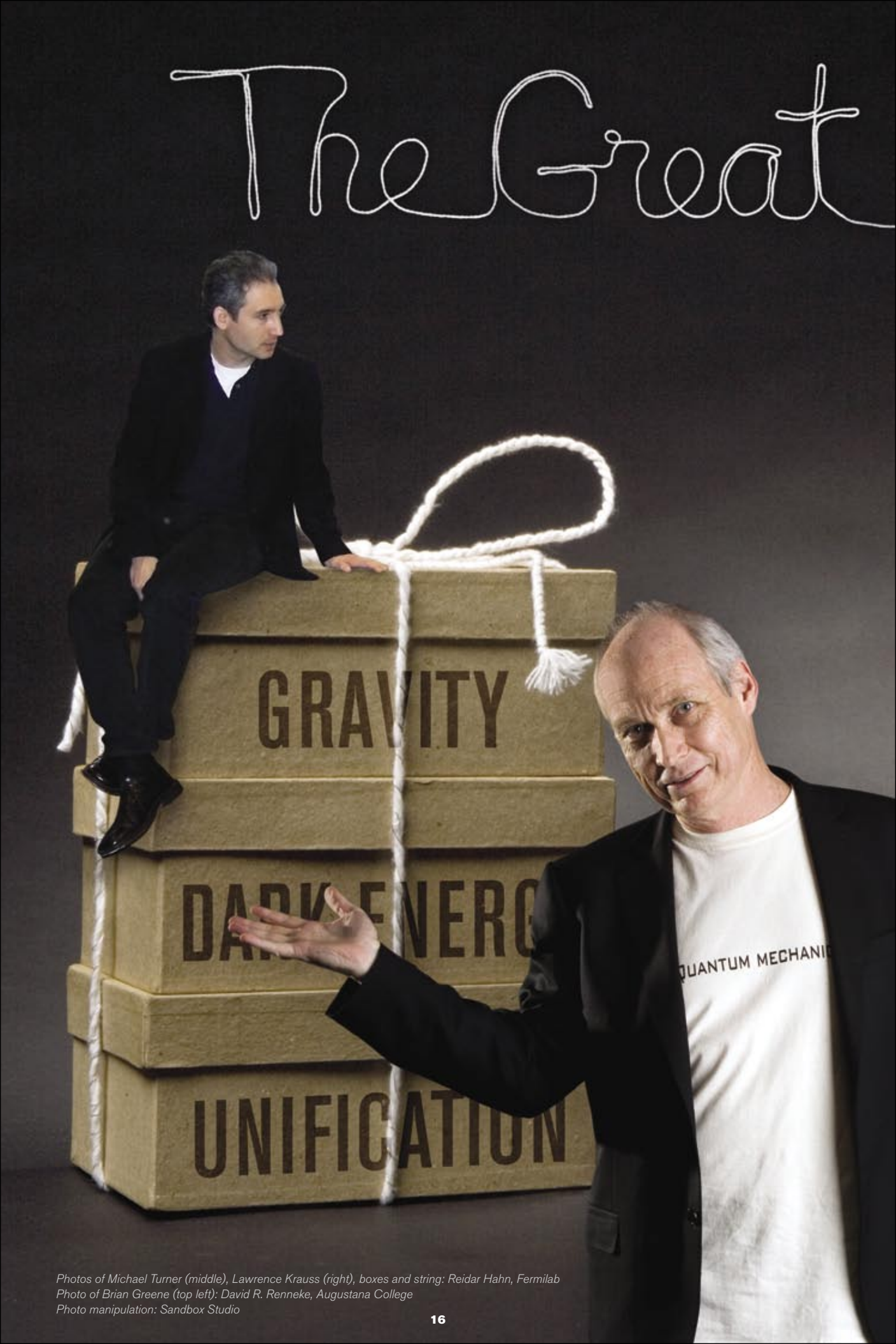
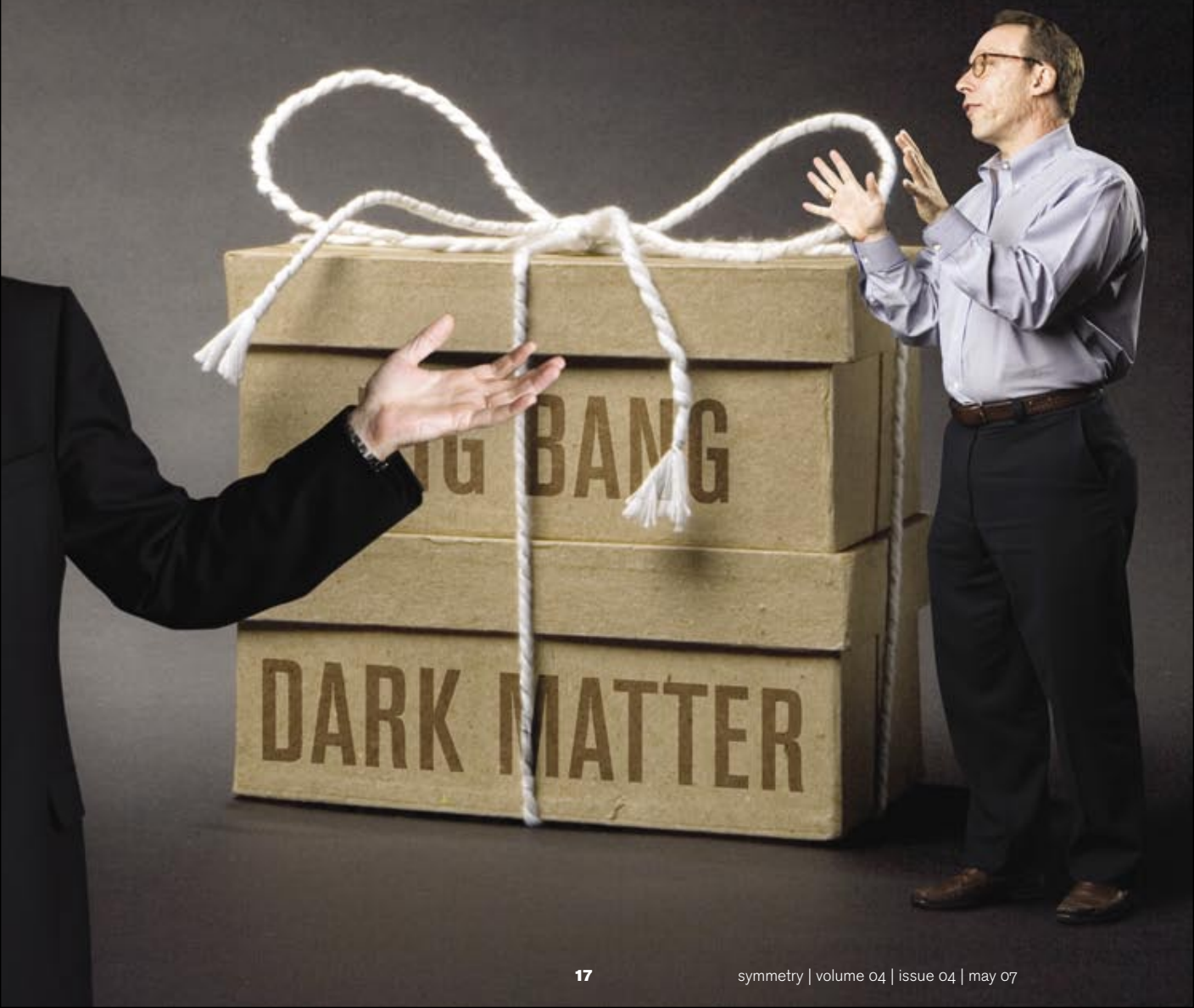


