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Warped Passages:

Unraveling the Mysteries of the

Universe's Hidden Dimensions

By Lisa Randall

HarperCollins, 500 pages, $37.95

Iam fairly certain that when Lewis Carroll wrote *Alice's Adventures in Wonderland* and *Through the Looking Glass*, he did not intend seven-year-old Alice to carry the metaphorical weight of some of today's most complicated scientific theories on her little-girl shoulders. Popular science writers seem unable to resist invoking Alice to describe the weird and wacky world of quantum theory.

And now the string theorists are doing it, too. Physicist Lisa Randall calls on Alice to help explain higher dimensions in her first book, *Warped Passages*. But to be fair, little Lisa actually spent some of her formative years at New York's Lewis Carroll School.

Lewis Carroll wrote his popular books in the 1860s, a time when higher dimensionality was gripping the imagination of a public disenchanted with the sterility of science and the industrial age. Table-tapping séances and communing with the dear departed in the fourth dimension were popular entertainments. The fourth dimension fascinated writers and thinkers, and spawned the Cubist movement in art.

But people weren't always sure what they meant when they talked about a higher dimension. In the H. G. Wells classic *The Time Machine*, the fourth dimension in which the machine was travelling was time. We routinely refer to our reality as having four dimensions -- three of space and one of time. But in *The Invisible Man*, Wells used the fourth dimension as an extra spatial dimension from which the protagonist could act on the visible world while remaining invisible to the characters limited to three-dimensional perception. The world of the Invisible Man is five-dimensional. This is where higher dimensions get interesting.

Particle physicists have had marvellous success in predicting how the "stuff" of the universe evolved from shortly after the Big Bang to the present. They've been able to test their predictions in high-energy particle accelerators at Conseil Européen pour la recherche nucléaire (CERN), in Switzerland, and at the Fermilab near Chicago. The resulting Standard Model explains why we have only three fundamental particles that make up everything in our universe today (electrons and the up quarks and down quarks that make up the proton and neutron of atomic nuclei), along with the four forces that "manage" the pulling together or pushing apart of the fundamental particles. The problem is that gravity refuses to co-operate and fit nicely into the model. The gravitational force is very, very feeble. In fact, the electromagnetic force is about 1,047 times stronger, and nobody can explain why.

Randall, a theoretical physicist at Harvard University, is an acknowledged leader in M-theory (the theory formerly known as string), which is the leading candidate in bringing the recalcitrant gravitational force into line with the three other forces (electromagnetic, strong and weak). She proposes that, while the other three forces are sequestered to our four-dimensional world, the gravitational force is not. According to

Albert Einstein's Theory of General Relativity, gravity is woven through the fabric of space and time, and cannot be confined to any particular universe, whether that universe has three dimensions or 20. That means universes can "communicate" with each other through gravitational force, but each dimension that gravity passes through significantly reduces its strength. Randall proposes that our weakened gravity comes to us via the warped space-time of the fifth dimension, hence "warped passages." She and her colleague Raman Sundrum have done the math to back it up.

M-theory does allow for 10 dimensions, but "compactifies" the extra dimensions to explain why we don't see them. We can't learn anything interesting from extra dimensions that don't have any measurable effect in our world and that are so tightly rolled up and so small that we can't ever see them. Such extra dimensions might make for interesting speculation, but we've entered the realm of angels dancing on the head of a pin. It's the dimensions that have some kind of impact in our world that are really interesting, and maybe five-dimensional gravity is it.

The Randall-Sundrum model has raised some skeptical eyebrows in the physics community, but it has something going for it that eludes M-theory. It's testable. According to Randall, evidence of gravity from a higher dimension could be tested at the high energies available when the new Large Hadron Collider at CERN powers up in about two years. There might, however, be an interesting side effect if Randall's model is true. Little black holes could form as protons crash into each other at high energies, but these would quickly dissipate due to Hawking radiation rather than grow and swallow the known world. We hope.

Although Randall's hefty volume does cover a lot of higher dimensional territory, it's ultimate *raison d'être* is to present a solution to the gravity head-scratcher. But to understand Randall's new theory, readers require some understanding of particle physics, general relativity, quantum mechanics and string theory. That's not a problem, because Randall does a rather nice job of covering them all, much in the same manner as Brian Greene did in his books on string theory (*The Fabric of the Universe* and *The Elegant Universe*).

Greene's books have been popular sellers and you might wonder why we would need yet another book to cover the same territory. But Randall's work is different from Greene's. She has, in my opinion, achieved that perfect balance of drawing the non-specialist reader into the complicated world of her research without coming across as condescending or patronizing. She is in the zone, and the result is a warmth and accessibility that is often missing in the more remote and impersonal writing styles of most scientist-cum-authors. I'm not sure if this warmer style of writing is because Randall is a somewhat rare creature -- a female theoretical physicist at an Ivy League university -- or because she was writing this book while confined to bed for two months after falling off a mountain. (Darned gravity!)

Randall does slip out of the zone in the middle chapters that cover the short courses in general relativity, particle physics, quantum mechanics and string theory. But, clever boots that she is, she provides a half-dozen or so bullets at the end of each chapter so that you don't have to read the heavier stuff to hang onto the thread of the story until it lightens up again in the latter part of the book.

Randall adds a leavening touch by starting each chapter with lyrics culled from songs by such artists as Jefferson Starship, Bob Dylan, Gloria Gaynor and U2. Although the lyrics chosen are sometimes rather oblique, it's a nice change from the usual quotes from dead scientists.

Warped Passages presents an intellectually challenging read, but you can get most of the intriguing ideas about higher dimensions and the implications for our reality by reading the chapters in the first third, the bullets in the middle third and then the rest of the book. Without this option, I suspect many readers might bog down in the more technical material and never get to the really interesting ideas at the end.

As Grace Slick would say, "Feed your head."

Sheilla Jones is writing a book about why nobody understands quantum theory, and she's doing it without