NEWS

Special Relativity Reconsidered

Einstein's special theory of relativity reaches into every corner of modern physics. So why are so many trying so hard to prove it wrong?

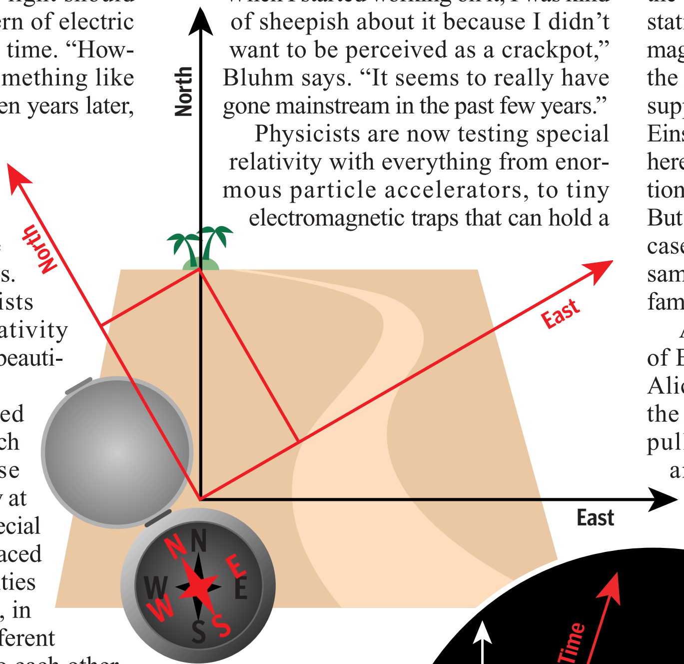
At an age when most boys would rather chase girls, Albert Einstein daydreamed of chasing light. When he was about 16 years old, Einstein later recalled, he realized that if he ran fast enough to catch up to it, light should appear to him as a wavy pattern of electric and magnetic fields frozen in time. "However," Einstein observed, "something like that does not seem to exist!" Ten years later, that insight blossomed into the special theory of relativity, which forbade catching light, overturned ancient conceptions of time and space, and laid the cornerstone for modern physics. Now, however, some physicists wonder whether special relativity might be subtly—and perhaps beautifully—wrong.

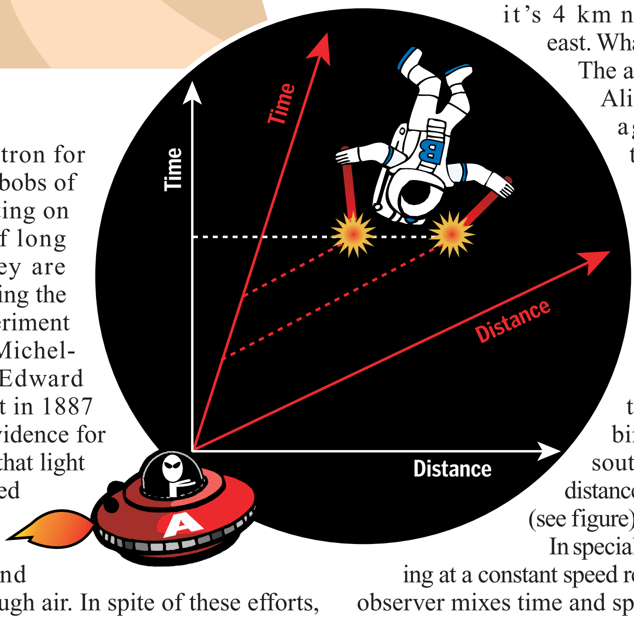
In 1905, physicists believed space was a grand stage on which the drama of the universe unfolded and time ticked away at the same rate for all actors. Special relativity denied all that. It replaced space and time as distinct entities with a single "spacetime" that, in mind-bending ways, looks different to observers moving relative to each other. But the theory's implications reach far beyond questions of when and where. Combined with quantum mechanics, it helps explain the stability of matter and even requires the existence of antimatter, says Steven Weinberg, a theoretical physicist at the University of Texas, Austin. "That's the only way nature can be if you're going to satisfy the requirements of both relativity and quantum mechanics," Weinberg says.

Yet a growing number of physicists are entertaining the possibility that special relativity is not quite correct. That may sound perverse, but researchers have good reason to hope Einstein's theory isn't the final word: Any deviation from special relativity could point physicists toward an elusive goal, a quantum theory of gravity. Candidate theories can be tested directly only with particle collisions a million, billion times more energetic than any produced with a particle accelerator. On the other hand, testing special relativity provides a far more practical, albeit indirect, way of probing quantum gravity, says V. Alan Kostelecký, a theorist at Indian University, Bloomington.

Only a decade ago, questioning special relativity would have struck many as heretical, says Robert Bluhm, a theoretical physicist at Colby College in Waterville, Maine. "When I started working on it, I was kind of sheepish about it because I didn't want to be perceived as a crackpot," Bluhm says. "It seems to really have gone mainstream in the past few years."

Physicists are now testing special relativity with everything from enormous particle accelerators, to tiny electromagnetic traps that can hold a single electron for months, to bobs of metal twisting on the ends of long fibers. They are even repeating the famed experiment by Albert Michelson and Edward Morley that in 1887 found no evidence for the "ether" that light was supposed to ripple through just as sound ripples through air. In spite of these efforts, special relativity remains inviolate—so far.





Unbearable coincidences

According to legend, Einstein invented special relativity to explain the Michelson-Morley experiment. In truth, he worried more about conceptual puzzles in the theory of electricity and magnetism, which had been hammered out in the 1860s by the Scottish physicist James Clerk Maxwell, says Michel Janssen, a historian of science at the University of Minnesota, Twin Cities.

Consider the simplest electrical generator—a loop of wire and a magnet moving toward each other at constant speed. Current will flow through the wire. According to Maxwell's theory, different mechanisms drive the current depending on whether the wire is stationary in the presupposed ether and the magnet is moving or the other way around. Yet the current is the same in either case. That supposed coincidence was too fantastic for Einstein. "The idea that we would be dealing here with two fundamentally different situations was unbearable to me," he later wrote. But Einstein found he could show that the two cases were different ways of looking at the same thing—if he abandoned the ether and familiar notions of space and time.

A simple analogy captures the essence of Einstein's insight. Imagine two explorers, Alice and Bob, lost in a vast desert. From the top of a dune they spot an oasis. Alice pulls out her compass and range finder and determines that the oasis is 5 kilometers due north. Bob takes his own measurements and finds that it's 4 km north and 3 km east. What's gone wrong?

The answer is simple: Alice and Bob disagree because their compasses don't line up. Each has a different notion of north, so what Alice takes to be a purely north-south distance, Bob takes to be a combination of north-south and east-west distances, and vice versa (see figure).

In special relativity, traveling at a constant speed relative to another observer mixes time and space in much the same way. For example, imagine that instead of explorers, Alice and Bob are astronauts in deep space. Suppose, in a fit of foolishness, Bob holds up a firecracker in each of his outstretched hands. He sets the explosives off as Alice zooms past at half the speed of light. If Bob sees both firecrackers flash at the same time, Alice will see them flash at different times. So what Bob perceives as a purely spatial distance, Alice perceives as a spatial

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