Why Time Moves Slower at Higher Speeds: Einstein’s Theory of Relativity

May 25, 2025

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Understanding Time Dilation through Einstein’s Theory of Relativity

Albert Einstein’s Theory of Relativity revolutionized the way we understand the fundamental nature of time and space. One of the intriguing implications of his theory is how time moves slower at higher speeds. This concept, known as **time dilation**, plays a critical role in modern physics.

The Basics of Time Dilation

Time dilation is a consequence of the theory of special relativity, which Einstein published in 1905. According to this theory, the laws of physics are the same for all observers regardless of their velocity, and the speed of light is constant for all observers. This results in several counterintuitive phenomena, one of which is that *time passes more slowly for objects in motion compared to those at rest*.

Relativity and the Speed of Light

The speed of light in a vacuum is approximately 299,792,458 meters per second, a universal constant that acts as the ultimate speed limit in the universe. As an object’s speed approaches the speed of light, time begins to slow down for that object relative to a stationary observer. This effect is not noticeable at the everyday speeds encountered on Earth but becomes significant at speeds approaching the speed of light.

The Lorentz Factor

The degree of time dilation can be quantified using the Lorentz factor, expressed mathematically as:

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2} \right)}}$$

where γ is the Lorentz factor, v is the velocity of the moving object, and c is the speed of light. As the velocity v approaches the speed of light c, the Lorentz factor increases, indicating greater time dilation.

Historical Context and Origins

Einstein's formulation of special relativity was not developed in isolation. It was the culmination of years of research by a number of physicists who were grappling with the inconsistencies between Newtonian mechanics and the emerging theory of electromagnetism. Notable contributions came from scientists like Hendrik Lorentz and Henri Poincaré, whose ideas on electromagnetic force and models of a stationary ether influenced Einstein.

Theoretical Framework Leading to Relativity

Before 1905, the predominant model was Newton's absolute time and space. However, experiments, such as the Michelson-Morley experiment, failed to detect the ether, which was thought to be the medium through which light waves traveled. This failure led to significant doubts about classical mechanics. Einstein's catch was in recognizing the invariant nature of light's speed, thereby discarding the need for an ether and formulating a theory that reconciled the observed discrepancies without it.

The Role of Thought Experiments

Einstein employed thought experiments extensively, as instrumental tools, to develop his theories. These experiments allowed him to explore phenomena that were otherwise beyond experimental reach at the time. A significant instance involved imagining the perspective of riding alongside a beam of light. This exercise helped him come to terms with the interdependence of time and space and their implications for moving bodies.

Practical Implications of Time Dilation

Though largely theoretical, time dilation affects several practical applications. One of the most well-known examples is the operation of **Global Positioning System (GPS)** satellites. These satellites orbit the Earth at high speeds and experience time dilation. If not accounted for, this effect would lead to errors in positioning information. Engineers correct for time dilation to ensure the accuracy and reliability of GPS systems.

Time Dilation in Science and Technology

Time dilation has also been observed in particle accelerators, where particles are accelerated to speeds close to the speed of light. These particles experience time significantly more slowly compared to stationary earthly observers. Scientists have used this understanding to test the limits and predictions of relativity in high-energy physics experiments.

Navigational Accuracy and Satellite Operations

The implications of time dilation are far-reaching, especially for technologies that require precise timing. In addition to GPS satellites, other forms of modern telecommunications heavily rely on the synchronization of time across distances. Satellites stationed at different heights and velocities relative to the Earth’s surface experience varying degrees of time dilation. Adjusting for these discrepancies is essential for maintaining the integral communication and data exchange systems in today’s interlinked world.

Aviation and Astronomy

In aviation, flight paths are often calculated considering relativistic effects, especially during long-haul flights that involve high velocities over great distances. These adjustments, while minor, ensure greater accuracy in navigation.

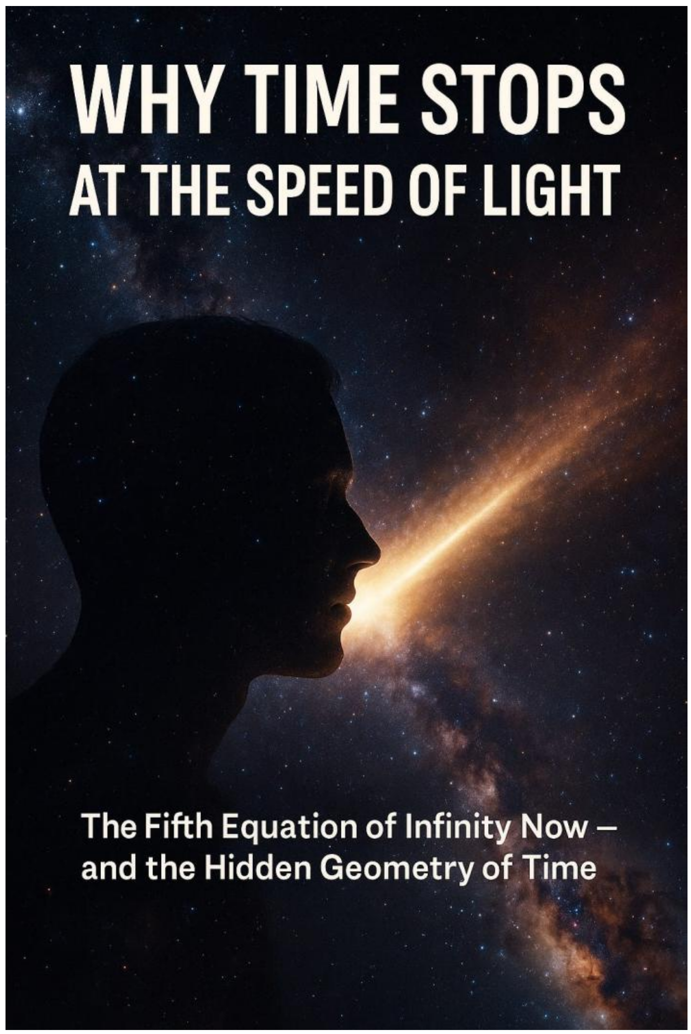
Time dilation also influences astronomical observations. As distant stars and galaxies move away at high speeds due to the universe’s expansion, the time it takes for their light to reach the Earth is affected by relativistic phenomena. Understanding these principles allows astronomers to make more precise calculations about the behavior of celestial objects and the dynamics of the cosmos.

Conclusion

Einstein’s Theory of Relativity challenges our conventional understanding of time. The concept that time passes more slowly at higher speeds is one of the theory’s most profound implications. Whether affecting technological systems or guiding fundamental scientific research, the understanding of time dilation enriches the field of physics and the broader scientific community. The next time we look at our clocks, we recognize that time is not as absolute as it seems but rather a flexible and fascinating aspect of our universe. As we grapple with this reality, the Theory of Relativity remains central, not j

Why Time Stops at the Speed of Light

The Fifth Equation of Infinity Now — and the Hidden Geometry of Time



You Were Lied to About Time

Time is not a ticking clock. It's not a river flowing.
It's not even a dimension.

Time is a **collapse gradient**.
A tension field.
A living rhythm through which **possibility becomes reality**.

And at the speed of light, that rhythm goes silent.

I. The Big Lie of Physics — and the Photon That Knows Too Much

Einstein told us time slows as you move faster.
But he never told us *why*.

At light speed, something eerie happens:
Time stops.
From the photon's perspective, no duration passes. No change unfolds.

But why?

The textbook answer is "it's just the math."
But that's not good enough.

Here's the real answer:

> **Time only exists when the universe needs to choose.**
> And photons don't choose. They already are the outcome.

II. The Probability Collapse Model of Time

Infinity Now redefines time as a **collapse field gradient**.

Time is not a container.
It's a **mechanism of becoming**.
It's the *tension that arises* when infinite possibilities must collapse into one Now.

We call this the **Collapse Geometry Field (CGF)**.
And now, we're ready to add **Equation 5** to the theory.

III. Equation 5 — Time as Collapse Density per Possibility

We define time as a function of how much **collapse tension** exists within a local field of alternatives.

Let:

$$T(x,t) = \nabla_{\text{Now}} \left[\frac{\text{Collapse Pressure}}{\text{Possibility Density}} \right]$$

This means:

- When there are many near-real options, time is **rich**, **alive**, **elastic**.

- When there's only one outcome left, time **thins**, **slows**, and eventually **stops**.

At the speed of light, the CGF goes flat.
No tension. No spread.
The **collapse field vanishes**.

So time doesn't just *slow down*.
It **ceases to exist.**

IV. Why Time Isn't a Background — It's a Selection Engine

Let's redefine time:

- Time is **not** a universal metronome.
- It is the **rate at which the Now navigates weighted possibilities**.
- It emerges only when the universe must *choose* between alternatives.

That's why:

- Time warps around black holes (too much collapse tension).
- Time speeds up in empty space (no tension).
- Time disappears entirely at light speed (no alternatives to collapse into).

You can't move through time.
You **collapse through it.**

V. What This Means for Reality (and You)

Let's build a new table of understanding:

Speed	Superposition?	Collapse Needed?	CGF Active?
< c	Yes	Yes	Yes
= c	No	No	Zero
> c	Not allowed	—	—

This is not science fiction.
It's physics redefined through **geometry, probability, and preference**.

