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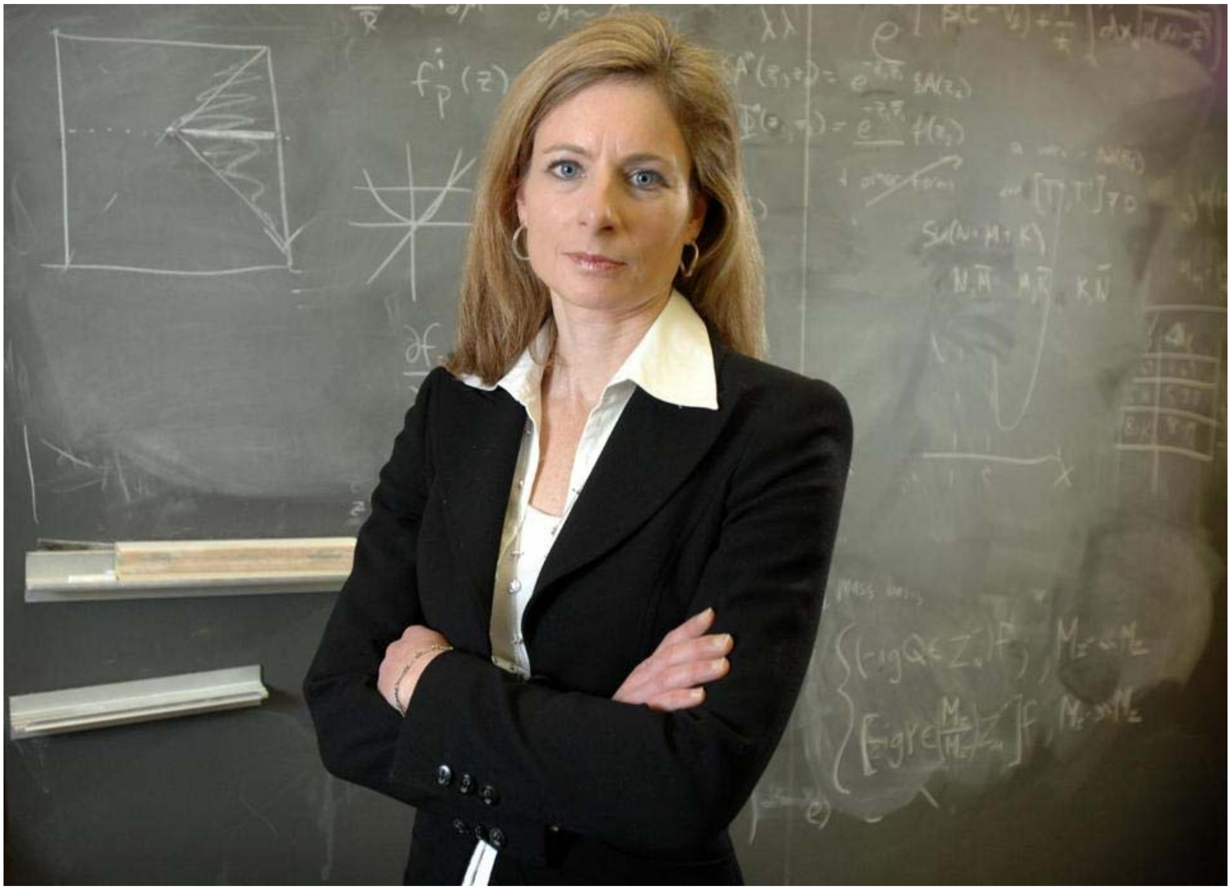
Ideas

Q&A

Lisa Randall: Physics is a universe of uncertainty

A star of the science world looks at what we aren't so sure about

By Peter Dizikes | OCTOBER 22, 2011



JOSH REYNOLDS FOR THE BOSTON GLOBE

Harvard physicist Lisa Randall, a noted researcher into string theory and dark matter, has written a new book about physics.

Contemporary physics has captured the public imagination by juxtaposing staggeringly tiny measurements with vast unknowns. The Large Hadron Collider, the enormous particle collider in Switzerland, can measure subatomic particles down to a tenth of a thousandth of a trillionth of a millimeter--and from studying how matter behaves at such small scales, physicists infer how our entire cosmos is structured.

