Poised on the edge: an interview with Lisa Randall

Lisa Randall is both a top research cosmologist and one of the best guides to the dizzying world of theoretical physics. *Manjit Kumar* collides with her

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Lisa Randall, photographed by Des Willie

“There is no question that there is an unseen world,” Woody Allen once said. “The problem is how far is it from mid-town and how late is it open.” The notion of parallel realities has been a staple of science fiction ever since 1923 when HG Wells wrote Men Like Gods, in which there exists an alternative world with “no parliament, no politics, no private wealth, no business competition, no police, no prison”. The Utopians who inhabit this world had shared our past until history inexplicably branched. Yet by the late 1950s science caught up when Hugh Everett III, a graduate student at Princeton, showed that theoretically one could treat each and every possible outcome of a quantum experiment, such as measuring the position of a particle like an electron, as actually existing in an alternative parallel reality. He believed that his theory was the simplest interpretation of quantum mechanics, but accepting it was “a matter of taste”. At the time no one took his

idea seriously. But as physics moves on, tastes change.

“I think multiple universes probably exist, but it’s very unlikely we’ll know about most of them,” says Lisa Randall as we chat over coffee during a visit to London to promote her latest book, Knocking on Heaven’s Door. The 49-year-old Harvard professor of theoretical physics leaves the door open to the possibility that there might be others that we can somehow glimpse. “The exception,” she says, “would be universes that affect properties of our own.”

It’s an idea that Randall expands upon in her book, as she tries to portray what is happening today in particle physics and cosmology in terms of both experiments and theory. For particle physicists and even cosmologists this is the era of the Large Hadron Collider, the gigantic particle accelerator under the Franco-Swiss border near Geneva that is smashing together protons at unprecedented energies in an attempt to recreate the conditions of the very early universe to test our understanding of the nature of matter and forces. “I wanted to convey the excitement and implications of the research taking place there,” says Randall, “so when discoveries are made, anyone interested can understand what was found and what it could mean.” And what it could mean is nothing short of mind-bending.

Theoretical physics at the cutting edge is an exotic discipline and not much is more exotic than the notion of extra spatial dimensions in addition to the three that we are all used to. These extra dimensions could be flat, like three dimensions of our everyday existence. “Or they could be warped,” says Randall “like reflections in a fun-house mirror.” They might be unimaginably small or infinite in size. “An infinite extra dimension might sound incredible,” concedes Randall “yet an unseen infinite dimension and parallel universes within it are some of the possibilities for what might exist in our cosmos.”

It was in the 1980s that superstring theory emerged as the leading candidate for the “theory of everything”. Superstring theory says that what we detect in our experiments as particles are really particles are at all but manifestations of the “vibrations” of one-dimensional objects called “strings”. Superstrings vibrate in ten dimensions but we don’t notice these extra dimensions because they are curled up into a space that is infinitesimally small. “Since we don’t see them,” explains Randall, “these new dimensions of space must be hidden.” We would not notice a curled-up dimension “just like a tight-rope walker would view his path as one-dimensional, but a tiny ant on the wire might experience two.”

Physicists had known for years that extra dimensions could be rolled up, but it was only in 1999 that Randall and her former student Raman Sundrum discovered another reason that extra dimensions might be hidden. “Einstein’s theory of relativity tells us that energy and matter curve space and time. We found that spacetime with extra dimensions could be so warped that even an infinite extra dimension could exist but escape detection.” The Randall-Sundrum theory mimicked three dimensions so uncannily that evidence that supports three dimensions of space can also be regarded as supporting the idea of such warped extra-dimensional universes.

Not long afterwards, Randall and another colleague discovered an even more startling theoretical possibility – the universe can have three spatial dimensions in some regions but have more or less in others. If

Randall is right then we might find ourselves living in an isolated region with three spatial dimensions inside a universe with many more. Randall's two papers soon became among the most cited of recent times.

However theoretically sound and mind-blowing the idea might be, the question remains: is there any compelling reason to take extra spatial dimensions seriously? Randall argues there is, for "they may help solve some outstanding problems that have no convincing solutions without them."

Why, for example, is gravity so weak compared to the other known fundamental forces? "Gravity might not appear to be all that weak when you're hiking up a mountain," says Randall "but bear in mind that the gravitational force of the entire Earth is acting on you." However, throw in an additional warped dimension and in this new five-dimensional spacetime gravity is strong in one region of a fourth dimension of space but very weak everywhere else. In this universal architecture it's natural for gravity to be weak in our vicinity.

Randall enjoyed maths at high school in New York but chose to study physics because "I wanted something that could connect to the real world." After getting her PhD from Harvard in 1987 she returned in 2001 as its first female tenured professor of theoretical physics. "I do what I do," she replies with good grace when I ask if she's a role model for other women contemplating a life in science. "One of the nice side benefits is that I can potentially inspire other women, and men, and defy stereotypes." It was an unfair question, but it's one that Randall doesn't often escape, especially after comparisons to Jodie Foster's character in the physicist-meets-aliens film Contact (there is, it must be said, a slight resemblance).

"Often people don't really understand what science is and what we can expect it to tell us," says Randall. The book was an attempt to correct some of the misconceptions and demonstrate that "we shouldn't be afraid to ask big questions or to consider grand concepts". A few days before we meet Randall appeared on Radio 4's Start the Week to discuss her book and found herself sharing a studio with Richard Dawkins and Chief Rabbi Jonathan Sacks. Finding "the word 'atheist' odd", Randall says she would categorise herself as a "nonbeliever".

"Religion puts things together to see what they mean, science takes them apart," said Sacks during the programme. I remind Randall that at one point in the discussion she had responded by saying that it wasn't science versus religion, but the rational versus the irrational. "It's odd how often scientists get asked about religion because they really are such different enterprises. I do think however that it helps to precisely pinpoint the differences so we can have sensible conversation."

"The answer," believes Randall, "has to do with understanding that contradictions arise when we treat religion as something other than a social or psychological enterprise. When we believe an entity or spirit literally affects the world, or our choices today, this goes against the material mechanist view of science. That is why when the Chief Rabbi said that God is a gardener, who sets everything in motion, I asked whether he thought God keeps gardening. We don't know what happens in the beginning. Scientists won't choose a deistic interpretation but we can't show a contradiction either. But in later times or today, that would run counter to what science shows, unless we believe God just acts according to the rules of science in which case the role is rather unclear."

Not one to shy away from the big questions, one of the things Randall is currently attempting to explain is the amount of dark matter in the universe. With the biggest and most exciting experiments in particle physics and cosmology under way, what they reveal could provide clues that could ultimately change our view of the fundamental constituents of matter, and even of space itself. “We are,” Randall believes, “poised on the edge of discovery.”

Knocking on Heaven’s Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World by Lisa Randall is published by Bodley Head