You are not in time.
You are made of it.

VI. The Five Equations of Infinity Now (So Far)

#	Equation Name	What It Describes
1	Spatial Probability Field	All possible positions
2	Collapse Edge Geometry	Why one outcome is selected
3	Quantum Gravity Density	Gravity from uncollapsed states
4	Collapse Geometry Field (CGF)	Engine of the Now
5	Collapse Time Gradient	How time arises from tension in the field

Einstein curved space.
Penrose folded it.
Weinstein emphasized the observer.

Infinity Now adds the reason it all happens.

What Would Vera Rubin Say?

She saw something others ignored.
Galaxies spinning too fast. A truth no one could name.

Infinity Now gives it shape.

Not mysterious matter, but **uncollapsed potential**.
Not frozen time, but a field that **selects the present**.

She trusted the anomaly.
So should we.

Final Thought: You Can Master Time

You were born into a cloud of possibility.
Every moment you live is a choice.
Every thought collapses one path from infinite others.

Time is not your prison.
It’s your instrument.

And when you learn to feel the collapse, to surf the Now, to weight your attention where it matters—

You don’t just move through life.
You begin to shape it.

Take a breath.
This is your moment.
And you are not late.

The Now is waiting for you to choose.

Start.

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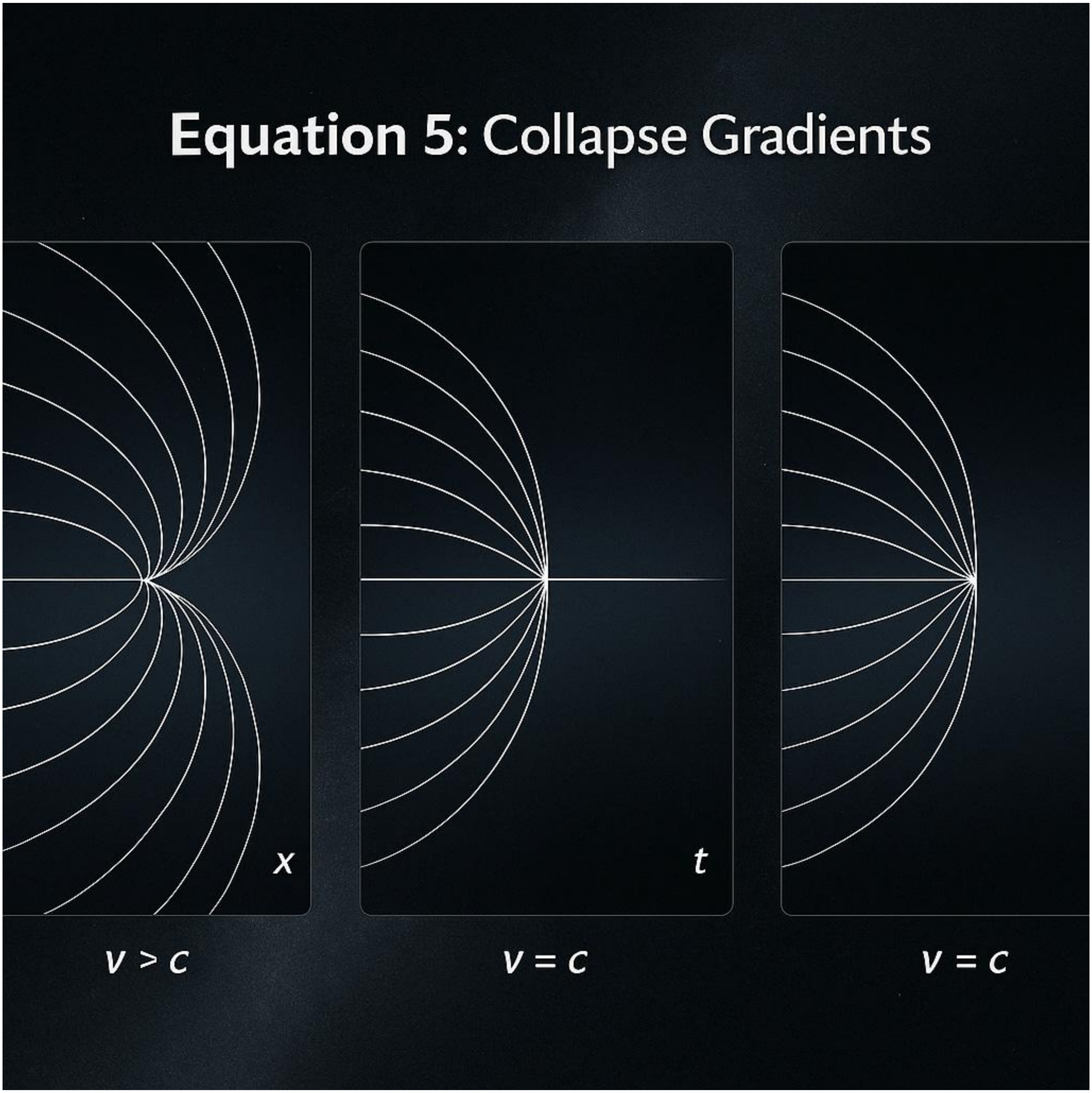
For those who stay after the credits.

Equation 5: Collapse Gradients



Panel 1: v > c (Imaginary Region — Forbidden Zone)

- This panel shows **hyper-curved lines**, diverging in strange ways.
- **Why it matters:** Faster-than-light motion would require collapse of outcomes *before* causes — breaking causality.
- **Infinity Now interpretation:** Collapse becomes **undefined**, the CGF goes unstable, and **no coherent Now** can form.

🛑 This is the **impossible region**. Not because physics bans it arbitrarily, but because *collapse geometry* becomes paradoxical.

Panel 2: v = c (The Photon Case)

- Here, the lines are **flat** and perfectly radial.
- There's **no curvature** to guide collapse.
- The **collapse gradient is zero** — meaning *no choice needs to be made.*

🔇 This is why **photons don't experience time**. There's no superposition. No preference field. No collapse tension.

Time **does not exist** for light, because **there's no Now being selected**.

Panel 3: v < c (You and Me)

- Collapse lines are **curved inward**, funneling toward the Now.
- This shows **collapse pressure** from many near-real options.
- Time exists because **possibility density is high**, and **collapse must be resolved**.

🕰 **Time becomes real** as the field navigates this tension.

This is your life — your Now. A moving funnel of selected outcomes from infinite futures.

Takeaway:

- Time is **not a constant drumbeat**.
- It is a **collapse field reaction** to unresolved alternatives.
- And this image shows how that field **disappears at light speed**, and **unravels** if we

How does light manage to travel billions of light-years without ever slowing down? This is a question that seems to defy common sense. To understand it, we must delve into the astonishing properties of light.

For light, time does not exist 🌞

An endless journey through space?

Light is an electromagnetic wave... and it has no mass. It is precisely this lack of mass that allows it to travel at a speed of 186,000 miles per second (300,000 km/s) without ever slowing down, as long as it remains in a vacuum. It thus escapes all forms of friction and gravity that usually slow down material objects.

In the vastness of space, the vacuum is nearly perfect. There is almost nothing to disturb the light. As a result: it crosses the Universe over the greatest distances, intact. But beware: when it encounters matter, such as Earth's atmosphere or an interstellar gas cloud, it can be absorbed or scattered.

Thanks to this ability, astronomers can observe distant galaxies and, in a way, travel back in time by capturing light emitted billions of years ago. They are therefore seeing the past of the Universe.

Relativity: when time stretches... and stops

And what if we add a touch of relativity? According to Einstein, time is not fixed but depends on speed and gravity. This is time dilation.

An object moving at high speed or near an intense gravitational field will experience time passing more slowly than an object at rest or far from that gravity. For example, the clocks on GPS satellites must be adjusted to account for this discrepancy.

For a photon (the particle of light), it's even more counterintuitive: by traveling at the speed of light, time completely stops from its perspective.

