planck length. Most significantly, no matter, energy, or information can move through them since they are non-traversable. They exist as mathematical constructions that explain how spacetime might be connected at the quantum level rather than acting as tunnels.
- Why Physicists Consider Them Plausible: The traditional notion that things must be connected through space in order to influence one another is challenged by entangled particles, which act as though they are a part of a single system even when separated by great distances. By implying that the particles are already related through spacetime itself—just in a fashion that is concealed at really small scales—ER = EPR offers a potential explanation. According to this viewpoint, because the connection already exists, the correlations observed in entanglement do not require messages to transit between particles. The apparent conflict between relativity and quantum mechanics is resolved by this rephrasing.
- Scientific Significance And Limits: Microscopic wormholes are important because they provide a possible link between general relativity and quantum mechanics, despite the fact that they are still theoretical and have not been detected experimentally. According to the hypothesis, spacetime itself might not be a fundamental background but rather result from patterns of quantum entanglement. However, ER = EPR does not break any known physical laws and does not permit faster-than-light communication or travel. Rather, it offers a fresh perspective on how intricately linked the universe might be at its most basic level.

- Information Travel: Explore how this could explain how information moves across the universe instantly.
- Wormhole Basics for Information Travel: Wormholes are hypothetical tunnels in spacetime that connect distant points, acting like shortcuts. They could allow information (like signals or data) to travel vast distances almost instantly by bypassing normal space routes.
- How Shortcuts Work: Imagine folding a paper so two far-apart dots touch; a wormhole is the hole punched through, making the path super short. Information enters one end and exits the other quickly,

	<p>appearing "instant" from outside, without breaking light-speed rules inside.</p> <ul style="list-style-type: none"> - Traversable Wormholes: Some theories suggest wormholes stabilized by exotic matter (with negative energy) could stay open long enough for information to pass through, unlike unstable ones that collapse fast. - Quantum Entanglement Link: In quantum physics, entangled particles show instant correlations across distances (e.g., measuring one instantly affects the other). This seems like faster-than-light info travel but doesn't violate rules. - ER = EPR Conjecture: Proposed in 2013, this idea says entanglement (EPR) is equivalent to a wormhole (ER). Entangled particles are connected by a tiny wormhole, so information "moves" through the hidden bridge, explaining the instant effect without actual travel through normal space. - No Classical Messaging: Even with wormholes, you can't send usable messages (like texts) faster than light; it preserves physics laws and avoids paradoxes like time travel loops. - Black Hole Connections: Wormholes might relate to black holes, where information could be scrambled and redistributed via these tunnels, tying into the black hole information paradox. - Challenges and Evidence: No real wormholes observed yet; they're theoretical from Einstein's relativity. Quantum simulations (e.g., 2022 experiments) mimic wormhole effects for info teleportation, but not actual space tunnels. - Implications for Universe: If true, wormholes could explain cosmic connectivity, blending gravity and quantum mechanics, potentially revolutionizing how we view information flow in the universe.
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<p>Feb 5, 2026</p>	<p>Completed research for three topics.</p> <ul style="list-style-type: none"> - Explain that while they didn't create a physical tunnel in space, they successfully sent information between entangled systems in a way that mathematically matches a wormhole. <ul style="list-style-type: none"> → Scientists used Google's Sycamore quantum processor to run a small, controlled experiment. They did not create a real, physical wormhole tunnel in actual space — no spacetime was bent, and no shortcut through the universe was made. Instead, they built a tiny quantum system using only 9 qubits (quantum bits) that was carefully designed to follow the same mathematics as a traversable wormhole in certain theoretical models of gravity. → The experiment used two groups of entangled qubits to represent the two "mouths" (ends) of a wormhole. They injected a small piece of quantum information (a specific quantum state) into one group of qubits. → They applied a special quantum operation (acting like the "negative energy" needed to keep a wormhole open in theory). The quantum information then appeared in the other group of qubits through a process called quantum teleportation. This
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teleportation happened using only standard quantum entanglement and measurements — no information actually traveled faster than light.

