[Music]

HOST: Light, we all know it travels at well, the speed of light, or does it? When it comes to the structure of space and time, could light be the key to unlocking the final secrets of the universe? Answers may lie in the journey of two photons across seven billion light years of space, recorded by the Fermi Gamma-ray Space Telescope. And these two tiny particles have just opened up a whole new chapter in our understanding of light, gravity, and the universe around us.

JULIE MCENERY: We're really excited because we've captured rare experimental evidence probing the fundamental structure of space and time.

HOST: Meet NASA's gamma-ray detectives. Led by project scientist Julie McEnery, they're searching for clues about the high-energy mysteries of our universe. But, they'll need more than a magnifying glass this. The team's one of kind tool? The Fermi satellite. Fermi looks at gamma-rays, the highest-energy form of light and it just surprised everyone with a discovery about the fabric of space and time.

JULIE MCENERY: So you might be thinking, two tiny particles of light, why is that important? Well you have to look at the very large and the very small together to understand the universe as a whole. So far, Einstein's Theory of Relativity, which describes space and time as a smooth fabric that's distorted, or bent by massive objects, has been a spectacularly sucessful explaination of gravity and the large scale behavior of the universe. Whereas Quantum Mechanics, another spectacularly successful model describes the workings of atoms subatomic particles and some of the fundamental forces of nature. Scientists have never been able to reconcile the two. Both Relativity and Quantum Mechanics are equally fundamental in their own regimes. So scientists want to find a theory of everything that describes the universe as a whole. And the observations that we've made these two photons with Fermi takes us one step closer to achieving the goal of having a Theory of Everything that combines the most sucessful aspects of Quantum Mechanics and Relativity into one unified theory.

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HOST: To add to this puzzle, other telescopes have observed gamma rays with different wavelengths arriving at Earth at different times. According to Einstein's Special Theory of Relativity, all forms of electromagnetic radiation from radio and infrared, to visible light, to X-rays and even gamma-rays moves at the same speed. So what would explain these differences in arrival times? One simple idea is that maybe the photons were just emitted at different times. More interestingly though, maybe there was something in the very fabric of space that was causing the higher-energy particle to slow down. If this is true, could Einstein have been wrong? Could a higher-energy particle move slower than the speed of light?

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HOST: Several ideas, which attempt to reconcile relativity and quantum mechanics suggest that space and time are not actually smooth and uniform. But are instead a seething froth when seen at the smallest scale. Like bubble wrap viewed from far away, at human scales this texture would be invisible. A low -energy, long wavelength photon is unaffected by the lumpiness of space. But a high-energy, short wavelength photon is hindered by the froth. This makes it move more slowly than lower-energy radiation, so it breaks Einstein's law that all light particles must travel at the same speed. However, this explanation had little experimental proof either way--until Fermi arrived.

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JULIE: We observed a gamma-ray burst. A gamma-ray bust is a huge explosion. That gamma-ray burst produced a large number of photons, one of which had enormous energy, and very short wavelengths. Those photons travelled seven billion year to reach us, and yet the highest energy, the shortest wavelength of photon arrived within 900 milliseconds of the lower-energy photons. That's a little bit like racing two speed-boats, one through water and the other through molasses, and having them arrive at the same time; it just doesn't happen. Because Fermi saw no delay in the arrival time of the two photons, it confirms that space and time is smooth and continuous as Einstein had predicted. And it shuts the door on several theories of everything that had predicted that space and time might be foamy enough to interfere with light.

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HOST: So, if space-time really isn't just invisible bubble wrap, what is it? Fermi's eliminated some ideas from the mix, and that means we're one step closer to potentially unifying Relativity and Quantum Mechanics. After all, science is a process of elimination, and unless we keep eliminating, we may never know if this Theory of Everything actually exists, hidden in the math of our universe. But for now, we'll have to keep searching for clues beyond our small planet, because the answers truly lie among the stars.

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