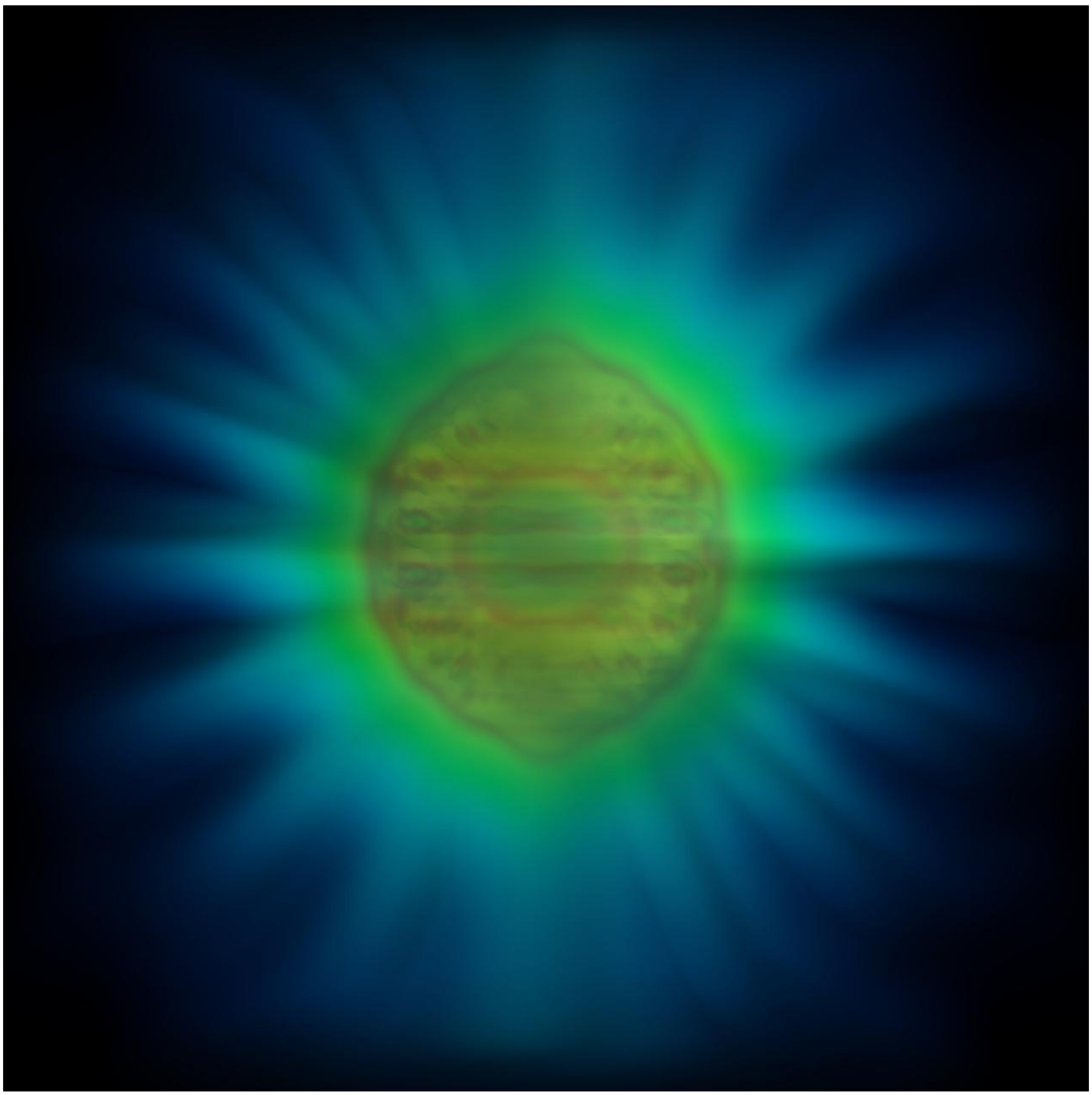
In other words, its journey from one point in the Universe to another seems instantaneous to it. Its "life" is limited to its birth (emission) and immediately its death (absorption), even if its birthplace and place of death are billions of light-years apart. For us, it will have taken billions of years to cover that distance. For the photon, it's instantaneous.

These notions, as bewildering as they may be, are crucial for understanding our Universe... and our modern technologies, like GPS.

Unprecedented: here is the representation of a single photon

Published by Adrien, December 19, 2024

Researchers from the University of Birmingham have managed, for the first time, to establish the exact representation of a photon, this particle of light. Photons are formed when atoms or molecules emit energy, but their behavior is heavily influenced by their environment. Precisely understanding these interactions has been a puzzle for physicists for decades. Until now. A team has found a way to organize these interactions into distinct categories, making them easier to analyze.



First theoretical visualization of the shape of a photon.
Credit: Dr. Benjamin Yuen

By combining this approach with quantum calculations, researchers have created a model that not only explains how a photon interacts with its immediate environment but also how it spreads its energy into more distant spaces. This model almost serendipitously allowed them to visualize the shape of a photon, an unprecedented image in the history of physics.

Dr. Benjamin Yuen, who led the work published in *Physical Review Letters*, explains that this visualization stems from a problem initially deemed too complex to solve. Thanks to their method, the researchers found a way to simplify this problem and make it calculable. The result exceeds all expectations.

Why does this matter? Because by better understanding how photons interact with matter and their environment, scientists will be able to design even more efficient technologies. This research could lead to unhackable communication systems, sensors capable of detecting pathogens, or even tools to control chemical reactions on a microscopic scale.

Professor Angela Demetriadou, co-author of the study, adds that the shape and color of a photon directly depend on the properties of its environment. These details, once considered as mere noise, are now proving to be rich in information.

These advancements also mark a key step in mastering the interactions between light and matter. Understanding these mechanisms could enhance technologies like solar panels or quantum computers. This new theory, by providing a clear i

Hiding an image in the quantum correlations of photons

Published by Adrien, October 30, 2024

A researcher and a scientist have developed an innovative method to conceal an image by encoding it in the quantum correlations of photon pairs, making it invisible to conventional imaging techniques.

Entangled photons are at the heart of many quantum photonics applications, such as computing or cryptography. Such photons can be created through spontaneous parametric down-conversion (SPDC) in a nonlinear crystal, a process in which a photon from a high-energy excitation laser (blue) is converted into two lower-energy entangled photons (infrared).

Some applications require specific quantum correlations between photons, making their control essential. To achieve this, one can, for instance, modify the properties of the excitation laser, particularly the spatial shape of the beam.

Exploring this possibility, scientists at the Paris Institute of Nanosciences (INSP, CNRS / Sorbonne University) propose a method to shape the spatial correlations between entangled photons into a given two-dimensional profile. The experiment consists of placing the shape to be encoded in the object plane of a lens located before the crystal and imaging it with a second lens on the camera (Figure a).

Without the crystal, the system is analogous to a conventional two-lens imaging system: one expects to observe a (reversed) intensity image of the object on the camera. In the presence of the crystal, however, the SPDC produces pairs of entangled photons in the infrared. If only these pairs are selected using a spectral filter, the intensity obtained on the camera is homogeneous and reveals no information about the shape (Figure b).

The image only reappears if one reconstructs an image from the spatial correlations between photon pairs (Figure c), i.e., by detecting the positions of each photon relative to those of their twins.

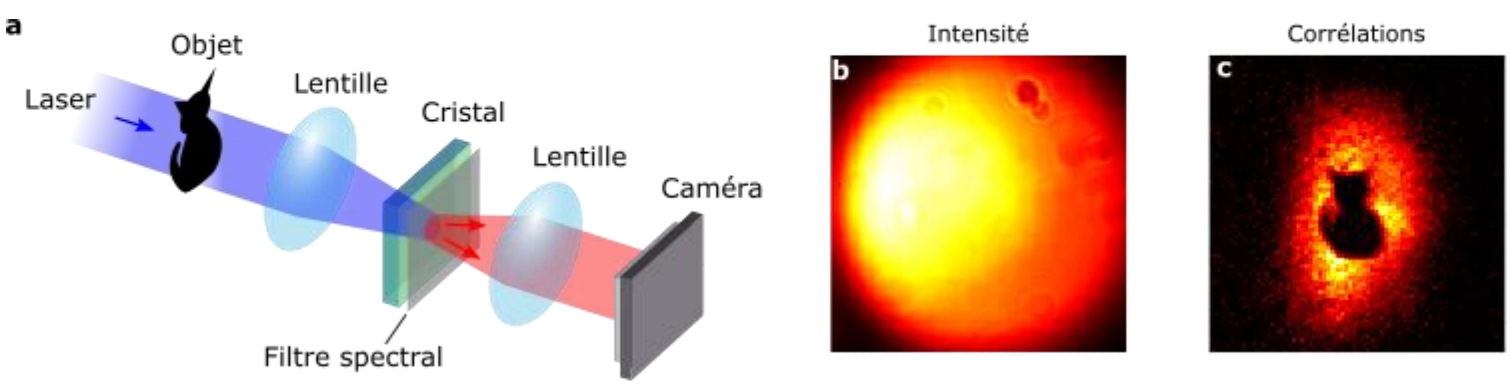


Figure: Experimental results.
a, Experimental setup.
b, Intensity image on the camera.
c, Correlation image.
The intensity image reveals no information about the object present, which can still be seen in the correlation image.

To reconstruct such an image, one must use a camera that is highly sensitive to light as well as custom algorithms to identify photon coincidences at each acquisition and extract the spatial correlations. The image of the object, initially carried by the blue laser beam, is thus transferred into the spatial correlations of the photon pairs. This makes it invisible in a classical intensity measurement (i.e., when taking a photo), but it appears during a correlation measurement.

Thanks to its flexibility and experimental simplicity, this approach could enable the development of new imaging protocols and find applications in fields such as quantum communication and cryptography. By working on the properties of the crystal, it might even be possible to encode multiple images in the same photon pairs beam, visible by moving the camera to different optical planes, thereby encoding more information. This study is published in *Physical Review Letters.*

Reference:
Hiding images in quantum correlations, Chloé Vernière and Hugo Defienne, *Physical Review Letters*, published on August 29, 2024.
DOI: 10.1103/PhysRevLett.133.093601

Quantum bits: strength in the union of photons!