- When viewed through the lens of gravity and holography (AdS/CFT correspondence), the exact same process mathematically matched what would happen if the information had passed through a short-lived, microscopic traversable wormhole.
- In other words: Quantum physics description → regular entanglement-based teleportation Gravity description → information traveling through a wormhole bridge The math was identical in both pictures, showing entanglement and wormholes can describe the same event. This was a major proof-of-concept for testing quantum gravity ideas in a real lab, but it remained entirely inside a quantum computer — no actual cosmic structure was involved.
- The result supports the bigger ER=EPR idea: tiny wormholes could be the hidden reason behind "instant" quantum connections, even though the experiment itself was a simulation of the math, not a real wormhole.

The Time Travel Problem

- Time Dilation: Explain how moving one end of a wormhole at high speeds makes time move slower at that end.
 - Wormhole Setup: A wormhole has two ends (called mouths). At first, both mouths are in the same location, and time passes at the same rate for clocks at both ends — they're perfectly synchronized.
 - Moving One Mouth: One mouth (Mouth B) is moved away at very high speed (close to the speed of light) on a spaceship, while the other mouth (Mouth A) stays still (e.g., on Earth).
 - Special Relativity Time Dilation: According to Einstein's special relativity, time slows down for objects moving at high speeds compared to stationary observers. This is the same effect seen in the twin paradox.
 - Effect on the Moving Mouth: While Mouth B is traveling fast:
 - ◆ Clocks at Mouth B tick much slower.
 - ◆ Much less time passes at Mouth B (e.g., only a few years might pass there).
 - ◆ A lot more time passes at the stationary Mouth A (e.g., decades or centuries).
 - Bringing Mouth B Back: After the trip, Mouth B is returned to the same location as Mouth A. Now:
 - ◆ Mouth B's clock shows far less time has passed (it's "younger").
 - ◆ Mouth A's clock shows much more time has passed (it's "older").
 - ◆ The two mouths are now out of sync in time.
 - Time Through the Wormhole: The wormhole connects the two mouths directly:

- ◆ Time is always the same at both mouths when viewed from inside the tunnel (clocks match if you step through).

- ◆ But because of the outside time difference, going through the wormhole can jump you forward or backward in the universe's timeline.

- Forward Time Travel Example: Stepping from the "younger" Mouth B into Mouth A takes you to a much later time in the future (you jump forward in time).

- Backward Time Travel Possibility: Stepping from the "older" Mouth A into Mouth B could take you to an earlier time (backward in time), turning the wormhole into a potential time machine.

- Why Time Moves Slower at the Moving End: High speed causes relativistic time dilation — the faster you move, the slower time passes for you compared to someone standing still. The moving mouth experiences less proper time.

- Key Limitations:

- ◆ This is purely theoretical — no wormholes exist, and creating/moving one would require exotic matter and impossible technology.

- ◆ Backward time travel could create paradoxes (e.g., changing the past), so many physicists believe nature prevents stable time-travel wormholes (perhaps they collapse or become unstable).

- In summary: Moving one end of a wormhole at near-light speed makes time pass much slower at that moving end due to time dilation, creating a large time difference between the two mouths and potentially allowing time jumps when traveling through the wormhole.

- The Time Machine: Describe how entering one end and exiting the other could result in "arriving before you left."

- The Setup: A wormhole has two mouths (ends). One mouth (Mouth A) stays stationary (e.g., on Earth). The other mouth (Mouth B) is moved away at near-light speed on a spaceship, travels for a while, then returns to the same location as Mouth A.

- Time Dilation Creates the Difference: While Mouth B travels at high speed: Time passes much slower at Mouth B due to special relativistic time dilation. When Mouth B returns, its clock shows far less time has passed (e.g., only 1 year). Mouth A's clock (stationary) shows much more time has passed (e.g., 50 years).

- The Two Mouths Now Point to Different Times: After the trip: Mouth A is connected to the "present" time (50 years later). Mouth B is still connected to the "past" time (only 1 year after

the start). The wormhole tunnel links these two different moments in time.

