A life with extra dimensions

Lisa Randall spends her working life considering whether we live in a world with more than three spatial dimensions. Although the idea might sound odd, her new book tries to show why it is not as crazy as it sounds, as **Matin Durrani** reports

There is one thing you need to know about Lisa Randall: last autumn she was named the most cited theoretical physicist over the previous five years. Her speciality is particle physics and, in particular, the consequences of "extra dimensions". Randall, who is based at Harvard University, is interested in whether we live in a world with not just three spatial dimensions, but possibly four, five, six or more.

One motivation for her work is string theory, which attempts to unify gravity and quantum mechanics. It assumes that subatomic particles are not fundamental but are, in fact, the oscillations of "strings". The problem with the theory is that it only works properly if the universe has 10 dimensions. Indeed, string theory may be the "classical" limit of a more fundamental theory, known as M-theory, which has 11 dimensions, and possibly more. M-theory suggests that the universe also contains extended, membrane-like objects called "branes".

Until the 1990s most people thought we could not see these extra dimensions because they are "rolled up" to extremely tiny sizes. But in 1999 Randall – working with Raman Sundrum who was then at Boston University – came up with an alternative idea. They argued that branes have energy – so much, in fact, that they can warp space and hide the extra dimensions.

"We could be stuck on a lower-dimensional membrane in a higher-dimensional world, but because space is so warped, we do not see the physical consequences of extra dimensions," says Randall. Later she and Andreas Karch from the University of Washington discovered an even more radical possibility – that we could be living in what they call a "sink-hole", where we see only four dimensions even though the rest of the universe has more.

JACK R LINDHOLM

Highly cited – Lisa Randall.

Definitely not crazy

Although Randall is aware that extra dimensions might be regarded as bizarre, she has found that people are intrigued by the concept – more so, in fact, than by run-of-the-mill particle physics. To feed that latent interest, she has spent the last three years writing a popular-science book about the subject. Entitled *Warped Passages*, the book is published by Penguin on 16 June.

"The idea of extra dimensions is definitely speculative – I am not going to deny that – but it is not crazy," she says. "The reason we think there are three dimensions of space is because that is all we can see. It seems a little short-sighted to rule out the possibility of extra dimensions. Of course, you don't want to just make up new things to get easy answers that are not based on reality, but there are good reasons why higher dimensions might exist."

Extra dimensions could, for example, explain why gravity is so weak compared with the other fundamental forces. They could also account for the fact that we see some interactions between elementary particles but not others. Experimental consequences of extra dimensions could be tested experimentally at the Large Hadron Collider (LHC), which comes online in 2007.

"Extra dimensions have a very distinctive experimental signature in the form of 'Kaluza–Klein' particles," explains Randall. "In some models with extra dimensions, all we would see is the missing energy – the particles would carry off energy into extra dimensions. And if gravity is warped, the consequences could be even more spectacular. We could then measure the spin and mass of the particles and tell if they are partners of the graviton – the particle that mediates the gravitational force. It will be really quite beautiful if we see them."

Harvard life

Given the glut of popular-science books, why did Randall write her own? One reason she gives is that many books do not properly reflect how physics is done. "I wanted to highlight the creativity, fun and imagination that is involved in physics," she says. *Warped Passages* also examines whether parallel universes could exist in the extra dimensions. These universes could experience very different forces and be composed of entirely different elements. The only force we would share with such parallel worlds would, in Randall's view, be gravity. "I see no reason why such universes such not exist," she says. "We might not know about them and they might not communicate with us, but it is narrow-minded to think we might be the only ones who could exist."

Another motivation for the book is to show that not all particle physicists are geeky men. In fact, Randall is a keen skier, rock-climber and movie-goer who has a "completely useless talent" for remembering lyrics to pop songs, a selection of which appear throughout the book at the start of each chapter.

But Randall is at a loss to explain exactly why physics is so dominated by men. Part of the problem, she says, is sociological – people think you have to be a certain type of person to do physics. "Girls do have other interests as well, but that does not mean they can't do maths and science," she says. "By writing the book I want to show that you don't have to give up the rest of your personality or interests to do physics."

However, Randall is against setting quantitative targets for women in physics. "I hate that sort of thing," she says. "We just need a level playing field. There really are prejudices, both inadvertent and deliberate, and if we get rid of those, we don't need any targets. Plus, the more women there are, the more women there will be."

The issue of women in science has been a hot topic in the US following comments made by Harvard president Larry Summers during a speech in January. He caused outrage by allegedly suggesting that differences in "intrinsic aptitude" between men and women could be why there are so few senior female scientists. Randall dubs his comments "silly and misguided" but refuses to be drawn on how she voted in a no-confidence motion in Summers that took place in March among members of the arts and sciences faculty. (The motion was passed by 218 votes to 185, but Summers retains the backing of the university's board.)

However, Randall admits that intelligence is a hugely complex issue. "Ask a biologist why a fish moves in a particular way and they have no idea," she says. "So how can we expect to figure out the origins of intelligence?" It is certainly a question with many dimensions.