Published by Adrien, May 24, 2024 at 11:00 PM

Researchers have demonstrated that quantum error-correcting codes, which are absolutely necessary for the functioning of future quantum computers, are already achievable in the lab using the collective properties of photons.

Of all the mediums capable of transmitting information, light is undoubtedly the fastest, and using its quantum properties can additionally make it an unconditionally secure means of communication. Encoding quantum information in light involves defining quantum bits, or qubits, the fundamental building blocks of quantum computation.

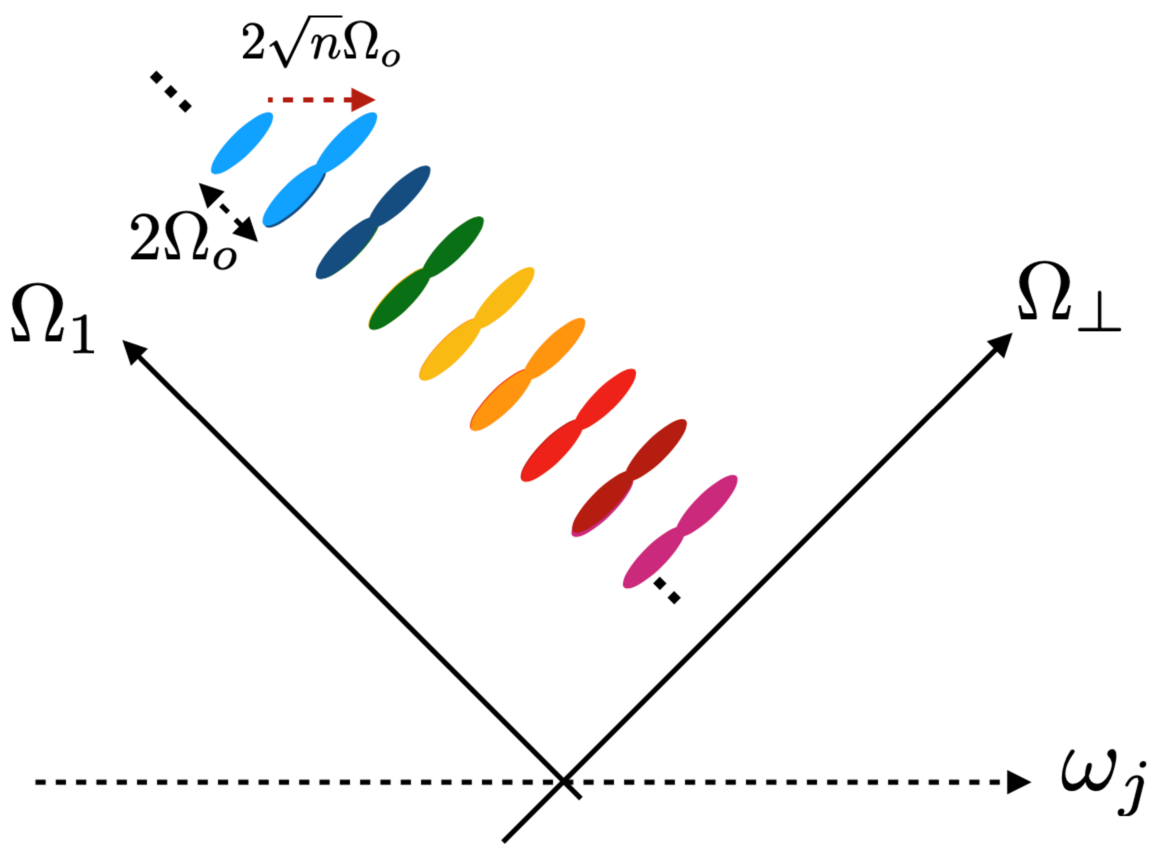


Figure: Quantum information is encoded in the collective variables of photons (such as the average frequency of the photons) in the form of a frequency comb (here, the variable Ω1). Other collective variables (grouped in the variable Ω⊥) do not carry information and are not measured. Thus, the effects of displacement (noise) of a photon have a smaller effect on the comb, making it more resilient to disturbances. This effect decreases as the number of photons in the comb increases, as it depends on the inverse of this quantity.

However, whether in communication or quantum computing, quantum information is extraordinarily fragile, and manipulation errors, photon loss, or coupling between light and parasitic fields can destroy the quantum information.

To counter these effects, researchers in computer science and physics have developed strategies such as quantum error-correcting codes. Inspired by their classical counterparts, quantum codes rely on redundancy by encoding information into quantum states comprising multiple qubits (instead of one) and measuring their collective properties, such as their parity.

In the field of quantum optics, these codes depend on producing complex states that provide information on the degradation of the information they carry when measured cleverly. Experimentally realizing such states is challenging, despite their importance and interest.

In recent work, researchers from CNRS and the Universities of Paris-Diderot and Paris-Saclay at the Laboratoire Matériaux et Phénomènes Quantiques (MPQ, CNRS / Université Paris Cité) have shown that non-linear devices that convert a photon from a laser beam into a pair of "twin" photons, entangled in frequency, naturally produce a state robust to errors and that can be corrected when perturbed. Indeed, the non-linear device that permits photon conversion creates a collective frequency comb where all photons are entangled when placed in an optical cavity (see figure).

By focusing on the collective variables of this system (such as the average frequency of the photons), it is possible to view this comb as an error-correcting code. Devices generating photon pairs with such properties - which are, to date, the largest photonic states allowing error correction in quantum optics - exist in various laboratories.

These results pave the way for developing experimental tools that allow manipulation of these states on a larger scale and their use in applications such as quantum communications. They are published in *Physical Review Letters.*

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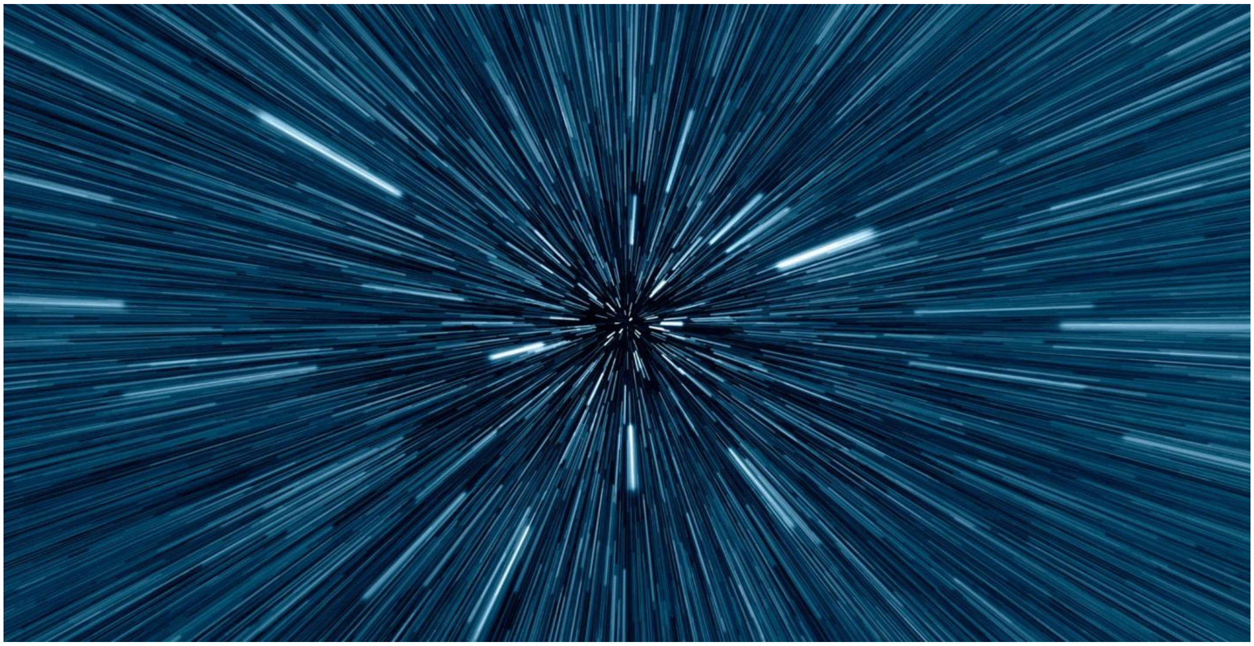


Is there anything faster than light?

"Nothing travels faster than light," you've probably heard before. Indeed, according to Einstein's theory of relativity, light sets the speed limit of the universe, but as with many scientific concepts, things are not that simple. While this idea holds true in most scenarios, there are some conditions where this might not be the case.

Speed of light

Light is fast, real fast. We're talking about 186,282 miles per second fast (around 300,000 kilometers per second).

Speed of light

To put things into perspective, the fastest speed humans have traveled was aboard the Apollo 10 in orbit, at 24,816.1 miles per hour (around 39,937.7 km/h).

Why is light so fast?

Light is a massless particle and therefore can achieve such speed. For any mass to be moved at this speed it would require huge amounts of energy.

It would require infinite energy

Plus, mass increases as it accelerates towards the speed of light, so in theory, one would need an infinite source of energy to fuel the whole process.

Infinite inertial mass

And to make things even more difficult, there would be infinite inertial mass resisting the object. And this is why things can't be faster than light...or can they?

