Smithsonian.com

PRINTTHIS
Powered by Limelight

Lisa Randall's Guide to the Galaxy

The famed cosmologist unveils her latest theories on the invisible universe, extra dimensions and human consciousness

By Ron Rosenbaum

Smithsonian magazine, June 2013,

Lisa Randall is telling me she may have a clue to the next great mystery in cosmology.

We are having lunch in a restaurant at the Charles Hotel, not far from Harvard where she teaches theoretical physics, with specialties in particle physics, string theory, mathematics, astrophysics and cosmology. Randall, a slender woman, now 50, reminds one of a younger Joan Didion—light-years of consciousness behind her eyes.

She is a star professor of the stars, a cosmological celebrity, and only in part because she is the first female theoretical physicist tenured at Harvard . It was really her conjecture in the late '90s about string theory's "extra dimensions" that gained her prominence in the field. She garnered more attention for her explication of the Higgs boson quest, and for her subsequent writings attempting to explain to the rest of us what she does and how exciting it is to do it, most recently *Knocking on Heaven's Door*.

And now she thinks she and her Harvard physics colleagues have found something new. What she is excited about is "dark matter," which—along with "dark energy"—makes up the vast majority of the known universe. The current estimate is that 70 percent of the universe is dark energy and 26 percent dark matter. Which adds up to 96 percent. Meaning that what we see and know adds up to a measly 4 percent.

Four percent! The invisible 96 percent apparently keeps the universe in gravitational equilibrium, preventing it from collapsing on itself or dissipating into virtual nothingness. But we know almost nothing else about it. The problem has been that the dark stuff doesn't seem to interact with the 4 percent we know in such a way that gives us a clue to its nature.

But Randall believes she may have found a clue. In fact, the day before we met she delivered a talk at an American Association for the Advancement of Science conference in Boston in which she announced that she may have found evidence of the interaction of dark matter with our matter. A potentially sensational development for cosmologists just now setting out into the uncharted vastness of the dark matter universe.

It started, she tells me, because "there was a signal that I wanted to understand."

"A signal from outer space?" I asked her.

"A signal from a satellite that could see into the center of a galaxy." Far, far away, near the heart of the Milky Way, two infinitesimally small dark matter particles could have collided and "annihilated" each other. But instead of leaving no trace, signals of the annihilation traveled across the vastness of space to be detected by the Earth-orbiting Fermi satellite. If those signals are validated, Randall says, they might be evidence of dark matter interactions—perhaps the first legible fingerprints of dark matter to be picked up in our humble 4 percent realm.

"I know full well that the signal may be spurious," she says, but what's important "is the process of trying to make a model that predicts it. I was considering a model where there were interactions for the dark matter and then realized that actually this is a whole other scenario that's interesting in its own right, and in fact works better and could lead to a cooling off of a component of dark matter, which would make it collapse into the disk the way baryons do."

At this point, where "the baryons collapse into the disk," I am totally lost, but "the important thing," she continues, "is that it's just a scenario that oddly enough no one has considered. People thought about dark matter interacting—but having all the dark matter interacting. And [in this model] it's very constrained." It's an infinitesimal piece of the 96 percent deigning to interact with our poor, pitiful 4 percent.

The reporter in me suddenly feels this could be a huge scoop, a cosmic scoop—just yesterday the curtain may have been lifted on much of the 96 percent of the universe we have been clueless about. But the math program dropout in me despairs at truly understanding what she's telling me.

Fortunately, she shows me a copy of her notes for her AAAS talk, titled "What Is Dark Matter?" Although it leaves many things obscure to me, it gives a great sense of her voice when speaking to her peers—careful but sometimes exuberant.

Here are a few samples:

—It's not dark—it's effectively transparent!
—Hopes to see it based on it being a little opaque.
—Talk today...alternatives to standard WIMP paradigm.

WIMP, Randall tells me, stands for "Weakly Interactive Massive Particles," the dominant paradigm about dark matter to this point.

—Why should everything be like our matter?
—What is mysterious is that energy stored in dark matter and ordinary matter is so similar.
—Experimental Lampposts: LHC.

(The LHC is the Large Hadron Collider, the multibillion-dollar particle accelerator on the Swiss border that found evidence of a Higgs particle—or "something more elaborate," as she says in the new preface to *Heaven's Door*, since she believes there are some ambiguities in the evidence that the

Big Discovery actually was a Higgs particle. The LHC is in the shop now, so to speak, getting retrofitted to produce even more astoundingly energized collisions of particles, which, she told me, might discover more anomalies that indicate something about dark matter.

—Waiting for higher energies, more intensity.
(Aren't we all?)
—Don't know yet if this lamppost in the right region.
(Meaning not Switzerland but super-subatomic infinitesimality.)
Now here's her signal:
—Dark matter particle hits another dark matter particle and annihilates.
—Annihilation produces Standard Model [already discovered 4 percent type] particles.
—Not dark!

After that there's a page headed, in nearly inch-high letters:

—This changes everything!

