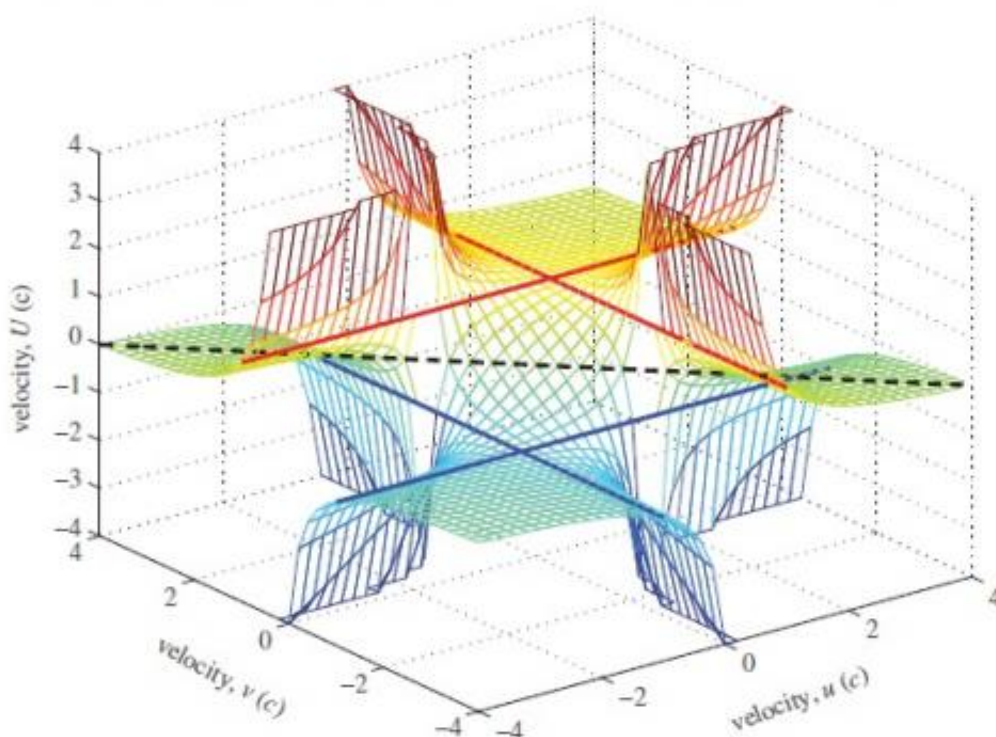


Physicists extend special relativity beyond the speed of light

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This 3D graph shows the relationship between three different velocities: v , u and U , where v is the velocity of a second observer measured by a first observer, u is the velocity of a moving particle measured by the second observer, and U is the relative velocity of the particle to the first observer. Image credit: Hill and Cox. ©2012 The Royal Society

(Phys.org)—Possibly the most well-known consequence of Einstein's

theory of special relativity is that nothing can travel faster than the speed of light, c . According to the mass-energy equivalence formula $E = mc^2$, an object traveling at c would have infinite mass and would require an infinite amount of energy to reach c . Over the past 100 years, numerous experimental tests of special relativity have confirmed its validity.

Now two [physicists](#) – James Hill and Barry Cox from the University of Adelaide in Australia – have shown that [Einstein's theory of special relativity](#) can be logically extended to allow for faster-than-light motion. They're quick to point out that their finding in no way contradicts the original theory, but simply provides a new aspect of it.

"As far as I'm aware, this is the first natural, logical extension of Einstein's own theories," Hill said. "We certainly haven't superseded Einstein. The two theories are entirely consistent."

There have been other suggestions of objects exceeding c – tachyons, for example – but these superluminal motions require complicated mathematics such as imaginary masses and complicated physics to ensure real, meaningful outcomes. In contrast, Hill and Cox's proposal arises from the same [mathematical framework](#) as Einstein's theory.

As the physicists explain in their paper, the Lorentz transformation is traditionally used in special relativity to reconcile different observations made by different observers in different inertial reference frames, and it applies to relative velocities less than the [speed](#) of light. Here the scientists have proposed two new transformations that complement the Lorentz transformation to explain different observations, and both new transformations apply to relative velocities greater than the speed of light. The physicists aren't sure which of the two new transformations is the correct one, and they don't ignore the possibility that both transformations may be equally plausible if for some reason Einstein's theory bifurcates at c into two variations.

The two new transformations apply for relative velocities between c and infinity (not including either). Like Einstein's [special relativity](#) with the Lorentz transformation, the proposed extensions break down at exactly c , resulting in a singularity. Passing through the speed of light is not defined.

As a result, the singularity forms a kind of boundary so that all inertial reference frames fall into one of two sets relative to some rest frame: those with a relative velocity less than c , and those with a relative velocity greater than c . The physicists explain that there is no objective way to identify whether a particular reference frame is in the subluminal or in the superluminal set of frames other than by reference to some arbitrary rest frame.

Although the theories cannot answer what happens at c , the scientists suspect that an object crossing the "light barrier" may have some very interesting consequences. They compare our current understanding of this boundary to that of an object crossing the sound barrier for the first time, an event that was highly disputed before it was achieved in 1947.

"People wondered what would happen," Hill said. "Were we all going to disintegrate? Would the plane fall apart? It turns out passing through the speed of sound led to a big bang. I suspect going through the speed of light will be more interesting. I have a feeling the world will change in some dramatic way as we move through the speed of [light](#). All sorts of things could happen. Time and space could interchange."

He thinks that an experimental test of such a feat is not out of reach.

"I think it's only a matter of time," he said. "Human ingenuity being what it is, it's going to happen, but maybe it will involve a transportation mechanism entirely different from anything presently envisaged."

More information: James M. Hill and Barry J. Cox. "Einstein's special relativity beyond the speed of light." *Proc. R. Soc. A*. DOI: [10.1098/rspa.2012.0340](https://doi.org/10.1098/rspa.2012.0340)

Abstract

We propose here two new transformations between inertial frames that apply for relative velocities greater than the speed of light, and that are complementary to the Lorentz transformation, giving rise to the Einstein special theory of relativity that applies to relative velocities less than the speed of light. The new transformations arise from the same mathematical framework as the Lorentz transformation, displaying singular behaviour when the relative velocity approaches the speed of light and generating the same addition law for velocities, but, most importantly, do not involve the need to introduce imaginary masses or complicated physics to provide well-defined expressions. Making use of the dependence on relative velocity of the Lorentz transformation, the paper provides an elementary derivation of the new transformations between inertial frames for relative velocities v in excess of the speed of light c , and further we suggest two possible criteria from which one might infer one set of transformations as physically more likely than the other. If the energy–momentum equations are to be invariant under the new transformations, then the mass and energy are given, respectively, by the formulae $m=(p_{\text{inf}}/c)[(v/c)^2 - 1]^{-1/2}$ and $e=mc^2$ where p_{inf} denotes the limiting momentum for infinite relative velocity. If, however, the requirement of invariance is removed, then we may propose new mass and energy equations, and an example having finite non-zero mass in the limit of infinite relative velocity is given. In this highly controversial topic, our particular purpose is not to enter into the merits of existing theories, but rather to present a succinct and carefully reasoned account of a new aspect of Einstein's theory of special relativity, which properly allows for faster than light motion.

[University of Adelaide press release](#)

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