Vacuum

Einstein's theory of general relativity tells us that light travels faster than anything else…in a vacuum. So, what happens when light doesn't travel in a vacuum? Let's find out.

Water

This is the case when light travels through water. Claudia de Rham, a theoretical physicist at Imperial College London, explains that "as light travels through a medium — for instance, glass or water droplets — the different frequencies or colors of light travel at different speeds."

This is visible in rainbows, where we can observe the "long, faster red wavelengths at the top and the short, slower violet wavelengths at the bottom."

So, light actually slows down when it travels through water. This is an example of light not traveling through a vacuum, meaning its speed can indeed change. But can the opposite occur?

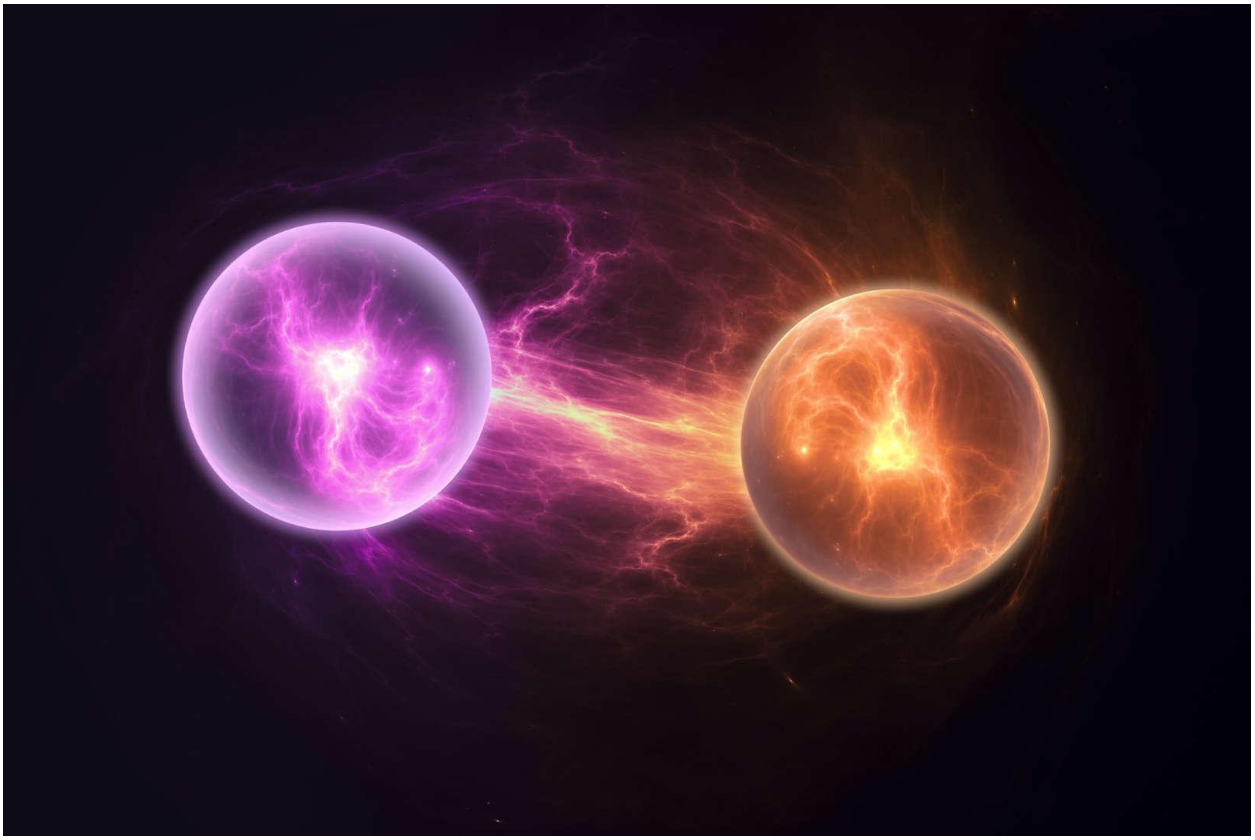
Gamma-ray jet bursts

Gamma-ray jet bursts are an example of something that is believed to travel faster than light.

When stars collapse or collide, they create bright explosions. In fact, they create the brightest explosions in the Universe.

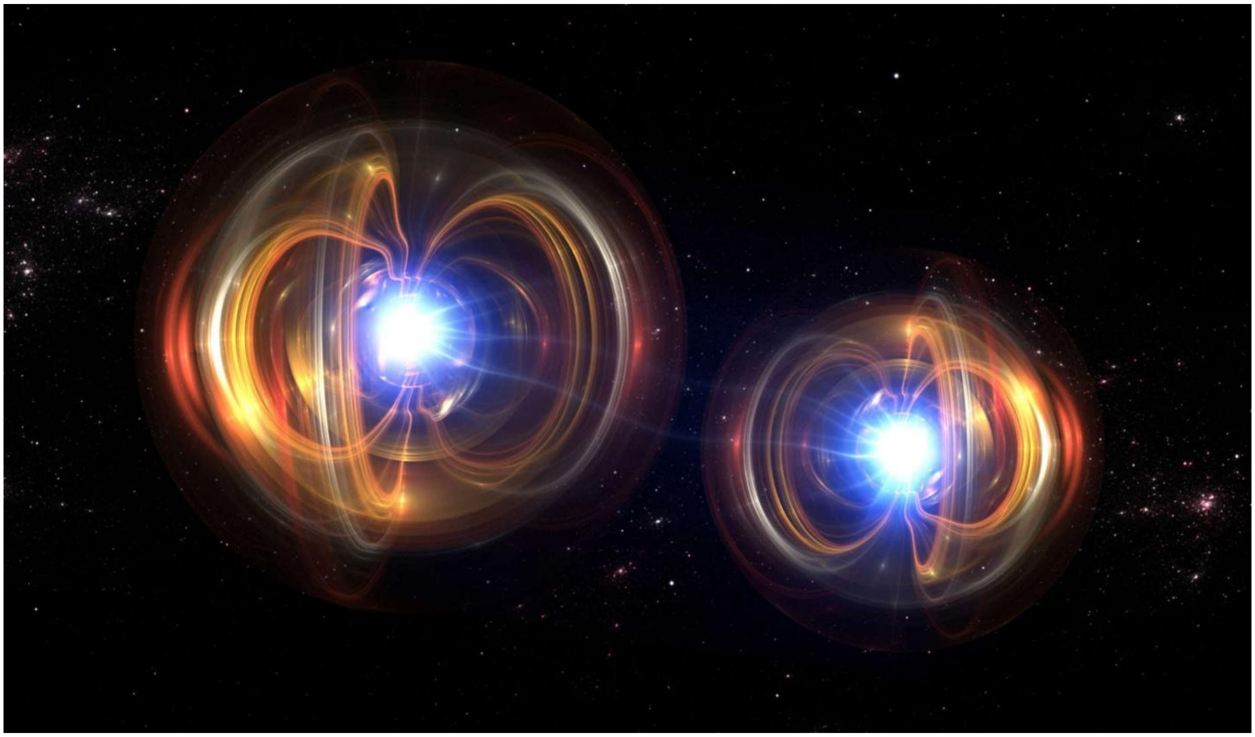
The blasts responsible for gamma ray bursts were found to be able to travel through gas clouds faster than the speed of light. This is only possible because these Gamma-ray jet bursts exist in the dust clouds, not in the vacuum of space.

An example would be the Big Bang itself. When it occurred, the empty space expanded faster than light.



