BOOKS: PHYSICS

The Seductive Melody of the Strings

Sidney Perkowitz

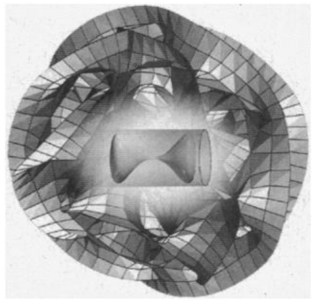
Scientific literacy seems to be in short supply among the American public. Too many graduates of our best universities do not know the ABC's of science, such as basic facts about the solar system. Mathematics and physics may be the biggest problems; in fact, physicists learn to suppress a sigh when a new acquaintance says, almost inevitably, "physics was my worst subject in college." Yet people love hearing about exotic physical ideas, from quantum computing to black holes. That explains why books like Brian Greene's *The Elegant Universe* get written; the difficulty of conveying cutting-edge physics explains why such books are hard to write well.

Greene, a physicist at Columbia University, works in the area called string theory and does his best to present its abstract ideas to the general reader. The heart of the theory is this: physicists have long thought that the minuscule electrons, quarks, and so on that constitute matter at the smallest scale behave like mathematical points. String theory says no, there is a deeper structure: Each elementary particle is a particular mode of vibration of a minute oscillating string. To use a classical image, this change of perspective is like replacing Euclid's perfect geometric points with the harmoniously thrumming strings that Pythagoras related to the music of the spheres. That isn't all, for these elementary-particle strings vibrate in ten dimensions of space-time. We see only four, because six of the dimensions are "rolled up" or "compacted" into a tiny format.

The Elegant Universe
Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory
by Brian Greene
Norton, New York, 1999. 464 pp. $27.95. ISBN 0-393-04688-5.

If you are unused to the dizzying heights of theoretical physics, if you trust visceral reactions more than equations, all this talk of strings is extremely strange. But we have learned to live with weirdness. After nearly a century, both quantum mechanics and the theory of relativity remain full of puzzling outcomes remote from ordinary human experience. Yet both theories work—they give predictions that can be verified by experiment.

So Greene makes a valid point when he urges his readers not to dismiss string theory just because it seems odd. Still, why would we want to substitute intricate vibrating systems for the purity of dimensionless points? This seems to violate an axiom stated by the English philosopher William of Occam in the 14th century, and still beloved by scientists: "What can be done with fewer assumptions is done in vain with more." Moreover, there is the embarrassing fact that this refined mathematical edifice has yet to produce clear predictions that can be experimentally confirmed. This shortcoming has engendered considerable controversy over the value of the approach, which has been criticized by the likes of the Nobel laureate Sheldon Glashow, whose research has deeply probed elementary particles and their interactions. (Glashow proposed the existence of the "charm" quark, which was later found; and, with Steven Weinberg and Abdus Salam, he showed that electromagnetism and the weak nuclear force—two of the four fundamental interactions that make the universe work—are aspects of a single "electroweak" interaction.)



String shield. By encircling a tear in the fabric of space, a string can prevent the catastrophic effects that would otherwise be encountered.

But as Greene explains it, the apparent complication is actually a great simplification, worth pursuing because the prize is so tempting. String theory seems to unite quantum physics, which describes the smallest scales, with general relativity, Einstein's theory of gravity that describes the biggest structures in the universe. Such unity has long been the brass ring that physicists strain to reach. Our best effort so far, the Standard Model, correctly describes the elementary particles and goes beyond electroweak theory to include the strong nuclear force. But it does not explain gravity, the fourth force. Now strings offer the possibility of including that as well to give, finally, a "theory of everything."

Greene's style in explaining string theory follows many of the prescriptions about science writing I give my students: a look at the history of the subject (it all began in 1968, with an insight made by a young theorist named Gabriele Veneziano); plentiful application of metaphor and analogy; and—often overlooked—the use of pictures when words fail, expressed here with especially handsome drawings. But to provide sufficient background to appreciate the potential power of the theory, Greene must cover quantum physics and general relativity as well as strings themselves. This is a lot of deep material, and its presentation is not helped by the dense writing and level of detail in much of this 450-page book. For the non-expert, less would have been a great deal more.

Nevertheless, Greene's belief in strings comes through as he writes about what it means to have a theory that awaits experimental verification, and his stake in that. Greene is correct in saying that opinion among even Nobel laureate physicists is turning toward giving strings a chance, if only because no better theory is available; still, he puts the rosiest possible spin on the prospects for confirmation. This is perfectly understandable, for Greene is one of the string theorists who, he writes, "know that they are taking a risk; that a lifetime of effort might result in an inconclusive outcome."

The risk seems enormous when we consider that the most direct test of string theory would require a particle accelerator at least the size of our galaxy. For the ultimate benefit of physics, and to save a great deal of theorizing from going to waste, let us hope that a more attainable test will show whether reality truly does dance to the music of these particular strings.

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BOOKS: CHEMISTRY

Toward Benign Ends

Walter Leitner

The "green" vogue has hit chemistry! "Green chemistry" is now an established part of the Gordon Conference series, and the Royal Society of Chemistry has just launched a new periodical with the same title. "Green chemistry," "sustainable chemistry," "clean chemistry," "environmentally benign synthesis," and other synonyms for the same approach find increasing attention and application in industry. The topic is currently entering many re-