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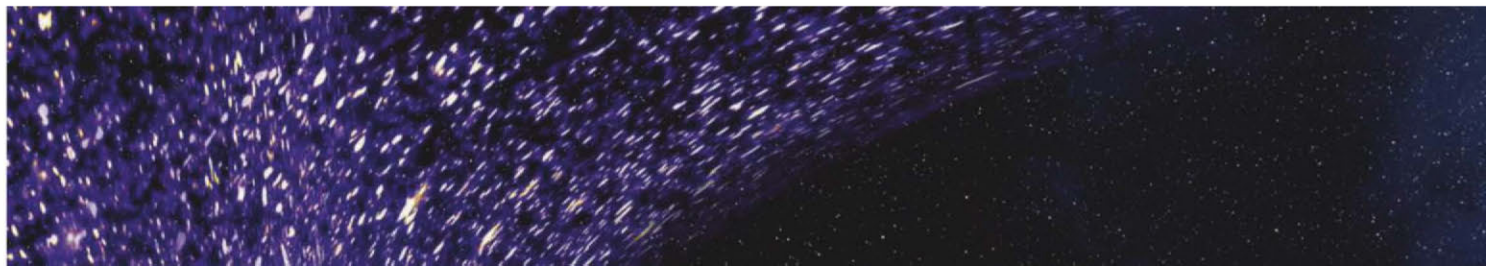

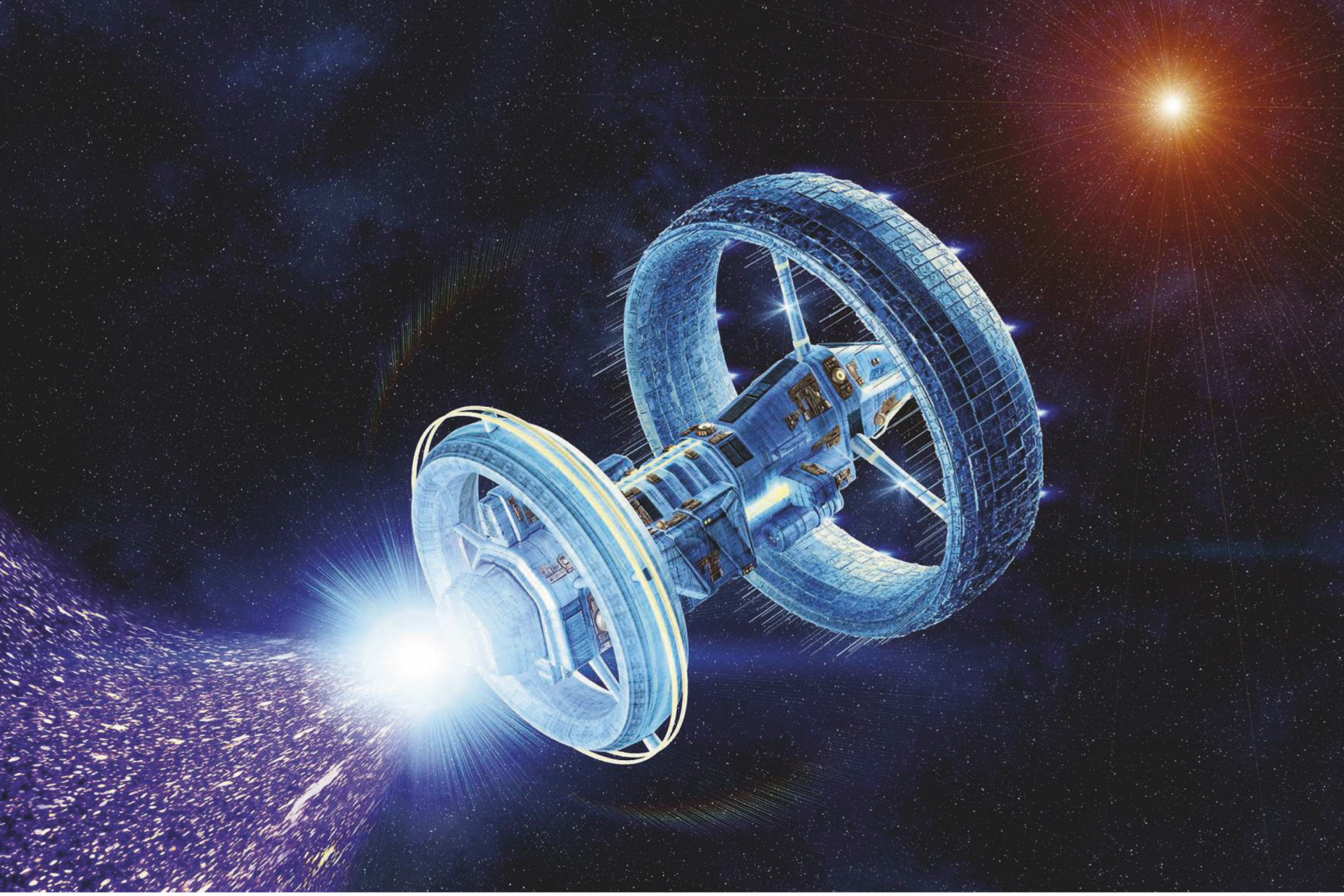

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ANALYSIS

FASTER-THAN-LIGHT TRAVEL: IS A WARP DRIVE REALLY POSSIBLE?