She concludes with these wry lines:

—I know what everyone wants to know is when will we see dark matter.
—Answer could be sooner—or later—than we think!

It seems fairly certain that when it happens, if it happens anytime soon, Lisa Randall will be among the first to know.
(Recent reports emerging since our talk hint at other possible dark matter observations, but Randall believes her partial interaction scenario is still salient.)

***

Although Randall's work takes her thoughts into outer space, it is a question about another dimension, inner space, that she gives the most elaborate answer to during our lunch. The subject comes up near the end, as she is spearing forkfuls of my blueberry cobbler. I ask her about human consciousness—the dark matter within us—namely whether she has thought about the mind/brain question: Is the mind the product of the brain, all our thoughts neurochemically determined (as the "materialists" say), or is the mind not a slave of the physical brain, somehow capable of free will (as the "dualists" believe)? Or can we never answer that question? The philosopher Colin McGinn calls himself a "Mysterian" as an homage to the '60s one-hit wonder band ("96 Tears") Question Mark & The Mysterians because he thinks our consciousness may never be capable of comprehending the mystery of its own nature.

Randall seems to take McGinn's argument as a challenge: "First, I think it's always a mistake to say 'never,' because we probably can understand a lot more about it even if we don't ultimately understand it. Second, we haven't been trying to answer this question for a very long time. We understand a lot of things now that we didn't understand before. And it's terrifically hard, because we don't even know what we mean by consciousness."

What Randall talks about when she talks about consciousness is a continuum.

"I do think one mistake we often make is we think of it as a binary thing, like we're either conscious or not conscious. I think there's a spectrum of consciousness and I think it's interesting to study that—the difference between a plant and a dog, the difference between a dog and a baby, between a baby and a slightly older human... I think it's sort of a continuum." Looking at it that way, she says, "would be a good start."

"I'd love to see you take that on," I say.

"Yeah maybe I'll take that on next," she replies, laughing—next after solving the question of the 96 percent of the universe we don't know about.

Her notion of a continuum of consciousness reminds me of an observation by the great Shakespearean director Peter Brook. "To say someone is alive is not enough," Brook said. "You can be one percent alive, you can be twenty percent alive. With Shakespeare one has something very extraordinary—a man who's not merely a hundred percent alive, but perhaps a thousand, even ten thousand, a million percent alive."

This is what we find so fascinating, so awe-inspiring about cosmologists, astrophysicists, mathematical geniuses. How much more alive to the nature of existence—to the vast realms of extra dimensions—they seem to be. What must that be like? Thrilling, frightening, perhaps isolating since there are so few humans on earth who can comprehend it, much less share it.

I ask Randall about the question of how inspiration figures into her work. She has quoted the great Russian poet Pushkin: "Inspiration is needed in geometry just as much as in poetry." The inspiration for her career-making notion of "extra dimensions," she then tells me, came on a walk she took across the old stone-arched bridge over the Charles River.

"You got the idea for extra dimensions on that bridge?" I ask her.

She declines to burnish the anecdote—there's already a lot of famous eureka-moment stories in the annals of physics—and just says, "Well, it was an insight," pronouncing the latter word in a self-deprecating way. An insight doesn't necessarily mean a new truth. Sometimes it's just a new way of looking at things. "A lot of the time when we're doing our work, we're [indoors], putting formulas together, and sometimes you don't think about it as the world you're living in." Taking that walk, she says, "it was just kind of fun to think maybe there are these extra dimensions."

Extra dimensions meaning mathematical realms beyond the three (or four if you count time—and you should) we are familiar with. String theory now counts up to at least 11 dimensions. Along the way, as it got more complex, it's become more controversial. In fact, in one of her rare displays of emotion during our lunch, Randall told me she was "fed up with people asking about what Lee Smolin says" about string theory. Smolin is a respected if contrarian theoretical physicist who argues string theories have gone too far in building castles in the air. Randall is protective of her extra dimensions.

Despite her affection for the Pushkin quote, she tells me she doesn't like to think of her work as being purely fired by "inspiration." She calls that

"top-down" thinking—coming up with a high concept first and then trying to find structures to support it. She prefers bottom-up thinking. Indeed she describes her method, with some humility, as mere "puzzle solving" and finds the best metaphor for it in her favorite sport, rock climbing.

"You're outside. It's beautiful," she says, "It's focused on an interesting problem...and you're getting up somewhere." Figuring out which pathway up a rock cliff will be fruitful and which will lead to a dead, or perilous end—and then doing it. With all the risks and dangers that entails. (She had a "bad fall" climbing in Greece not long ago, she says.) She takes that same step-by-step approach in her work. As a result, she is less than infatuated with romantic science-world terms like "beauty" and "elegance." "I don't think in terms of 'truth is beauty' or 'beauty is truth,'" she says. "I prefer what works, not elegant so much as economical"—if not the shortest distance between two points, the simplest way to get there.