Photos of Michael Turner (middle), Lawrence Krauss (right), boxes and string: Reidar Hahn, Fermilab
Photo of Brian Greene (top left): David R. Renneke, Augustana College
Photo manipulation: Sandbox Studio

String Debate

WISECRACKS FLY WHEN BRIAN GREENE AND LAWRENCE KRAUSS TANGLE OVER STRING THEORY. BY GLENNDA CHUI



Photos: John Boswell

Inside, the auditorium at the National Museum of Natural History in Washington, DC, was packed and humming in anticipation. Outside, a man waved a sign at stragglers hurrying for the door: "Need One Ticket for String Theory Debate."

Onstage, there would be surprises.

In the hands of two seasoned popularizers of science—theoretical physicists Brian Greene and Lawrence Krauss—what could have been a scientific food fight turned out to be a lively back-and-forth full of zingy one-liners and laughter.

The fact that the March 28 debate sold out the museum's 600-seat Baird Auditorium reflected both the star power of the debaters and the delight people take in ideas that boggle.

Greene, a professor of mathematics and physics at Columbia University, began delving into string theory as a graduate student. His first book, *The Elegant Universe*, sold 1.2 million copies and spawned a three-hour PBS miniseries; his second, *The Fabric of the Cosmos*, spent six months on the *New York Times* best-seller list.