A NASA scientist recently released a report analysing the feasibility of a warp drive as a means of faster-than-light travel. Could this *Star Trek* technology really be possible?

In the universe of *Star Trek*, on 5 April 2063, humanity ventures out into the Galaxy on the first ship capable of faster-than-light travel, the *USS Enterprise*. The newly invented 'warp drive' not only lets humans explore the cosmos, but also attracts the attention of Vulcans and brings about our first contact with an alien species.

It's been 54 years since we were first introduced to the *USS Enterprise*, and many of the futuristic technologies from *Star Trek* have since been invented, from handheld communicators to universal translators. A warp drive is the next obvious choice: Voyager 1, which has travelled further from Earth than any spacecraft, took nearly 35 years to leave the Solar System. Not exactly handy for interstellar travel.

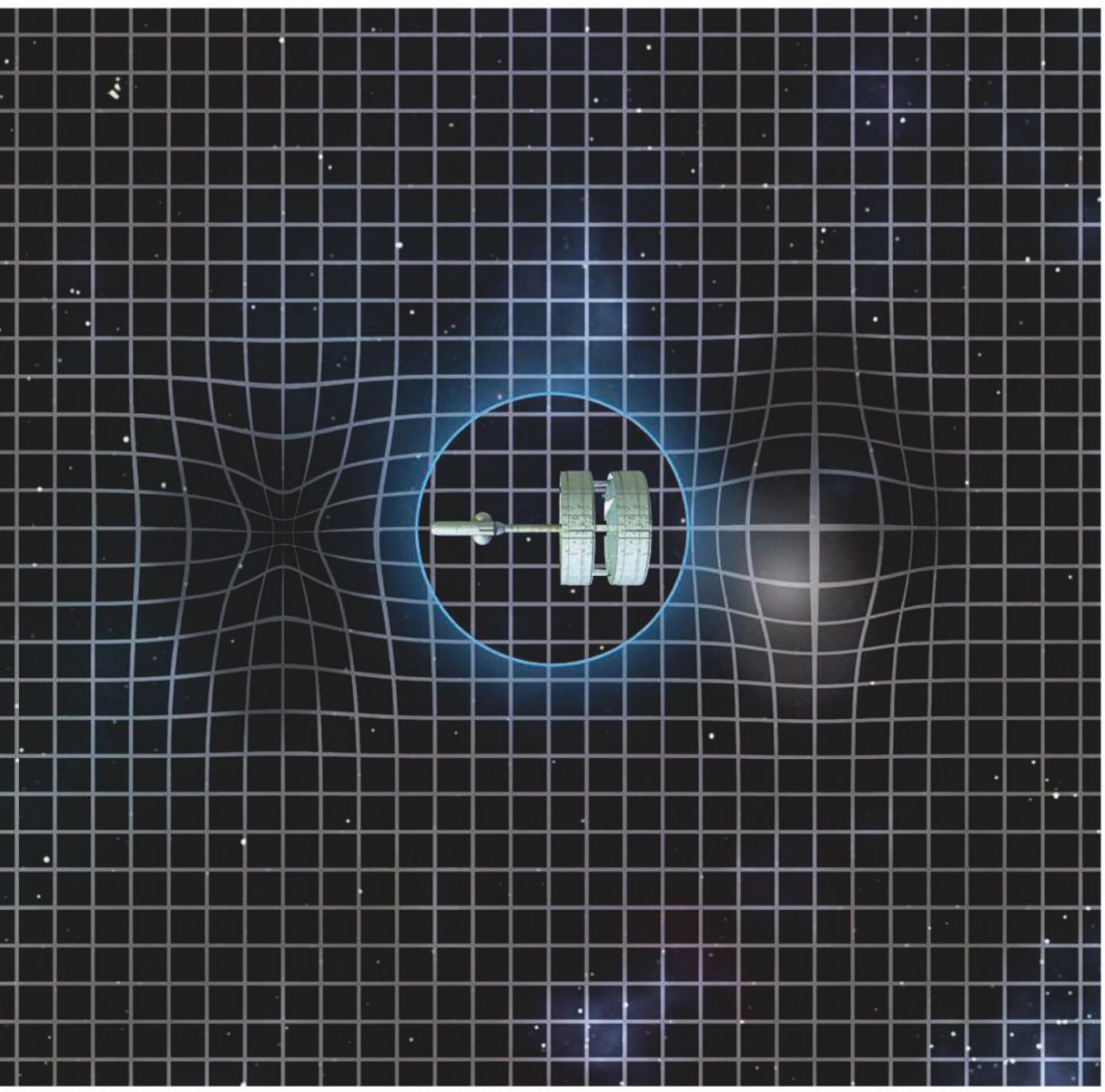
Luckily for humanity, theoretical physicists have been working on it. In May 2020, NASA scientist Dr Harold 'Sonny' White released an internal feasibility report discussing the technology from the point of view of 'early mission planning'.