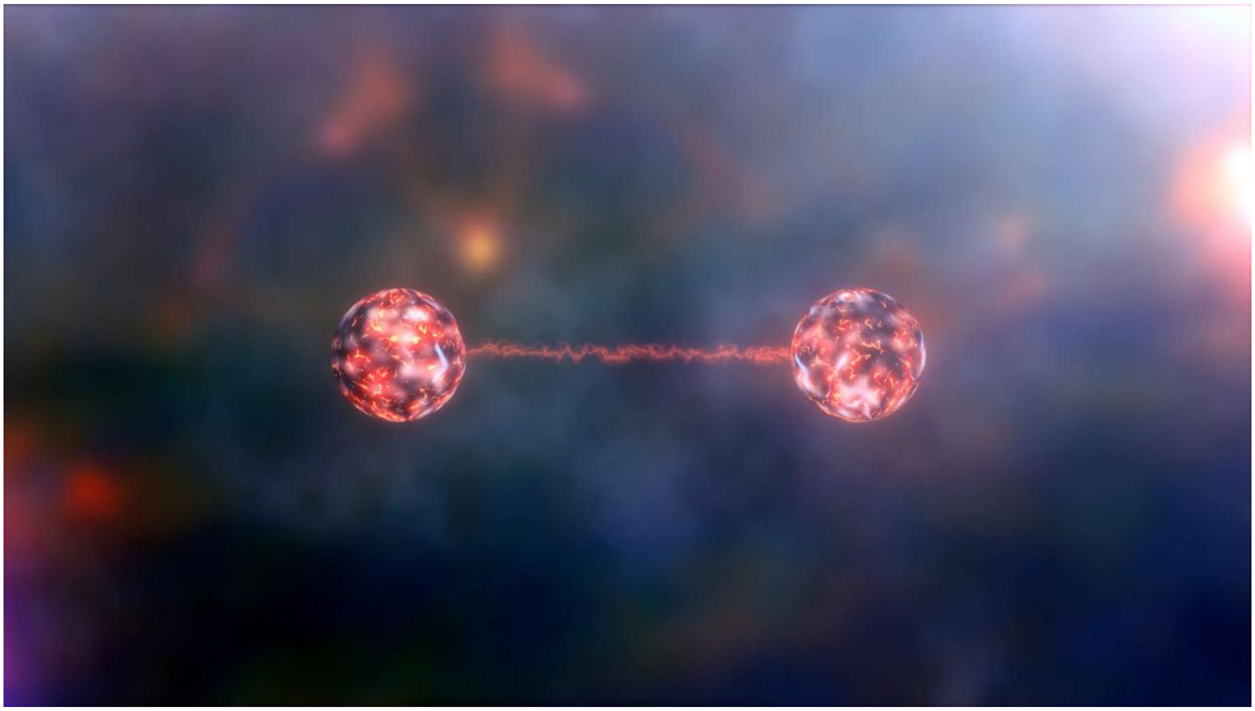
Quantum entanglement

Quantum entanglement is like a bizarre long-distance relationship. It says that two subatomic particles can be linked together, despite being separated by light-years.



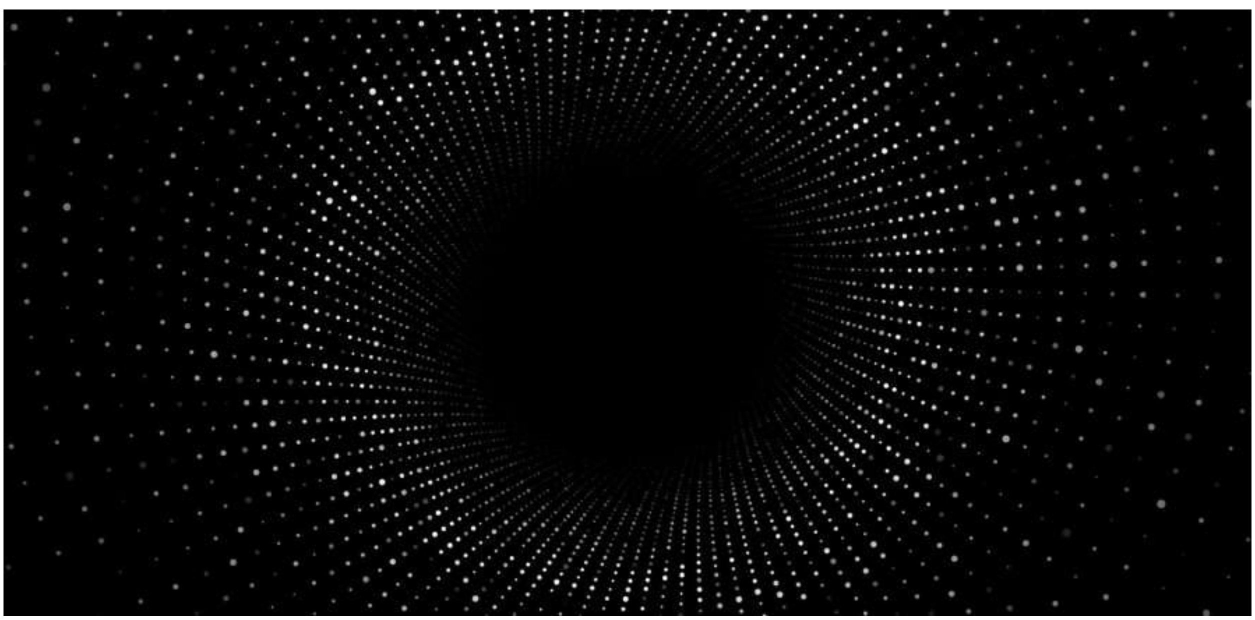
Quantum entanglement

According to the theory, change induced in one particle will affect the other, no matter how far they are from each other. So, does this mean there is something traveling faster than light that connects them?



Quantum entanglement

This “spooky action at a distance,” as Einstein called it, is not an easy concept to grasp, but in a nutshell, the link seems to be a product of randomness, rather than the effect of something traveling faster than the speed of light.

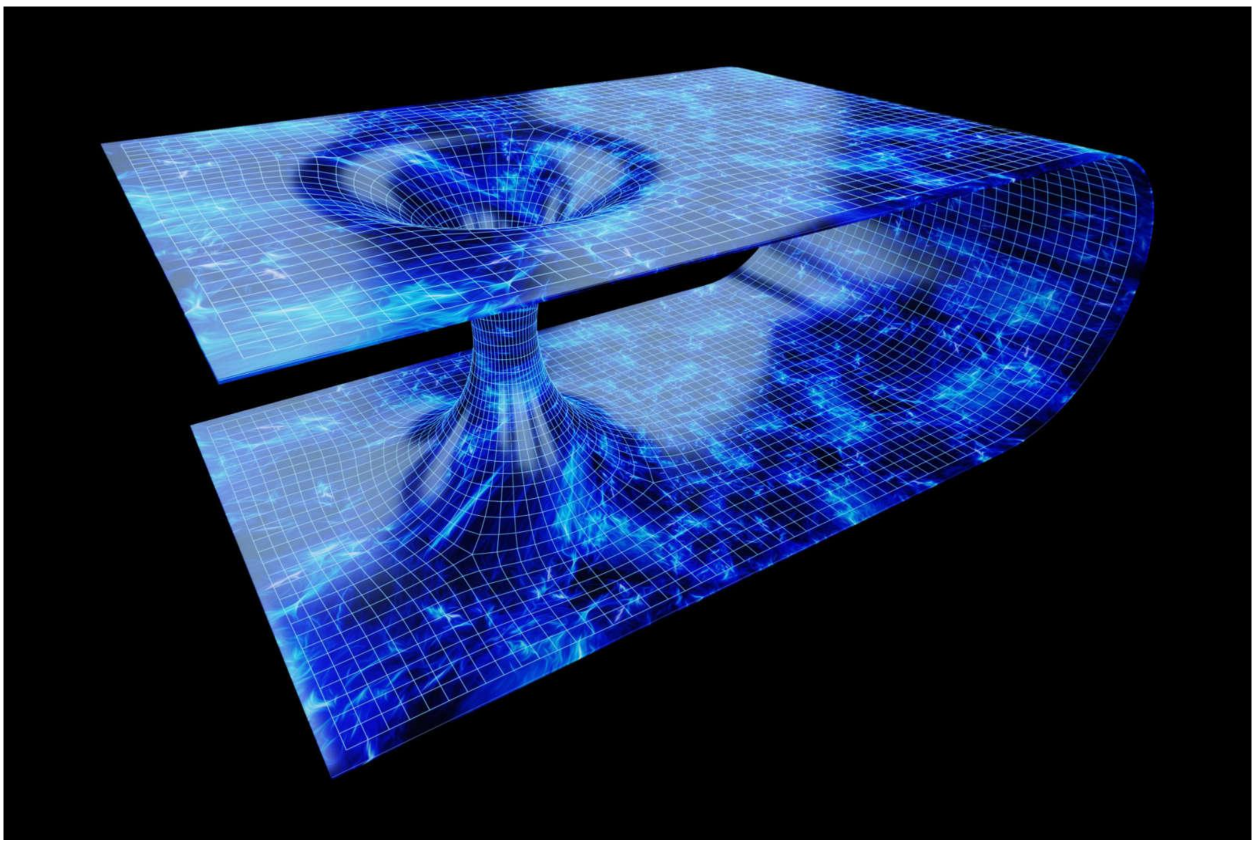


Wormholes

Speed allows us to cross a determined distance in a specific time. For example, if you travel 100 miles at the speed of 100 miles per hour, it will take you one hour to travel that distance. Think of wormholes as shortcuts. In this case, you'd reach the destination faster than in one hour.

