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THE BIG QUESTION

Is travelling faster than the speed of light possible?

As much as we want to tell Mr Sulu to "Take us to warp factor five", dangerous causality problems, tricky maths and negative energy could get in the way

by DR STUART CLARK

We've all seen it so often in science-fiction movies that the concept seems utterly plausible: a character enters a command and their starship leaps to warp speed, jumps to hyperspace, or creates a wormhole through space and time. Whatever the terminology, the result is always the same: they fly through their fictional universe faster than the speed of light, making travel between star systems not only possible, but practical.

In the real Universe that we inhabit, however, a gigantic barrier appears to forbid this. According to Albert Einstein's Special Theory of Relativity, nothing can travel faster than light.

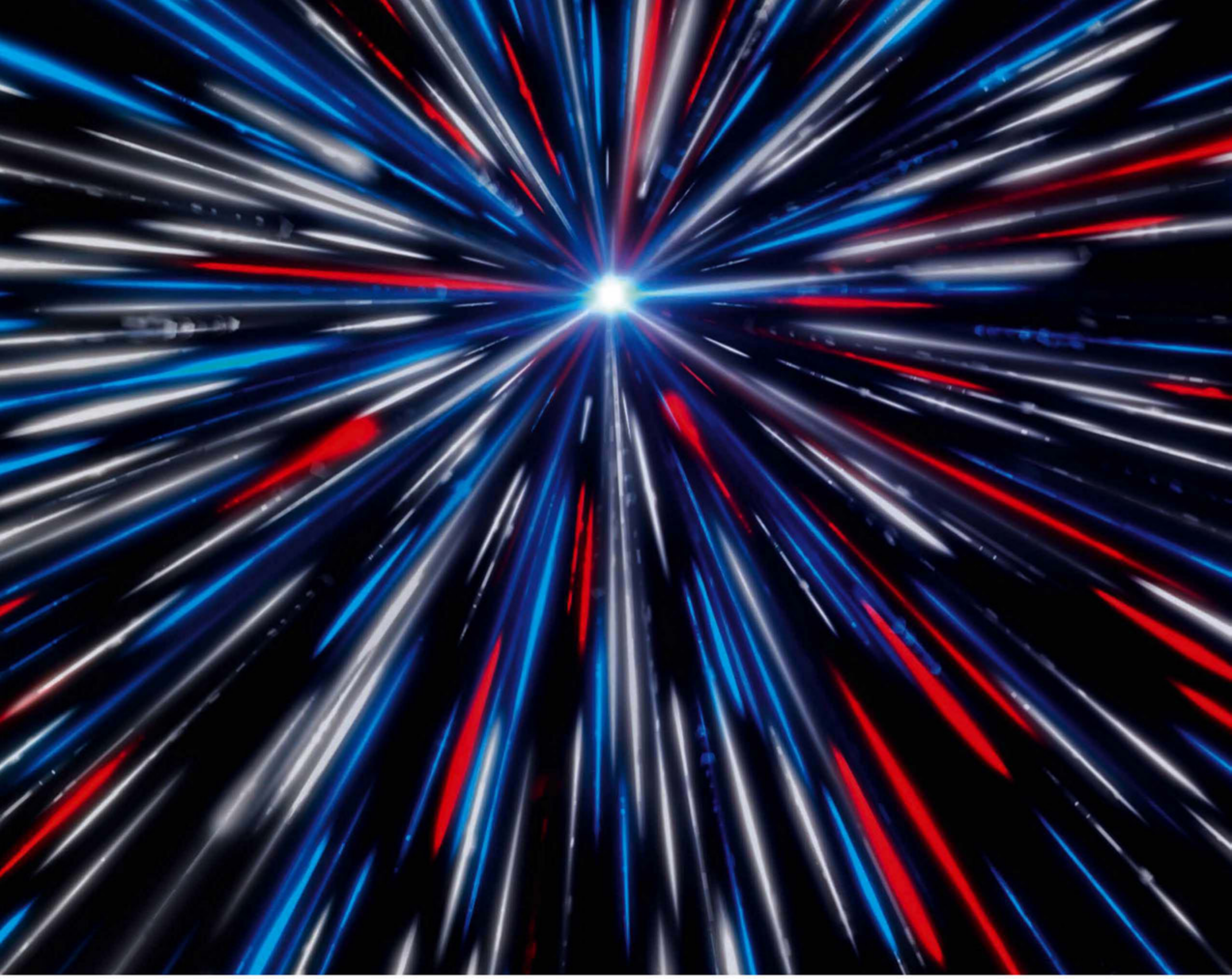
Light travels at a tremendous speed of approximately 3 x 10^8 metres per second. This means that when we look out into the Universe, we don't see celestial objects as they currently appear – we see how they appeared when the light from them first set out across space.