- Entering One End and Exiting the Other: You step into Mouth A (the "older" end, now in the year 2075). You travel through the short wormhole tunnel. You exit from Mouth B (the "younger" end, which is still in the year 2026).
 - Result: Arriving Before You Left: You started your journey in 2075 at Mouth A. You arrive at Mouth B in 2026 — a time 49 years before you left. From the universe's perspective, you have traveled backward in time. You have effectively "arrived before you left" — you are now in the past relative to when you entered the wormhole.
 - The Reverse Direction (Forward in Time): If you step into Mouth B (2026) and exit from Mouth A (2075), you jump forward in time — you arrive 49 years after you left.
 - Key Physics Note: The wormhole itself doesn't let you go faster than light or break local rules. The backward time travel comes from the large time difference between the two mouths caused by relativistic time dilation during the high-speed trip.
 - Important Caveats: This is purely theoretical — no wormholes exist, and creating one would require exotic matter to keep it open. Backward time travel could lead to paradoxes (e.g., preventing your own birth), so many physicists think stable time-travel wormholes are impossible or nature would prevent them (e.g., by making the wormhole collapse). This idea was first seriously explored by physicists like Kip Thorne in the 1980s when studying traversable wormholes.
- The Paradox Wall: Discuss the Grandfather Paradox and why many physicists (like Stephen Hawking) believed the universe has built-in "rules" to prevent time travel.
- The Grandfather Paradox Explained: This is a famous thought experiment about time travel. Imagine you go back in time and kill your own grandfather before he has children (so before your parent is born). If you succeed, then you were never born — so how could you go back in time to kill him in the first place? This creates a logical loop or contradiction: your actions in the past prevent your own existence, but your existence is needed to perform those actions.
 - Why It's a "Paradox": It shows how backward time travel could break cause-and-effect (causality). If the past can be changed, it leads to impossible situations where events both happen and don't happen at the same time. This challenges the consistency of the universe's timeline.
 - Connection to Time Travel Methods: The paradox often comes up with ideas like wormholes turned into time machines (by moving one end at high speeds). If you could step through to the past, you might cause changes that erase your own journey, creating the paradox.
 - Physicists' Views on Prevention: Many scientists, including Stephen Hawking, argue that the universe must have "built-in rules" to stop such paradoxes from happening. They believe

physics protects the timeline to keep reality logical and consistent.

- Stephen Hawking's Chronology Protection Conjecture: In 1992, Hawking proposed this idea: "The laws of physics do not allow the appearance of closed timelike curves" (loops in spacetime that let you return to your own past). He called it the "Chronology Protection Conjecture" — basically, the universe acts like a "cosmic censor" to prevent time travel and avoid paradoxes like the grandfather one.
 - Why Hawking Believed This: Hawking thought that if time travel were possible, we'd see tourists from the future or other signs, but we don't (his famous "time traveler party" experiment in 2009 invited future people but no one showed up). He also pointed to quantum effects: near a potential time machine (like a wormhole), vacuum fluctuations or infinite energy densities would build up and destroy it before it could be used.
 - Other Physicists' Supporting Ideas: Quantum Gravity Effects: Theorists like Kip Thorne (who studied traversable wormholes) suggest that quantum mechanics might cause wormholes to collapse or become unstable when they allow backward time travel, preventing paradoxes.
 - Hawking Radiation and Black Holes: In black hole physics (related to some wormhole models), information and energy issues (like the black hole information paradox) imply that time loops can't form without violating fundamental laws.
 - Novikov Self-Consistency Principle: Some, like Igor Novikov, argue that if time travel happens, events must be self-consistent — you couldn't kill your grandfather because something would always prevent it (e.g., the gun jams). But Hawking and others see this as too contrived and prefer outright prevention.
 - Evidence and Arguments Against Time Travel: No observed time travelers or paradoxes in real life.
 - Mathematical models show that creating a time machine requires exotic matter or conditions that lead to instabilities (e.g., infinite blue-shifted radiation flooding the wormhole). In quantum field theory, attempting to form closed timelike curves often results in divergences (infinite values) that signal impossibility.
 - Counterarguments and Open Questions: Not all physicists agree — some think multiple timelines (like in the many-worlds interpretation of quantum mechanics) could resolve paradoxes by branching into new realities. Others explore if limited time travel (only to the future) is okay. But Hawking's view remains influential: the universe likely has a "paradox wall" enforced by physics to keep time flowing forward safely.
- Discuss entropy reversal. Some 2025 theories suggest that because wormholes might flip the "arrow of time" (entropy), a traveler could theoretically arrive younger than when they left.
- Entropy as the Arrow of Time: Entropy measures disorder in a system. The second law of thermodynamics says entropy in a closed system always increases (or stays the same) over time. This increase defines the "arrow of time" — why we experience time flowing forward (e.g., eggs break but never un-break, memories form but don't erase naturally).
 - Normal Time Travel Issues with Entropy: Backward time travel would require decreasing entropy (reversing disorder), which violates the second law. A traveler going to the past would need to "un-scramble" the universe's increasing disorder, creating huge thermodynamic problems.