FASTER THAN LIGHT

The first scientific theory of warp drives came about in 1994, when theoretical physicist Dr Miguel Alcubierre used Einstein's theory of General Relativity to develop a framework that would allow faster-than-light travel within the confines of the laws of physics. The key that makes it possible is that, technically, the ship itself doesn't travel faster than light.

"What a warp drive is doing is basically saying that there is no law of physics that says space-time itself can't go faster than the speed of light," says Dr Erin Macdonald, astrophysicist and science consultant for *Star Trek*. "And so the concept of a warp drive is to say, all right, let's take our ship, let's build a bubble of space-time around it, and then we'll have that propel us faster than the speed of light." It's similar to the idea of a car driving inside a moving train: someone standing by the tracks would see the car travelling much faster than its top speed.

According to the theory of General Relativity, the Universe is a flat sheet of space-time which is warped by any object with mass. "We think of a bowling ball on a trampoline and that bowling ball dips the trampoline down," explains Macdonald, "and that's what mass [the ball] does to



ABOVE The Alcubierre drive works because the ship is surrounded with a bubble of space-time, which is compressed in front of the ship and expanded behind it

space-time [the trampoline].” This distortion of space-time is what we experience as gravity.

The Alcubierre drive uses the same concept. The ‘bubble’ surrounding the ship is an area of space-time that is compressed in front of the ship and expanded behind it. As with gravity, you could create this distortion using a large amount of mass. Alternatively, thanks to Einstein’s $E = mc^2$ (energy is equal to mass, multiplied by the speed of light squared), you could equally use a huge amount of energy.

Inside the bubble, space-time is completely flat, meaning the space travellers wouldn’t notice any strange, relativistic effects. The result is that the bubble of space-time is hurled across the Universe, with the travellers sitting comfortably inside their ship, speedometer still reading the same number.

Unfortunately, actually creating a warp drive is even harder than it sounds. “You have to have a very, very large amount of energy,” says José Natário, associate professor in mathematics at the Instituto Superior Técnico at the University of Lisbon.

“To have the deformation that you need for this kind of thing to work, you’d need much, much more energy than the Sun or the Galaxy,” he says. “But also, it’s negative energy.”

Negative energy is not something that we can currently create – certainly not in the quantities needed to power a warp drive. How could energy be negative at all? One way to think about it is to consider a particle with negative mass. These particles would react to gravity in the exact opposite way to particles of positive mass. Instead of being pulled towards a planet or star, they would be thrown away.

“If we had some sort of component like that where we had a negative mass, whatever is keeping that mass together would be that negative energy,” says Macdonald. This isn’t a problem that will go away with refining the idea, either: Natário proved mathematically that any form of warp drive will require negative energy.

IMPOSSIBLE MISSION?

Natário believes there’s an even greater problem with the concept of the Alcubierre drive. Imagine a supersonic aircraft travelling faster than the speed of sound. You don’t hear the aircraft until it has already gone past, because the sound waves can’t keep up. The warp drive experiences the same effect with light waves, meaning there is no way to send a message ahead of you.

“I call it the ‘you need one to make one’ problem,” says Natário. How do you create the warped space-time geometry around your ship? First, you would need to send a signal ahead of you to ‘tell’ space-time to warp, Natário says. “To make it go faster than light, you need something that would be going faster than light to begin with so that you’d be able to communicate outside the horizon.”

These two problems – combined with the slight issue that the travellers would be bombarded with incredibly high-energy radiation – are the downfall of a warp drive, Natário believes. “The bottom line is, in my opinion, it’s completely impossible,” he says.

Macdonald is more hopeful. “I’m an eternal optimist with this because I want to join Starfleet,” she says. “The way I think about it is it’s like we never know what’s going to come down the pipe with some of these weird, exotic, fun thought experiments.

“I agree at this stage, right now, it’s a fun thought experiment. But that’s not to preclude some massive discovery that may happen that we can’t predict.”

by **SARA RIGBY**
Sara is the online assistant at BBC Science Focus.

DISCOVER MORE

ON THE PODCAST *Visit **bit.ly/erin-macdonald** to listen to an interview with Erin Macdonald on the science of* Star Trek.

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