> "If you watched a faster-than-light spaceship travel towards you, you would see the ship in two places at once"

Within the Solar System, those delays are relatively short. For example, it takes sunlight just over a second to bounce off the surface of the Moon and reach Earth, but it needs eight minutes to cover the distance between the Sun and our world.

The further out we look, the longer the delays become and this gives rise to the concept of the light-year as a measure of distance. The nearest star to us, Proxima Centauri, is roughly 4.25 light-years away, meaning that it takes light 4.25 years to get from there to here. Hence, we see the star not as it appears now, but as it was 4.25 years ago.

Across the vast expanse of the Universe, distances are eventually measured in billions of light-years. This is what makes cosmology possible: the further we look into the Universe, the more ancient the objects that we see are, allowing us to chart their evolution into the stars and galaxies of today. Wouldn't it be great, though, if we



Faster-than-light travel would make it possible for us to boldy go when no one has gone before, but there are hurdles to overcome if we're ever going to do that

ALAMY

could just travel there and see what those objects look like right now?

As appealing as having a warp drive might sound, there would be some pretty weird consequences. For one thing, it would mess with the concept of causality.

Causality is our common-sense perception that cause precedes effect. But if you watched a faster-than-light spaceship travel towards you, you would see the ship in two places at once. The light carrying the information of the ship's departure wouldn't have arrived at your eyes before you saw the ship on its way.

Worse still, according to the mathematics of relativity, if velocities exceed the speed of light, then literal time travel becomes possible. This would give rise to the possibility of full-blown causal paradoxes such as the well-known 'grandfather paradox', in which you travel back in time and kill your own grandfather, thus preventing the possibility of your own birth. And how would that work – would you just cease to exist?

The negative energy within

At first glance, Einstein's theories appear to protect us from such head-melting conundrums because they seem to make it impossible to travel faster than light – so-called 'superluminal motion'. According to the equations, the energy required to accelerate a ship to such speeds would be infinite. But then researchers began to look more closely at the maths.

In General Relativity – Einstein's extension of his Special Relativity – he proposed the Universe is made of a malleable fabric, termed the space-time continuum, and he explained gravity as being warps in this fabric. In 1994, physicist Dr Miguel Alcubierre at the University of Wales, Cardiff, showed that a solution existed within General Relativity that could be interpreted as a warp drive. The trouble was that making it work required an exotic substance known as 'negative energy'.

Astronomers have since toyed with using the concept of negative energy to explain why the expansion of the Universe appears to be accelerating, but our understanding of physics doesn't allow for the substance to comfortably exist. Then, in May this year, a group of researchers re-examined the maths to see if they could produce the Alcubierre warp phenomenon using only the kinds of particles and energy that make up planets and people. Their conclusion: yes, they could.

Dr Jared Fuchs and colleagues at the University of Alabama in Huntsville, →

→ in the US, found that they could arrange ordinary matter and energy to create the warp phenomenon and transport people through space. But there was a catch: they could only get it to work at sub-light speed.

"You need a lot of energy to make any small change in space," says Fuchs. To move a passenger compartment the size of a small room would require a 'warp bubble' the size of a small house. And to make that would require squeezing a few times the mass of Jupiter into a volume the size of a small asteroid.

"Now, [is that] possible? Maybe. [Is it] practical? I wouldn't say so," says Fuchs.

Even if it were possible to make such a device, the old boundary still exists: accelerating it faster than the speed of light would require an infinite amount of energy.

"It's not going to solve the *Star Trek*-like future of rapid transport," Fuchs admits.

The trouble with tachyons

Other researchers are conducting their own investigations into relativity. Prof Andrzej Dragan and collaborators at the University of Warsaw, Poland, decided to look at possible solutions within Einstein's equations for particles travelling faster than light.