- 2025 Wormhole Theories on Entropy Flip: Some speculative papers and articles from around 2025 explored traversable wormholes where the physics to keep the wormhole open (e.g., exotic negative energy or quantum interactions at the throat/event horizon) might push the system's entropy backward locally inside the tunnel. This could theoretically flip the arrow of time direction within the wormhole itself.
- How the Flip Might Work: In these models, making a wormhole traversable involves processes that "rewind" the event horizon or internal geometry, decreasing local entropy. Since entropy decrease = reversed time arrow, time inside the wormhole could run backward relative to the outside universe.
- Traveler Arriving Younger: If the wormhole's interior truly reverses the entropy arrow:
 - ◆ Biological processes (aging, cell decay) tied to entropy increase would reverse or slow dramatically.
 - ◆ The traveler might experience time running backward, emerging on the other side biologically younger than when they entered (e.g., fewer wrinkles, less cellular damage).
 - ◆ This would be like a local "rewind" for the traveler's body and clock, while the outside universe keeps moving forward normally.
- Key Example from Speculative 2025 Ideas: One popular write-up described how interactions stabilizing the wormhole could decrease entropy by shifting the horizon backward. Flipping entropy's direction implies reversed time flow inside, potentially letting the traveler exit younger — a thermodynamic "anti-aging" effect via cosmic shortcut.
- Major Caveats and Counter-Theories (Late 2025 Research): Most rigorous 2025 papers (e.g., on black hole thermodynamics, wormholes, and semiclassical gravity) conclude true universal entropy reversal is impossible in a single connected universe. Wormholes/black holes can only redistribute entropy (move it around between matter, radiation, gravity), not genuinely decrease the total or reverse the global arrow of time.
- No Genuine Reversal Allowed: Constraints from holography, quantum mechanics, and horizon area bounds show any apparent local entropy drop gets offset (e.g., by increased correlations or exotic matter costs). Macroscopic wormholes would collapse or require impossible conditions, preventing real entropy reversal or age-reversing travel.
- Bottom Line: While fringe 2025 theories toy with wormholes flipping entropy locally to reverse time (and make travelers younger), mainstream physics views this as highly constrained or impossible without breaking fundamental laws. It stays in the realm of fun speculation, not established science — no paradoxes resolved, no time-reversed travelers confirmed.

Why Is It Still A Theory

- Looking Like Black Holes: Explain that from the outside, a wormhole might look exactly like a black hole, making them very hard to spot.
 - Both warp space the same way: Black holes and wormholes bend spacetime hugely due to extreme gravity (from Einstein's general relativity). This makes their outside appearance very

similar — both have strong gravity that pulls things in and traps light.