Krauss—Greene's "very worthy opponent, in the same height and weight class," cracked moderator Michael S. Turner—is a professor at Case Western University and a pioneer in applying particle physics to cosmology. Often described as a "public intellectual," he has written seven popular books, including *Hiding in the Mirror: The Mysterious Lure of Extra Dimensions, from Plato to String Theory and Beyond*, and the international bestseller *The Physics of Star Trek*. He has also fought to defend the teaching of evolution in public schools.

Turner, a well-known astrophysicist at the University of Chicago, channeled the discussion with a series of questions.

Too often, he said in his opening remarks, discussions of string theory—the controversial notion that the fundamental building blocks of the universe are not particles, but tiny, vibrating strings—"have generated more heat than light. There have been some strong statements exchanged, like 'String theory is a theory of everything,' or 'String theory is a theory of nothing,' or 'String theory is not a science,' or 'Those who don't embrace string theory will be left behind.' The only good thing about that last one is I don't think they're talking about the rapture."

Later, in an interview, Turner said the problem with this kind of heated debate is that "instead of people going away feeling excited by the science, they feel a little dirty. Well, gosh darn it, there are exciting things going on. Here's an opportunity to have some high-level discussion."

It was Turner who proposed the event, which was co-sponsored by the Department of Energy's Office of Science and the Smithsonian Associates. He says he didn't want it to be the classic high-school-style debate, aimed at scoring points by rhetorically stomping out opponents. Instead, it would use the debate format—and the heightened buzz that debates often generate—to let people know "we are on the verge of a major revolution in our understanding of the universe and the laws that govern it. This revolution, I think all three of us believe, promises to be as profound and as exciting as the one launched by Einstein and others 100 years ago with quantum theory and relativity theory," as he put it in the debate's opening moments.

Judging from the audience's reaction, the strategy worked.

"I thought it was very thought-provoking," said Stephanie Gotfried, a teacher from Stone Ridge, Virginia, as she headed for the exit. "It just makes us realize how tiny we are in the big picture. I liked the camaraderie, and the sense of humor throughout. In my opinion it's all good even if something doesn't pan out. It still focuses our interests and allows us to go forward."

CONTROVERSIAL FROM THE START

Although string theory dates back to 1970, the field took off in the mid-1980s when researchers realized it had the potential to be the long-sought Theory of Everything—one that unifies the physics of the familiar, everyday world with the odd quantum behavior of atoms and even smaller things. A second wave of theoretical breakthroughs in the mid-1990s drew even more people into string theory research.

But skeptics are many, and they came out in full force last year with the publication of two books critical of the theory: *Not Even Wrong*, by Peter Woit of Columbia University, and *The Trouble With Physics*, by Lee Smolin of the Perimeter Institute in Canada.

Right or wrong, string theory has been drawing big crowds—from more than 900 people at the first Isaac Asimov Memorial debate in 2001 to a sold-out crowd at the 2003 Aspen Institute Ideas Festival.

More than an airing of opposing views, the March debate in Washington, DC, was also a contrast in styles. On one side of a low wooden table, Greene, in black and gray, leaned back in his chair like a guest on a TV talk show. Across the table, Krauss, professorial in a rumpled coat and tassled loafers, leaned forward, elbow on knee, and rested his chin on his hand, waiting for an opening for the perfect jab.

The challenge was to get the talk flowing at just the right level. String theory—actually a set of related theories that differ in the details—is so incredibly complex that it takes a solid grasp of mathematics to understand the nuances.

Yet, according to Greene, it's also the simplest thing in the world.

"In my mind," he said, "one of the wonderful things about string theory is that although it's a highly technical subject and you can delve into the mathematical details, the basic idea is far simpler than, say, the basic ideas in relativity and quantum mechanics."

The past decades have seen scientists break down the universe into smaller and smaller components, from molecules to atoms, to protons, neutrons, electrons, and quarks, and to particles that carry the forces that hold all these parts together.

String theory, Greene says, "simply takes that picture one step further and envisions that inside those particles is something else, and that something else would be a little filament of vibrating energy that we call a string."

"STRING THEORY ENVISIONS THAT INSIDE THOSE PARTICLES IS SOMETHING ELSE, AND THAT SOMETHING ELSE WOULD BE A LITTLE FILAMENT OF VIBRATING ENERGY THAT WE CALL A STRING."
Brian Greene

Brian Greene (far left) and Lawrence Krauss

NO EVIDENCE YET

Detractors, including Krauss, contend that after 37 years of effort, string theory has produced no experimental evidence to back it up and no testable hypothesis that could lead to those experiments.

"The point I want to make is it really hasn't lived up to its promise," Krauss said. "It hasn't really explained any of the things that originally we hoped it would explain. It, in fact, has gotten less and less clear as time goes on what the theory even is, and it's less and less clear what the ultimate predictions, if it can make them, are." In particle physics, he added, discoveries come from the interplay between theory and experiment, and "that interplay is missing in string theory. That doesn't mean it's wrong, but it means it's worrisome."

