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This design for a faster-than-light warp drive is making waves — but physicists disagree on whether its possible

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A physicist has crafted what he says is the first theoretical propulsion system that can move faster than the speed of light without the need of inaccessible negative energy. The design faces ongoing questions from other researchers but represents a significant improvement from previous attempts.

Detailed in a paper published March 9 in *Classical and Quantum Gravity*, the "warp drive" would bend the fabric of space and time around a spacecraft to circumvent the universe's speed limit of more than 186,000 miles per second. Though very far from humanity's technological reach, the research has seen viral spread online as it brings interstellar travel an alluring step toward reality.

Fast travel to other star systems is all but inaccessible to humans because of the large distances between stars compared with light speed, the fastest anything can move through space. The red dwarf Proxima Centauri, the closest star to the solar system at 4.25 light-years, or 5.88 trillion miles away, would take tens of thousands of years to reach with conventional rocket technology. Exploring the Milky Way galaxy, which has a diameter of at least 150,000 light-years, is an even more formidable task.

Extraordinary forms of space travel, such as hyperspace, wormholes and warp drives, are a mainstay in much of science fiction because, in concept, they significantly speed up the journey between stars or galaxies. A spaceship with a warp drive — a term popularized by *Star Trek* — generates a sort of "wave" in the space-time fabric around it and can ride that wave to its destination faster than a light wave could through unaltered space-time.

Although the ship could not travel faster than light in its local area of space, that speed limit does not apply to the expanding and contracting of space itself. The warp drive would create a "warp bubble" around the spaceship and the area immediately surrounding it, and the space-time "wave" would transport the bubble across distances faster than light speed.

Theoretical physicists have been exploring how a warp drive could abide by the rules of general relativity, Albert Einstein's theory of gravity that describes space and time as a combined four-dimensional geometry. In 1994, Mexican physicist Miguel Alcubierre created the first general relativistic solution to faster-than-light travel that did not require wormholes, hypothetical portals between two points in space. His theoretical Alcubierre drive contracts space-time in front of a spacecraft and expands space-time behind it.

But the Alcubierre drive and subsequent warp-drive models need to be powered by massive amounts of negative energy. In contrast to the positive energy that is involved in nearly all physical interactions, negative energy is not known to exist in meaningful quantities and would require hypothetical exotic matter, a no-go for real-world use — and possibly, the laws of physics.

However, one physicist says he has found a way around the historical negative-energy requirement. In his most recent paper, Erik Lentz, a postdoctoral researcher at the University of Göttingen, explained a way to bend space-time so that a craft can be transported faster than light with a warp drive using only positive energy.

Lentz laid out how a drive could be constructed to bend space-time in this way. It would contain a plasma made from a fluid with immense mass and electromagnetic fields, arranged in the shape of several slim diamonds around a spacecraft. They would produce a soliton or "warp bubble" made of bent space-time around the craft that transports it at any speed, including faster than light.

Although there is a possibly uncrossable chasm between Lentz's theoretical construction and practical interstellar spacecraft — for one, it requires the equivalent of about 10% of the sun converted to pure energy to travel at light speed — the paper is nevertheless the first to demonstrate that a warp drive can be consistent with the known laws of physics.

"This is kind of a childhood fascination come to life," Lentz said. "This project was something that I wanted to do since I was a kid, of course without any idea of the mathematics and rigor that would be necessary — even just research as preliminary as this."

Lentz began his research in late March 2020 as a cure for "cabin fever" during the start of the COVID-19 pandemic, he said. The physicist reviewed the scientific literature on warp drives, and he noticed mathematical pathways that had not yet been tried to construct space-time solitons that avoid the burden of exotic matter.

"There are two other classes that hadn't really been explored in the literature: parabolic and hyperbolic relationships between shift-vector components," which relate to the geometry of solitons, Lentz said. He "ultimately just pursued one of them in the paper, the hyperbolic relationship, to see if within that class of solutions a subset of solutions could be found that satisfied this positive-energy moving-warp-drive condition."