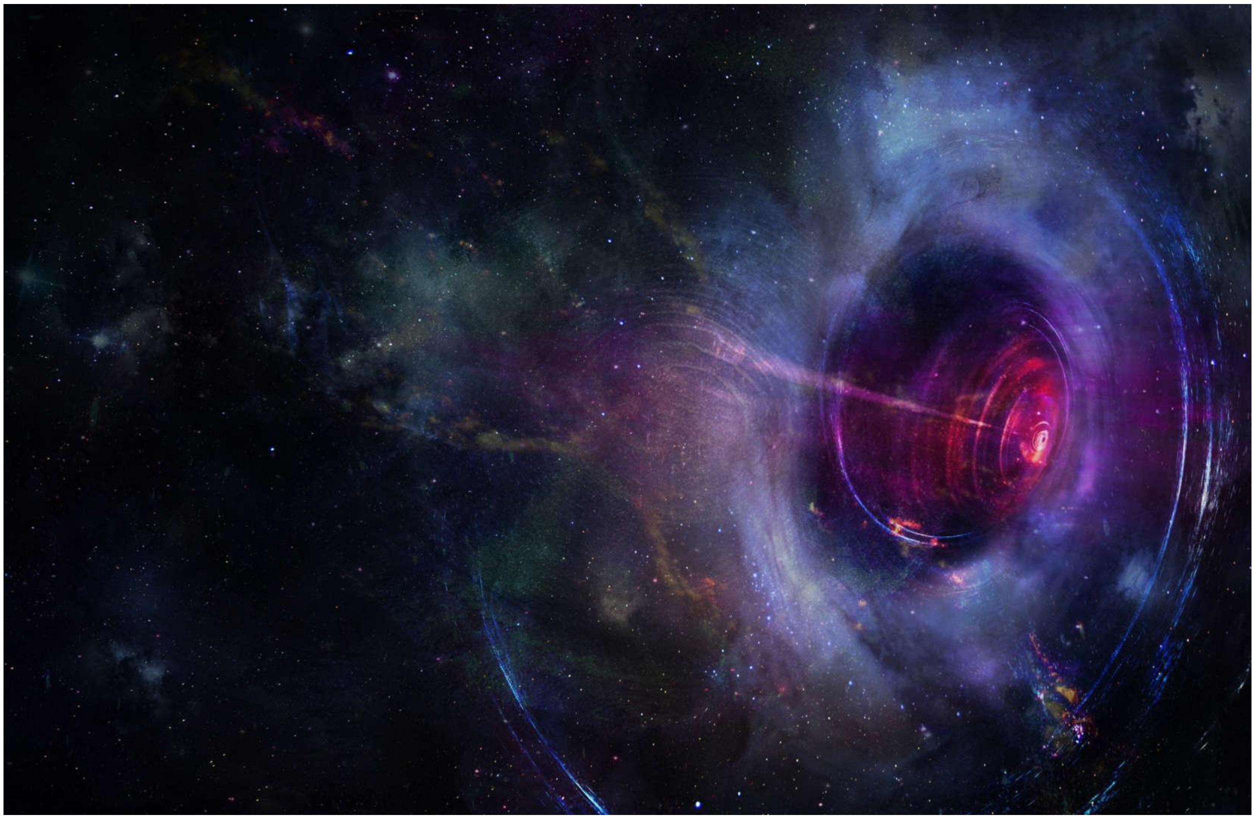
Wormholes

There's a caveat though: no one has ever actually seen a wormhole in space. The science behind them does however exist (and some theories even propose they can be used for space-time travel).



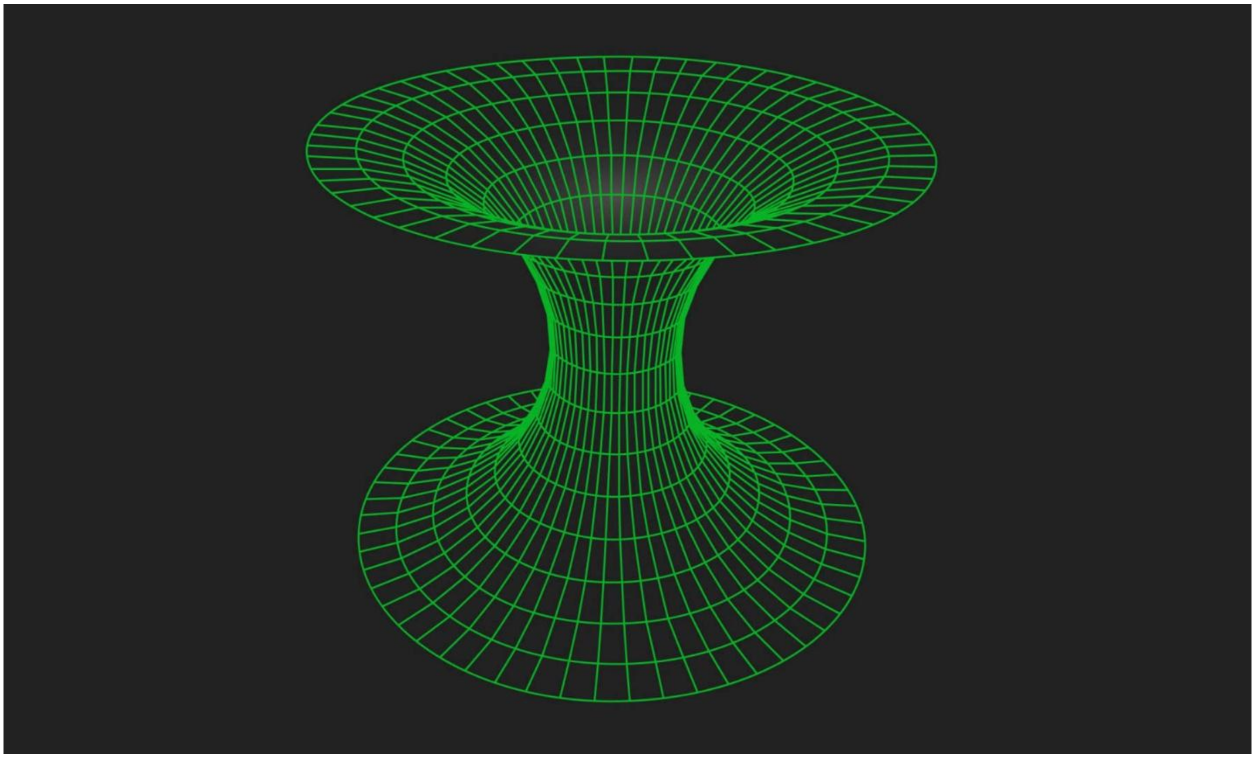
Wormholes

Two black holes could potentially be linked together somewhere in space and create a large enough mass that curves space-time.



Wormholes

In simple terms, a mass can be pulled into one hole and come out on the other side (of the other black hole).



Wormholes

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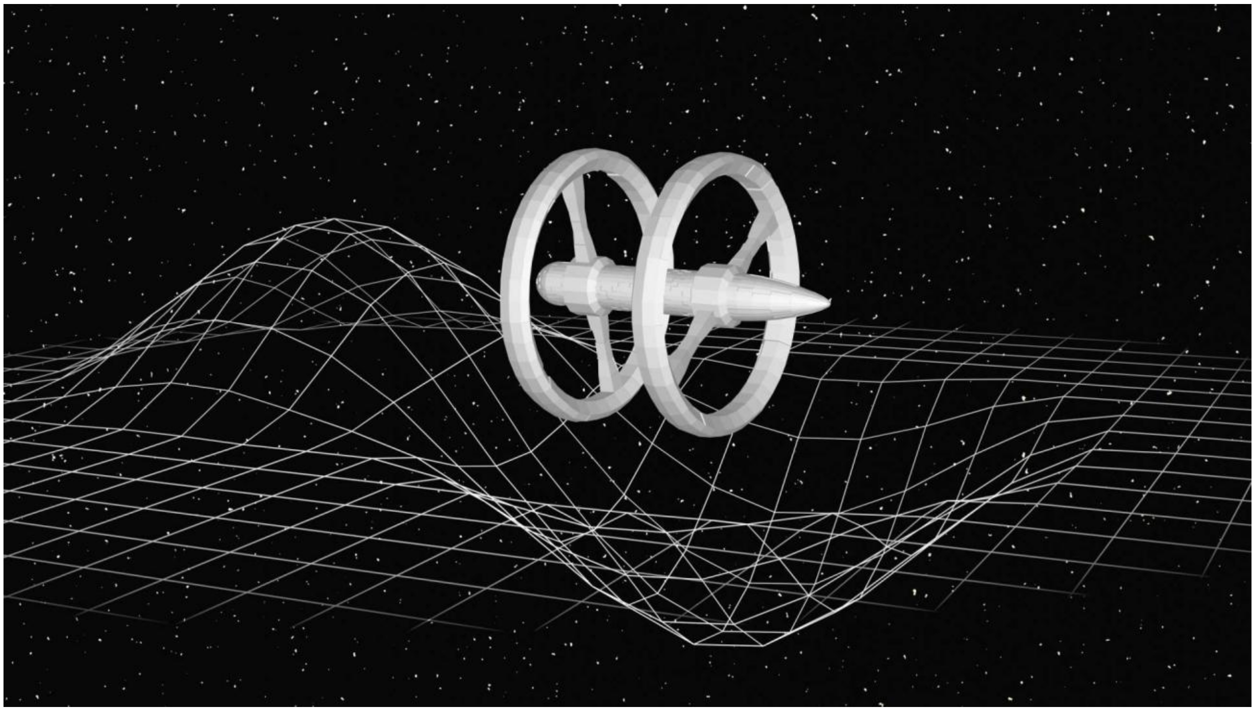
An apple-like shape is a good way to visualize wormholes. Mass would go in through the top and come out at the bottom. Can this shortcut be faster than the speed of light? Potentially. Though first we would need to have evidence that these indeed exist.