Even to an outsider, it's apparent that Randall is not only doing important science but she's also doing something very brave in the culture of science. In her talk, she's taking on the biggest mystery of the universe and telling the mostly male scientific community, who had favored the WIMP model, that they may be off course. One has to avoid the tendency to think of it as Nancy Drew versus the Hardy Boys.

You knew we'd have to talk about gender at some point, didn't you?

Harvard was ground zero for the gender-and-science wars several years ago when Larry Summers, then president of the university, made the incendiary suggestion that the reason there are so few women at the top of math and science professions might be that women are just not as suited for science and mathematics. With the implication that it was not cultural conditioning but genetic brain wiring.

"You've probably answered this question a million times," I say to Randall, "but let me ask you in a different way: not whether women are better or worse, but whether there's a difference in the way women perceive scientific questions."

"The thing I will say is that probably culturally, women are treated differently," she says, "which means I think you're criticized more, you have to listen a little bit more, you have to justify yourself. So I think there are ways that you probably have to work harder. I can be a good listener. I can ask the right questions a lot of the time. Often not being quite at home, you see things a little bit differently.

"It could be a good thing and a bad thing, right? You see things kind of like when foreigners come to a new country, see things a little bit differently."

Hear signalsothers don't...

"And, you know, I grew up pretty much in the same world, pretty much went to the same classes [as male peers], but you have a slightly different experience..."

The focus on science is misplaced, she says, in the gender discussion. "It's part of a bigger issue about women in society and I think [the focus on science] is like trying to solve the problem of a dying tree by looking at a little tiny root somewhere."

***

From the ends of the universe to the end of the universe: talking to Randall I recalled Woody Allen in *Stardust Memories* bemoaning a report that the universe will end when all matter "decays" after trillions of years. His gloomy implication—one that remains a contemporary subject of debate among physicists and philosophers—was that the cosmos has no ultimate purpose, no "teleology," and so what's the point of all of our striving to create lasting meaning when nothing lasts. Cheery, no?

I was glad I had the opportunity to ask one of the world's leading cosmologists her view of all this: "How do you think the universe will end?" I asked her.

"Given the energies we know, and the matter we know about," she says, "it's just going to keep expanding and the stuff that's around will eventually form black holes and it will eventually radiate away and will eventually expand into dilute nothingness. That's one guess. It's interesting," she says, "That's where it looks like it's going right now."

Not entirely different from Woody's fears—though without even a hint of Woody Allen angst. Rather a kind of cosmic equanimity. But that's not to say that Randall is incapable of joy, of expressing what it's like to feel the thrill of cosmic awareness. When I say I'm dismayed by our ignorance of 96 percent of the universe, after all this time studying it, she has another take on it: "I guess I think of it differently," she says. "I guess I think it's amazing that we know as much as we do. We're just people stuck on this planet in the midst of the solar system. It's incredible how much we've figured out. And why should everything be so much like us that we can figure it out? Even just something simple like knowing what plant life will be like in Africa, it's hard to do unless you actually get there, so we're in this one location and it's amazing how much we've figured out" about the places—deep space—we haven't been and may never go.

It is that sense of perspective—of different dimensions—that is so impressive with someone like Randall. So you can imagine the thrill of (nonscientific) discovery I felt when I found a new dimension to her—in the libretto of an opera she had written. Yes, Lisa Randall has written an opera, called *Hypermusic: Prologue,* at the invitation of Hèctor Parra, then a professor of electroacoustic composition at the Conservatory of Music of Aragon in Spain. The opera was first performed at the Pompidou Center in Paris and subsequently in Barcelona and, in excerpts, at the Guggenheim in New York City.

It incorporates passages from her books as well as original lyrics and it's very avant-gardish, but, simultaneously, almost shockingly impassioned in a very old-fashioned way.

Here are a few moments:

The soprano, the Lisa Randall figure, enters, in "PLANE 1," wondering:

—This landscape...?
This stage for our being?
Where is it?
Where does it end?

Structures support existence
Can I find them?
[or are they]
Puzzles I will never decipher from here.
Which is followed by the naked expression of:
—Anguish
Distortion.
Agony.

(You have to imagine these words dramatized by an operatic soprano.)

But in "PLANE III: FEAR AND HOPE" the conjecture about extra dimensions changes things:

—This step—a new dimension—
excites me
beyond anything I have ever felt.

Then suddenly in "Plane IVA," things get a little trippy as...

—I enter the fifth dimension...
—Space
and time
are alive!
—I see more—
The full extent of our universe...!!

There's more but I'll leave the opera text with her two exclamation points.

She ends PLANE V with:

—How do I share this with you?

And in a way, in the operatic form, she's found a means of sharing the operatic emotions, her sense of wonder and awe at experiencing the cosmos. The extra dimensions within her mind. Randall can't bring us to her visionary level, but she can give us a sense of how thrilling and frightening and ultimately fulfilling it is to have such visions. To be, let's say, one thousand percent alive.

Find this article at:
http://www.smithsonianmag.com/science-nature/Lisa-Randalls-Guide-to-the-Galaxy-208338141.html

☐ Check the box to include the list of links referenced in the article.

© Smithsonian Institution