His study garnered significant attention from the day it was published on March 9. A Reddit post sharing a press release for the paper went viral, and soon after, Lentz's work was featured at media outlets such as *The Sun* and *Popular Mechanics*.

Its time in the limelight coincided with another popular *Classical and Quantum Gravity* paper on warp drives, which was authored by science and technology firm Applied Physics and concluded that classes of positive-energy warp drives exist.

Lentz said his inbox has been filled by many "enthusiastic" emails from the general public. The response from other scientists was more cautious; some were optimistic about the work, while others interrogated it with detailed questions.

One skeptical scientist is Ken Olum, a research professor of physics and astronomy at Tufts University. In 1998, Olum proved the theorem that all faster-than-light travel requires negative energy if the accompanying space-time geometry has a single pathway that is faster than all others, which can be described as "point-like."

He said that Lentz's warp drive is "very unlikely" to be correct because it is in violation of his theorem.

The new warp drive, however, has multiple equally fast pathways, meaning the theorem does not apply to it. But Olum said this distinction is "only a very technical point," and that any small disturbance to the warp drive would alter it and bring it under the purview of the theorem.

"When there is a theorem that rules something out, and a claim of a construction of the ruled-out thing, it's the theorem you should believe," Olum said. "Theorems require proofs, and the proof is generally examined closely by lots of people, so if there's a flaw, it gets detected."

"Meanwhile, new constructions may easily have flaws, and it may not be simple to find the flaw," he said.

But according to Lentz, who corresponded with Olum before the paper's publication, mathematically finding such disturbances is not as simple as the Tufts professor implies. Lentz said he has not yet been able to find perturbations that would reduce his warp drive's soliton into a point-like state, nor has he been able to rule out their existence.

Olum also believes his theorem extends to non-point-like solutions like Lentz's warp drive, even without perturbations, but he has not proved that conclusion.

"At this point, it is still somewhat of an open question how these two papers precisely mesh together. Or does one necessarily disprove the other?" Lentz said. "Well, the point-like proof appears fairly straightforward, but does my solution actually provide a counterexample to the broader extension of the proof that Ken believes exists?"

The Germany-based researcher acknowledges some missing details and shortcomings in his design that he hopes to pursue and improve in future research. The paper doesn't tackle how the warp drive would accelerate, decelerate or be constructed out of real-world materials. And although the drive's gargantuan energy requirement may be reduced with shortcuts, they are also dramatic approaches — one includes bending space-time to make a spacecraft appear microscopic to an outside observer before moving faster than light.

The published warp drive also struggles with the "horizon problem," Lentz said, which concerns the spacecraft's inability to communicate with the rest of the warp-drive soliton while traveling at faster-than-light speeds.

Andrew DeBenedictis, a professor of physics at Simon Fraser University, in Canada, said that the warp drive's avoidance of negative energy is "quite interesting" and has advantages over previous designs, despite the massive energy requirements. DeBenedictis, who in a 2018 paper similarly avoided negative energy in warp drives in a modified theory of general relativity, said he did not try to reproduce the calculations but found no reason to believe Lentz made any errors.

The professor also observed that scientists generally treat warp drives as an "academic curiosity" but do not believe they will realistically be built in the future. Previous studies have also shown that warp drives may be unstable and be destroyed by minor external disturbances, he said.

"As an avenue towards a realistic propulsion system, there is no chance that with anything even remotely associated with our current technology that we could produce such things," DeBenedictis said.

Lentz agrees with DeBenedictis on the perception of warp drives in the scientific community, and he believes that the transformative technology has a long road ahead before it could be feasible. But following his efforts to circumvent the assumed negative-energy requirement, Lentz said he wants to see what other theoretical progress can be made, and whether experiments can at least demonstrate related space-time-bending effects at some scale.

"I would like to spend some more time to see how much progress I can make — I haven't quite given up on it yet," Lentz said. "Seeing how the previous rule with exotic matter seems not to hold, perhaps some other wisdom is also in need of an update."

The study, "Breaking the warp barrier: hyper-fast solitons in Einstein–Maxwell-plasma theory," published March 9 in Classical and Quantum Gravity, was authored by Erik Lentz, University of Göttingen.