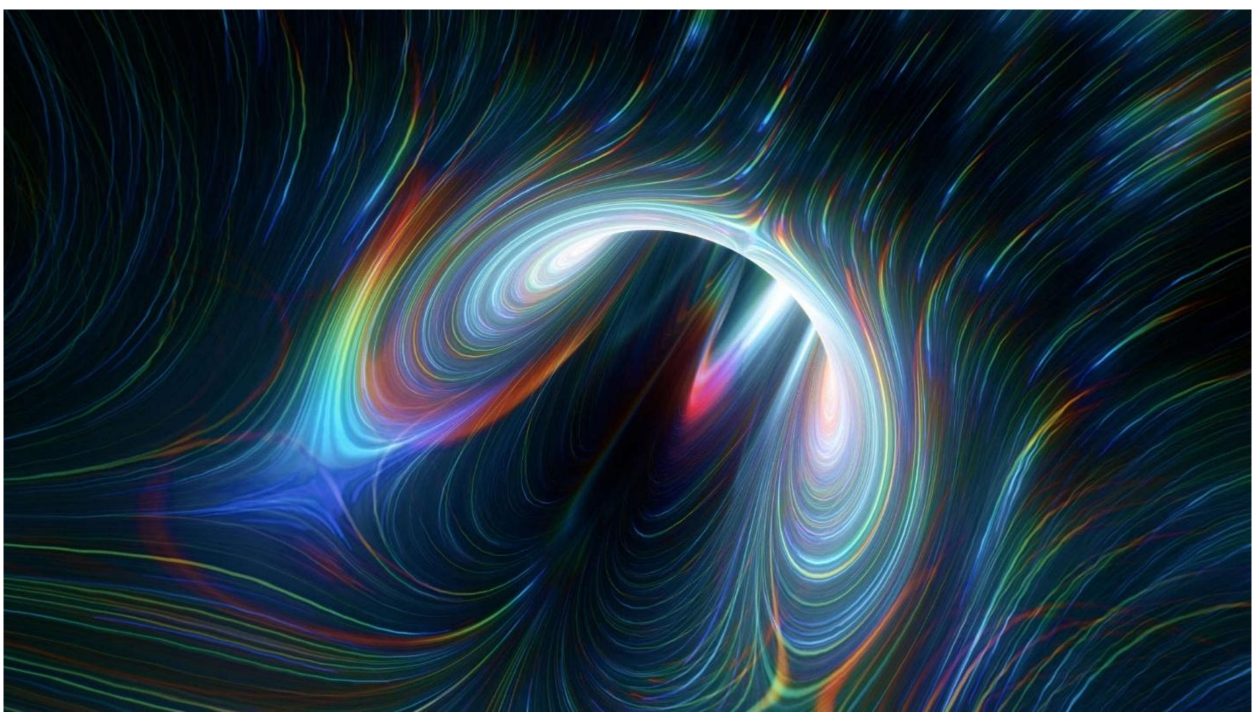
Alcubierre Drive

The Alcubierre Warp Drive is pretty much a speculation that a spacecraft can travel faster than the speed of light. All it needs is to travel in a vacuum. If the space in front of it is contracted and the space behind it is expanded, the spacecraft can travel like an isolated wrap bubble.



Alcubierre Drive

The theory is valid, mathematically speaking, but so far, NASA experiments with creating a wrap bubble were inconclusive.

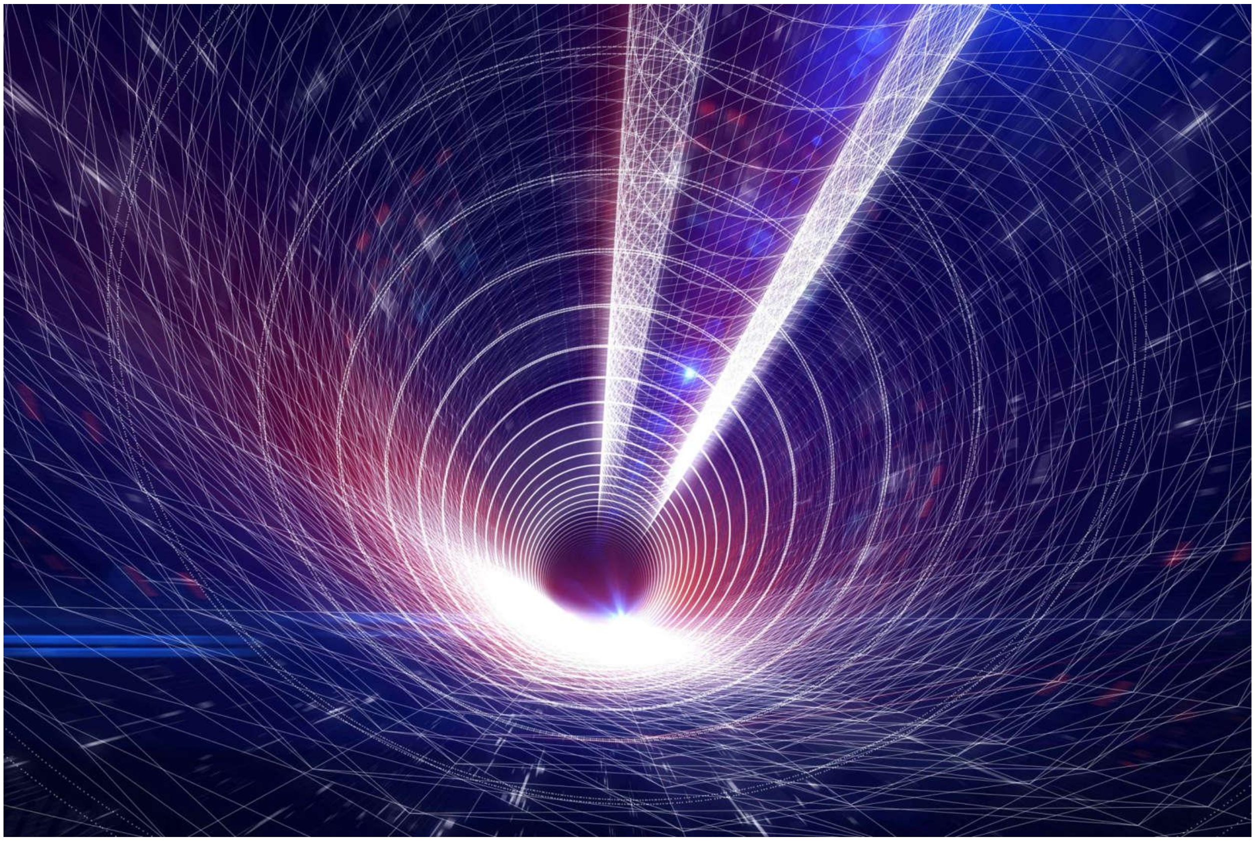


Krasnikov tubes

The Krasnikov tubes theory is based on the Alcubierre Warp Drive. A Krasnikov tube is a mechanism that would allow a spacecraft to travel by creating a wrap behind it.

Krasnikov tubes

The wrap would propel it to its destination, and at the same time, it would create a "tube" where the spaceship would be able to travel back.

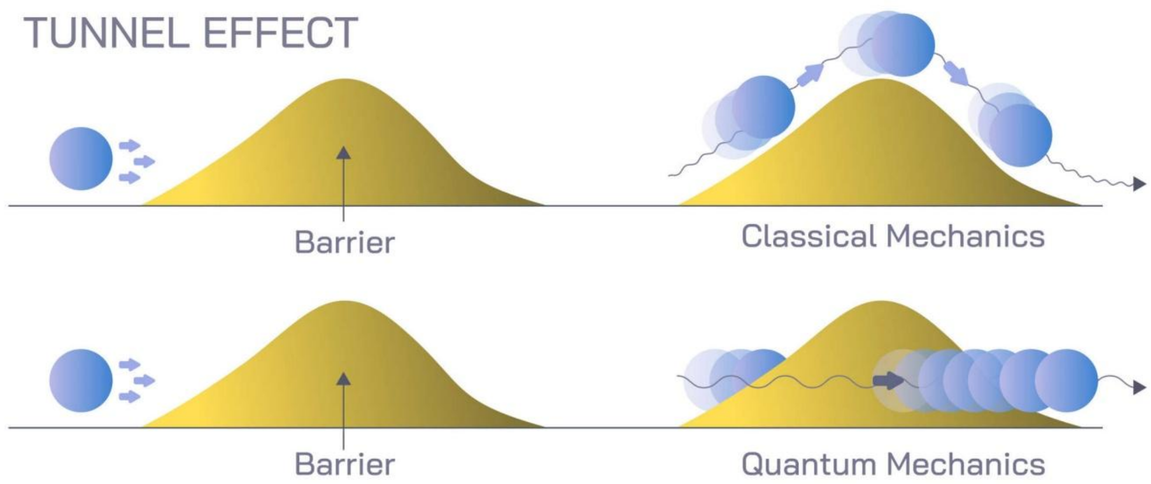


Krasnikov tubes

This tube unwinds time, so a journey that would take thousands of years could be done in just a few years through these superluminal tunnels. In theory, at least.

Quantum tunnels

Some particles can tunnel through barriers. The discovery was made in 1932, but it wasn't until 1962 that semiconductor engineer Thomas Hartman published a paper about it.



Quantum tunnels

This was huge, and for years, scientists have been experimenting with it. After all, quantum tunneling seems to allow faster-than-light travel.