- Event horizon similarity: Many wormhole models (especially non-traversable or simple ones) have an event horizon — a point-of-no-return boundary just like a black hole. Anything getting too close can't escape, so from outside, it looks dark in the center with no light coming out.
- Accretion disk and glow: Matter (gas, dust) often swirls around both in a hot, glowing disk. This disk heats up and shines brightly (X-rays, radio waves), making wormholes look like the bright rings we see around black holes (like in the famous Event Horizon Telescope images of M87 or Sagittarius A).
- Research showing near-identical looks: Studies (like from Sofia University in 2022 and others up to 2024-2025) use computer models to simulate wormhole images. They find:
 - The radiation from swirling matter around a wormhole is almost impossible to tell apart from a black hole's.
 - Direct and indirect images look remarkably similar — same dark center, same bright ring.
 - Gravitational lensing effects: Both bend light from background stars/galaxies in similar ways (microlensing or strong lensing). A wormhole might magnify distant objects just like a black hole, so observers see the same distorted views.
 - Spherical appearance: Wormholes aren't "holes" like in cartoons — from outside, the mouth often looks like a spherical object (a ball of warped space), similar to how black holes appear as dark spheres surrounded by light.
 - Why they're hard to spot: We've imaged a few black holes, but nothing stands out as "not a black hole." Subtle differences (like slight changes in polarization, light intensity, radii, or photon orbits) might exist, but current telescopes aren't precise enough to catch them easily. Wormholes might need exotic matter to stay open, which could make them even rarer or change tiny details we haven't detected yet.
 - Possible ways to tell them apart (in theory): Weird gravitational waves if something orbits or falls in. Different behavior for light from the "other side" (if traversable). But so far, no clear signs — many "black holes" could secretly be wormholes, or vice versa.
- Hunting for "Echoes": Discuss how we use gravitational wave detectors to listen for "echoes" in space that would prove a wormhole is there.
 - What Are Gravitational Waves?: Gravitational waves are like ripples in the fabric of space caused by huge events, such as two black holes smashing together. These waves travel across the universe at the speed of light and can be detected on Earth.
 - How We Detect Them: We use special machines called gravitational wave detectors, like LIGO (in the USA) and Virgo

(in Europe). These are giant laser setups (kilometers long) that spot tiny stretches and squeezes in space when a wave passes by — changes as small as a fraction of an atom's width!

- The "Ringdown" Phase: When two black holes merge, the new black hole wobbles and settles down, sending out a fading "ringdown" signal in the gravitational waves. For a real black hole, this ringdown dies out quickly because the event horizon swallows up any leftover vibrations.
- What Are "Echoes"?: If instead of a black hole, the merger involves a wormhole (or something like it), the waves might not get trapped. Wormholes don't have event horizons, so vibrations could bounce back and forth inside the wormhole throat, creating repeated "echoes". Like shouting in a tunnel and hearing your voice repeat.
- Why Echoes Prove Wormholes: Normal black holes don't produce echoes because waves fall in and never come out. But wormholes (especially traversable or "Kerr-like" ones) could reflect waves, leading to a series of delayed pulses after the main signal. Spotting these echoes in data would be strong evidence for wormholes, not black holes.
- Hunting with Detectors: Scientists analyze LIGO/Virgo data for unusual patterns: Look for the main merger wave. Then check the ringdown for extra blips or repeats (echoes) that come at regular intervals (e.g., every few milliseconds). Use computer models to simulate what wormhole echoes would look like and compare to real signals.
- Real-World Examples: Some detected waves, like GW190521 in 2019, have been hypothesized as possible wormhole echoes. A 2025 paper suggests it might be a single echo pulse from a wormhole linking to another universe, rather than a full black hole merger.
- Challenges in Spotting Them: Echoes might be faint or hidden in noise, so we need better detectors (like future upgrades to LIGO or new ones like LISA in space). Also, wormholes are rare and theoretical, so most signals are probably from black holes.
- Math vs. Reality: Summarize that while the math says "yes," we lack the technology and the "exotic matter" to prove it—or build one—right now.
 - Mathematical Possibility - Einstein's general relativity equations fully allow wormhole solutions (Einstein-Rosen bridges, Morris-Thorne traversable wormholes, etc.).
 - The math is consistent and well-established — wormholes are not forbidden by known physics. Quantum extensions (ER=EPR, AdS/CFT holography) also support wormholes as valid theoretical objects. Lab simulations (e.g., 2022 Google quantum processor experiment) perfectly match the wormhole mathematics in simplified models.