Greene shot back that the theory does make predictions, but testing them is beyond the reach of current technology. "Naturally," he said, "you'd like to make a powerful microscope and look down and say, 'There it is, the string!' But the strings we envision are pretty damned small, about a billion billion times smaller than the distances we can probe with even our most powerful accelerators."

He added that no matter how radical string theory sounds, its proponents are not trying to step outside the scientific method: "We will not believe this theory until it's experimentally tested."

Greene said he's hoping to find evidence for string theory out in the cosmos, in the heat signature left over from the big bang that gave rise to the universe.

Experiments at the Large Hadron Collider, scheduled to start up next year at CERN, a particle physics lab near Geneva, Switzerland, could produce results that, while not directly confirming string theory, would at least reassure its supporters that they're on the right track. Although it's a long shot, the collider could bounce particles into other dimensions or detect the vibrational resonances of the strings themselves.

On this final point, the opponents found a scrap of common ground. "If I saw a lot of resonances," Krauss said, "it would be an indication that string theory is heading in what could be the right direction." Although, he added, it would still not constitute proof.

"You're being really grudging here, Lawrence," Greene quipped, setting off a collective chuckle from the audience.

Nor, Krauss conceded, are there any viable alternatives to string theory at the moment.

Turner shot the audience a bemused look over the rims of his glasses. "What I heard Lawrence say is we don't have any better ideas right now," he said.

"Well," Krauss said, "I dunno if, well, we…I'll cede that for the purpose of moving on."

More laughter.

"THE POINT I WANT TO MAKE IS IT REALLY HASN'T LIVED UP TO ITS PROMISE."
Lawrence Krauss

ADVANCING SCIENCE

Krauss also acknowledged that the theory has pushed research ahead in one respect: "It has caused people to think of what might be possible if there are lots of extra dimensions." And not tiny ones, either, he said. "There may be infinitely big extra dimensions that we can't see. It's a fascinating idea and I have to say it might not have come up except for string theory."

No matter what the pros and cons might be, string theory has attracted hundreds of young theorists, to the dismay of some who fear the field has become unbalanced and that other potentially promising areas are being neglected as a result.

Proponents say young people are simply voting with their feet, confirming that string theory is the most exciting thing around.

"I do think it's important to recognize, in the marketplace of ideas, the fact that so many students want to work on string theory," Greene said. "These are hungry students. I have to tell you that in my experience they are the most critically minded scientists I have met. They always push back, to try to find a flaw or a hole in it."

Krauss shot back: "Some of my students have gone on to become relatively well-known string theorists. And, you know, I wouldn't want my daughter to marry one, but still…," setting off the biggest round of laughter of the evening.

He continued, "I firmly believe that students should work on whatever interests them, and physicists should work on whatever interests them. They have to be driven by their curiosity…. The only reason to do this is because you find it exciting and fascinating."

Krauss did add, however, that from his point of view string theory has been in the doldrums for five or ten years, with more students and faculty turning to other things: "I actually think the minute one of the colliders finds something exciting, you're going to see a lot of rats jumping the sinking ship."

Not so, according to Greene. The field went through two exciting, even revolutionary, periods in the 1980s and 1990s, he said, and while it is not operating at that same intensity today, "it has not been in the doldrums at all."

THE HARDEST QUESTIONS YET

"This is a really difficult problem, the really big picture, and it's going to take a long time," said Greene. "I'm saying this is not the time to judge the theory. We are trying to answer the most difficult, the most profound questions in the history of science…. [Even] if we haven't gotten there in 50 or 100 years, that's a pursuit we should keep on with."

Greene and Krauss say they've been talking about taking their string theory show on the road, not as a debate but as a series of public discussions. With this in mind, both are involved in the World Science Festival scheduled to take place next year in New York City—Greene as co-founder and Krauss on an advisory board. Aimed at the general public, the festival will encompass about 40 events, ranging from lectures and theater, to music and film (see http://www.sciencefestivalfoundation.org/).

If the perspectives of the people who came away from the March debate are any indication, there's still a healthy appetite out there.

Dale Newcomb, a 3D graphics programmer from Leesburg, Virginia, had brought his copy of *The Elegant Universe* for Greene to autograph. His wife, Chris, a technical editor, calls herself a physics newbie.

"I think it was interesting," she said. "They were very witty. It was fun to see them play off each other."

He, nodding: "It could have been very, very dry, but instead…I'll be back for the next one, that's for sure."

Photos: John Boswell