Lisa Randall is one of the most-cited theoretical physicists of the last two decades, and one of the best-known scientists in any field: In 2007, Time named her one of the world's 100 most influential people. Among other things, Randall's work links the subatomic and cosmic by suggesting an answer to the "hierarchy problem," the puzzling relative weakness of gravity among the four fundamental forces binding matter together. Gravity's pull is much weaker than the other forces, Randall posits, because the universe has a tiny additional dimension absorbing more gravitational force. The "warped" geometry of this cosmic model, developed with physicist Raman Sundrum, includes two branes, or regions of space, with different levels of gravity; we inhabit the low-gravity area.

In her new book, "Knocking on Heaven's Door," Randall takes a surprising tack, illuminating how physics, for all its power and mathematical rigor, is also a realm of major uncertainty: ambiguous evidence, untested theories, and the recognition that most of the universe consists of as-yet unidentified "dark matter" and "dark energy." The Large Hadron Collider might provide evidence for Randall's ideas--or might create new puzzles. Rather than minimizing these doubts, Randall uses her book to take a hard look at the difficulties inherent in exploring the frontiers of knowledge.

Ideas spoke to Randall, a professor in the Harvard University physics department, by phone during her current book tour.

IDEAS: We think of science as offering definitive answers, but in your book you say that in science, "the road to progress is rarely clear"--and that you work on many physics models at once, knowing they cannot all be correct. Why?

RANDALL: The Large Hadron Collider, when it does experiments, is recording every interesting piece of data it can....We need to identify the distinguishing features of interesting new events, even if they happen one out of every trillion times. I don't know which of my models is correct, but over a few years, I can work on various alternatives that answer some of the questions we have. We don't need to look at one model at a time because the same data could be interpreted in different ways.

The extra-dimensional work about warped geometry is an example of this. I was originally concerned about superconnection theory, involving the symmetries of space. But some of the pieces didn't fit together, and [implied] particle interactions that shouldn't happen. So we started thinking about an extra dimension, as a way of separating particles into different places. And in the process of working that out, we found an entirely new solution to the hierarchy problem.

IDEAS: Many of us were taught there is one "scientific method" that leads to new discoveries: Scientists make an observation, come up with a new hypothesis, and then run experiments to prove or disprove it. But you imply science is less cleanly structured than that.

RANDALL: It depends on what time scale we're talking about. Over a long period, we do have observation, hypothesis, and evaluation. But on any given day or even year, that isn't the way it feels; we're just trying to put together the most comprehensive theory that offers the most economical explanation.

IDEAS: Many scientists assert that a beautiful theory is likely to be true: If it has a classical elegance or simplicity, it's usually correct. But you're skeptical of this.

RANDALL: Beauty is subjective. If any physicist showed you a theory they thought was beautiful, you'd probably just look at it--this is beautiful? Furthermore, we associate beauty with order and symmetry, but a beautiful painting has an interesting breaking of symmetry, or interesting ingredients that draw your eye. We're guided by having economical theories, but they rarely have complete order and symmetry, because the world itself doesn't have complete order and symmetry. Beauty is not irrelevant, but it is not in itself enough.

IDEAS: Isn't this your view because your own work implies a baroque cosmic structure, with dimensions of different sizes, and an unequal distribution of gravity in space?

RANDALL: In my work, the unequal distribution of gravity comes out of the equations. As a theory this is actually rather economical, believe it or not, compared to some theories that address the hierarchy problem. It might be one of the more beautiful theories. That doesn't mean it's right. And do you think a world with an extra dimension and two branes is beautiful? Are theories that assume additional particles more baroque than theories that assume additional dimensions? There is no real answer.

IDEAS: Is physics a suitable model for research in the social sciences?

RANDALL: There are really hard problems in social science...where everything affects everything else, and [are] not totally solvable. Yet there is a strong emphasis on solvable problems, a real desire to make things as mathematical, formal, and predictable as possible. Science isn't just making predictable models. You have to make sure models conform to the interesting questions. Often problems are bigger than any solvable model we have; physics helps you identify what is solvable. Science isn't a neat progression. You need different methods working together and eventually, hopefully, the right ideas emerge.

IDEAS: In the public sphere, science draws a lot of credibility from this idea of certainty--it's based on data, so it must be true. Is it hard for scientists to admit uncertainty for political reasons?

RANDALL: It's true that scientists, and others, become fearful of acknowledging uncertainties. But doing so--paradoxically, perhaps--is a way of being more precise. Uncertainty doesn't mean you don't know anything. Allowing for uncertainties is a way of avoiding the "gotcha" moments where something doesn't conform to predictions and therefore the science gets dismissed altogether. In any case, when decisions are based on science, uncertainties are often much smaller than those involved with other policy decisions which have sometimes gone very wrong. So it's not just scientists who need to acknowledge uncertainty--it's politicians, too.