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Physicists Develop Test for 'String Theory'

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For decades, scientists have taken issue with “string theory”—a theory of the universe which contends that the fundamental forces and matter of nature can be reduced to tiny one-dimensional filaments called strings—because it does not make predictions that can be tested.

But researchers at the University of California, San Diego, Carnegie Mellon University, and The University of Texas at Austin have now developed an important test for this controversial “theory of everything.”

Described in a paper that will appear in the January 26 issue of the journal *Physical Review Letters*, their test involves measurements of how elusive high-energy particles scatter during particle collisions. Most physicists believe those collisions will be observable at the Large Hadron Collider, or LHC, a subatomic particle collider scheduled to be operating later this year at the European Laboratory for Particle Physics, or CERN.

“Our work shows that, in principle, string theory can be tested in a non-trivial way,” explained Ira Rothstein, co-author of the paper and professor of physics at Carnegie Mellon.

Rothstein and colleagues Jacques Distler, a professor of physics at The University of Texas at Austin; Benjamin Grinstein, a professor of physics at the University of California, San Diego; and Carnegie Mellon graduate student Rafael Porto developed their test based on studies of how strongly force-carrying particles called W bosons scatter in high-energy particle collisions generated within a particle accelerator. W bosons are special because they carry a property called the weak force, which provides a fundamental way for particles to interact with one another.

When the LHC turns on later this year, scientists will begin to investigate the scattering of W bosons, which has not been possible with other particle accelerators. Because the new test follows from a measurement of W boson scattering, it could eventually be performed at the LHC, according to the authors.

"The beauty of our test is the simplicity of its assumptions," explained Grinstein of UCSD. "The canonical forms of string theory include three mathematical assumptions—Lorentz invariance (the laws of physics are the same for all uniformly moving observers), analyticity (a smoothness criteria for the scattering of high-energy particles after a collision) and unitarity (all probabilities always add up to one). Our test sets bounds on these assumptions."

He added, "If the test does not find what the theory predicts about W boson scattering, it would be evidence that one of string theory's key mathematical assumptions is violated. In other words, string theory—as articulated in its current form—would be proven impossible."

"If the bounds are satisfied, we would still not know that string theory is correct," said Distler. "But, if the bounds are violated, we would know that string theory, as it is currently understood, could not be correct. At the very least, the theory would have to be reshaped in a highly nontrivial way."

String theory attempts to unify nature's four fundamental forces (gravity, electromagnetism, and the strong and weak forces) by positing that everything at the most basic level consists of strands of energy that vibrate at various rates and in multiple, undiscovered dimensions. These "strings" produce all known forces and particles in the universe, thus reconciling Einstein's theory of general relativity (the large) with quantum mechanics (the small).

Proponents say that string theory is elegant and beautiful. Dissenters argue that it does not make predictions that be tested experimentally, so the theory cannot be proven or falsified. And no particle accelerator yet exists that can attain the high energies needed to detect strings. Because of this technical limitation, tests of string theory have remained elusive until now.

"Since we don't have a complete understanding of string theory, it's impossible to rule out all possible models that are based on strings," said Rothstein. "However, most string theory models are based upon certain mathematical assumptions, and what we've shown is that such string theories have some definite predictions that can be tested."

Source: University of California, San Diego, By Amy Pavlak and Kim McDonald

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