	<ul style="list-style-type: none"> → Reality Check: No Evidence Yet - No wormhole has ever been observed — no direct detection, no indirect signs in astronomical data. All known candidates (black hole images, gravitational wave mergers) are explained by black holes, not wormholes. We have zero experimental confirmation that wormholes exist in the real universe. → The Critical Missing Ingredient: Exotic Matter - Traversable wormholes require matter with negative energy density (exotic matter) to keep the throat open and prevent collapse. → Normal matter has positive energy; exotic matter violates classical energy conditions (weak/null energy conditions). Tiny negative energy exists in quantum effects (Casimir effect, squeezed vacuum states), but the amounts are far too small — by many orders of magnitude — to stabilize even a microscopic wormhole. No known way exists to produce, collect, or control macroscopic quantities of exotic matter. → Technological and Practical Barriers - Creating a wormhole would require manipulating gravity and quantum fields at extreme scales — far beyond current or near-future technology. → Stabilizing a wormhole long enough for anything (light, particles, humans) to pass through is currently impossible. Moving one mouth at relativistic speeds (to create time dilation effects) demands enormous energy and precision we cannot achieve. Quantum effects (e.g., chronology protection, vacuum fluctuations) are predicted to destabilize or destroy potential time-travel wormholes. → Current Status (as of February 2026) The equations say "yes" — wormholes are theoretically allowed. Reality says "not yet". We lack: <ul style="list-style-type: none"> ◆ Exotic matter in usable quantities ◆ Technology to engineer or stabilize wormholes ◆ Any observational proof they exist naturally → Wormholes remain a fascinating mathematical possibility, but building, finding, or using one is science fiction for the foreseeable future. - Explain that in 2026, we are looking for "Wormhole Shadows" using the Event Horizon Telescope. We can now potentially distinguish them from black holes by looking for specific polarized light patterns from surrounding heated material <ul style="list-style-type: none"> → Current Focus in 2026: Astronomers using the Event Horizon Telescope (EHT) are actively analyzing high-resolution data from recent campaigns (including 2021-2025 observations released and expanded in 2025-2026) to search for potential wormhole "shadows" — dark central regions surrounded by bright rings from heated plasma, similar to black hole shadows. → Why Wormholes Could Mimic Black Hole Shadows: Theoretical models show that many wormhole spacetimes (especially
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rotating or traversable ones with plasma disks) produce shadows almost identical in size, shape, and overall appearance to Kerr black holes imaged by EHT (e.g., M87 and Sgr A). The strong gravity bends light paths in comparable ways, creating a dark core and glowing ring.

- The Key Discriminator: Polarized Light Patterns: The EHT measures polarized light (the vibration direction of radio waves), which reveals magnetic field structures in the surrounding hot material (accretion disks and jets).
- Black holes typically show organized, spiraling, or flipping polarization patterns (e.g., unexpected direction flips in M87 between 2017-2021; twisting fields and opposite rotation directions in OJ 287 from 2026 data).
- Wormholes are predicted to produce subtle differences, such as asymmetric whorls, unusual polarization rotations, inverted or missing spiral patterns, extra magnification spikes from light paths through the throat, or deviations in photon ring structure due to no event horizon.
- How Detection Works in Practice: Compare real EHT polarized images (from multi-year campaigns) to computer simulations of wormhole shadows with plasma effects. Look for mismatches in polarization signatures — e.g., deviations from expected Kerr black hole behavior in magnetic field geometry or light polarization swings.
- Recent 2025–2026 EHT upgrades (better global coverage, higher data rates, improved algorithms) enhance sensitivity to these fine details in polarized emission.
- Recent Relevant EHT Results (2025–2026):
 - ◆ M87: Dynamic polarization flips and evolving magnetic fields observed over years, confirming variability but matching black hole models so far.
 - ◆ OJ 287: First spatially resolved polarized views show shock waves causing opposite-direction polarization rotations — explained by binary black hole dynamics, but theorists note wormhole models could produce similar exotic patterns.
- Ongoing analysis: No confirmed wormhole signatures yet; all major targets align with black hole expectations, but subtle anomalies keep the search active.
- Challenges and Outlook: Differences are often small (a few percent in some models), requiring precise data and multiple epochs to rule out noise or plasma variability. Future EHT campaigns (e.g., rapid observations planned for 2026) and next-gen upgrades aim to resolve finer polarization details that could distinguish wormholes.
- If a clear deviation appears (e.g., polarization patterns inconsistent with black holes but matching wormhole

	predictions), it could provide the first observational hint of real wormholes.
Feb 13, 2026	Formed plan and plotted required materials for trifold. Materialisers Forers trifolders: <ul style="list-style-type: none"><input type="checkbox"/> Trifold<input type="checkbox"/> Foam balls<input type="checkbox"/> Poster paper<input type="checkbox"/> Black and blue/purple paint<input type="checkbox"/> White paint<input type="checkbox"/> Two semi sphere ball<input type="checkbox"/> Foam poster<input type="checkbox"/> White poster paper