Physicists have toyed with such concepts before. They even called such hypothetical particles 'tachyons', but they essentially regarded them as little more than mathematical curiosities. But Dragan and colleagues found equations to describe tachyon behaviour.

"Mathematically, they make perfect sense," says Dragan.

In other words, our familiar world of subluminal particles could be coexisting with a second family of superluminal ones: the tachyons.

Unfortunately, this still doesn't mean that you can accelerate a spacecraft to speeds faster than light. To do that, Dragan explains that it would still take the infinite amount of energy that Einstein predicted, as well as an infinite amount of energy to slow a tachyon down to subluminal speeds. "It wouldn't be possible to cross the speed of light in either direction," says Dragan.

Nevertheless, the research did suggest some fascinating consequences that might explain some of the most puzzling observations that physicists grapple with. When dealing with the tachyons, Dragan and co-workers ran into the causality problems they had expected. But the more they investigated the details of these, the more they realised something amazing was taking place: the lack of strict cause and effect began to look a lot like the behaviour of our normal everyday subatomic particles.

While relativity describes the behaviour of the Universe on its largest scales, quantum theory describes the subatomic realm as a very different place.

Quantum theory introduces probability into particle interactions. For example, an atom can absorb a photon of light, and while you know it'll re-emit that photon at some stage, you can't predict when and in what direction it'll go. In other words, the exact cause is hidden from us and all we're left with is an observable effect.

Dragan suggests that if a tachyon were to interact with ordinary matter, the outcome of that interaction would be unpredictable – rather like the emission of a photon.

So, while these latest ideas don't seem to open up a route to practical warp drives, they may just be showing us something deeper about the nature of the cosmos and the origins of quantum behaviour. SF

"To make that would require squeezing a few times the mass of Jupiter into a volume the size of a small asteroid"

by **DR STUART CLARK** *(@DrStuClark)*
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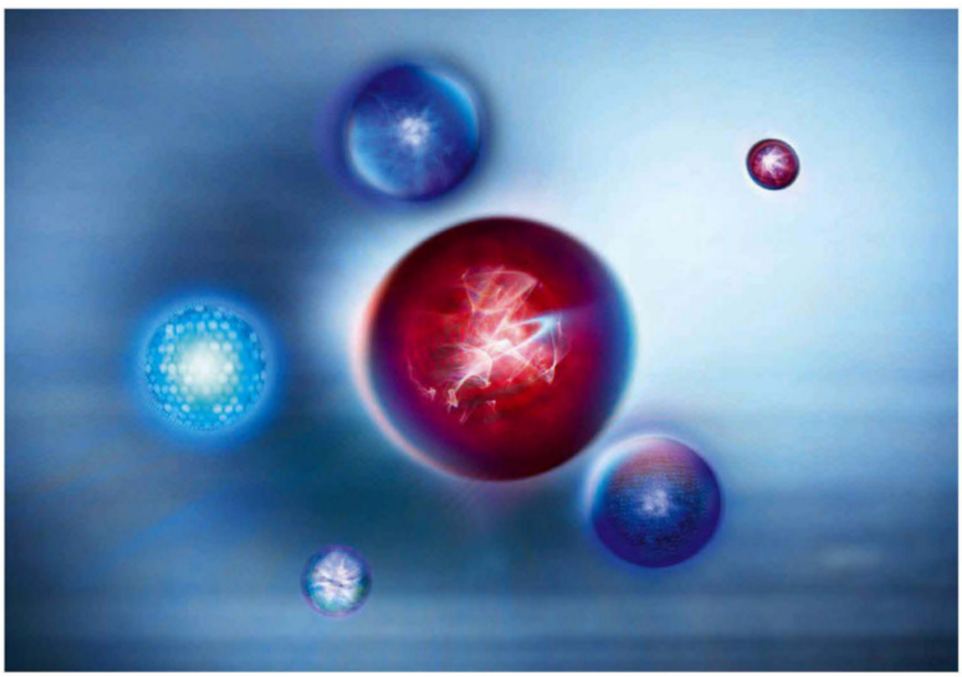

No one knows if tachyons exist, but if they do, theory suggests they'd travel faster than light